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Baseline monitoring of *Posidonia* seagrass beds in Corner Inlet, Victoria.

General disclaimer

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Cover design: Luisa Laino (Museum Victoria)

Front cover illustrations of animals from Corner Inlet, from top to bottom: 1) the majid crab *Trigonoplax longirostris*, previously not recorded from Corner Inlet; 2) the Southern Dumpling Squid (*Euprymna tasmanica*); 3) a nudibranch (*Ceratosoma brevicaudatum*) on *Posidonia australis* seagrass. Photos: Mark Norman.

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Figure 1. The two common sea-stars in Corner Inlet: the multicoloured *Patiriella calcar* (above) and the purple or brown *Patiriella brevispina* (below).

1. Background to the study

The Corner Inlet and adjacent Nooramunga are designated as a Marine and Coastal Park and the area is listed under the Convention on Wetlands of International Importance especially as waterfowl habitat. The region possesses some unique conservation values that include the largest stand of *Posidonia australis* seagrass in Victoria (Morgan 1986) and several invertebrates that appear to be restricted within Victoria to this region (O'Hara & Barmby 2000). The fauna has affinities both with the cool-temperate fauna of Western Victoria and the warm-water fauna of east Gippsland (Turner & Norman 1998, O'Hara & Poore 2000).

In July 2000, the Department of Natural Resources and Environment commissioned Museum Victoria to collect quantitative data on fishes, invertebrates, seagrasses and macroalgae from sub-tidal seagrass beds in Corner Inlet, focusing on the *Posidonia* seagrass meadows.

The objectives of the project for 2000/2001 for Corner Inlet were to:

(i) obtain quantitative baseline data on Corner Inlet subtidal seagrass communities that can be used in conjunction with future data for determining the effectiveness of management in protecting the region's marine flora and fauna;

(ii) obtain data that can be used for characterising the fish, invertebrate and plant communities of the area;

(iii) obtain data that can be used to assess the status of invertebrate species of conservation concern that occur in Corner Inlet/Nooramunga. These include species apparently restricted within Victoria to Corner Inlet/Nooramunga or *Posidonia* seagrass beds.

2. Executive overview

2.1. Methods

Eighteen sites were surveyed in *Posidonia* seagrass beds spread along the north and south sides of Bennison and Middle Banks in southern Corner Inlet. The location of each transect was determined by standard GPS and marked by a buoy. At each site (usually) two transects were surveyed that ran north-south from the channel bank into the seagrass bed.

Data from each site transect included:
- A fish/cephalopod check list.
- A qualitative description.
- Cover abundance per m^2 of seagrass, algae and sessile invertebrates from ten quadrats.
- Abundance of large invertebrates per m^2 for ten quadrats.
- Density of *Posidonia* shoots per m^2 for five quadrats.
- Maximum height of *Posidonia* shoots in ten 1.0 m^2 quadrats.

In summer (December-February), 18 sites were surveyed. In winter (June) ten of these sites were resurveyed.

Large fish species targeted by commercial fishers in Corner Inlet were not surveyed. These larger species are difficult to assess on SCUBA surveys due to diver avoidance and limited visibility.

2.2. Results

Spatial variation

- The seagrasses discovered were *Posidonia australis*, *Heterozostera tasmanica* and *Halophila australis*.
- *Posidonia australis* has longer leaves and is denser near the apex of each bank, particularly in summer.
- *Heterozostera tasmanica* is more common further back along the banks, although it can fringe the *Posidonia* banks at any point where the slope is gentle.
- No clear pattern for *Halophila australis*; occurs where *Posidonia* is not dense.
- No relationship between cover of seagrasses and channel or aspect (north and south of the bank).
- No deep-water seagrass beds could be found along the apical edge of Middle and Bennison Banks as shown in the Corner Inlet/Nooramunga Coastal Resource Atlas (MAFRI 1998). Instead these areas were covered in coarse shell debris.
- Only one seedling of *Posidonia* was found. Spent inflorescent spikes were common in December, but absent in June.
- No clear spatial patterns for algal or sponge cover; although both transects at a site generally had similar values.
- Invertebrate multivariate pattern did not correlate with floral cover pattern.
- Gastropods (predominantly *Thalotia conica*, *Astralium aureum*) were abundant at the rear of Bennison Bank.
- Sea urchins were uncommon.

- Very few fish were observed; not enough to be quantitatively analysed. This could be due to fishing pressure or predator avoidance (dolphins, penguins and cormorants were common). Most common fish/cephalopods sighted in the seagrass beds were pygmy squid, pipefish, gobies, leatherjackets, and gobbleguts. Fish were more common in deeper water in the channels, including flathead, stingarees and rays.
- A rare invertebrate (*Trochodota shepherdi*) was found on epiphytic algae in *Heterozostera* beds adjacent to the *Posidonia* beds.

Temporal variation

- The most notable temporal change was the reduction in the height and cover of *Posidonia* during the winter months. The tip of each blade was removed, mean shoot length changed from 585 mm (max 1100 mm) in summer to 243 mm (max 400 mm) in winter.
- Shoot length of *Heterozostera* and *Halophila* remained the same.
- No significant differences in the fauna.

Effects of Seining

- Several sites had unusually short *Posidonia* shoots during summer. At one site (site 15) there was evidence of haul seining, including tracks through the sand and rolls of seagrass leaf fragments and epiphytes on the seafloor.
- These site differed from the others in having:
  –*Posidonia* cropped to approximately 310 mm (mimicking the winter die-off)
  – fewer gastropods and large crabs
- Seastars and sessile invertebrates (eg sponges) appeared unaffected.

2.3. Conclusion

- The *Posidonia* beds supported a single faunal and floral community. There were few significant differences between Middle and Bennison Banks. Distance from the inlet entrance had an effect on the distribution pattern of some species, presumably derived from differences in tidal flow rates.
- The experimental design had enough power to detect a large, widespread temporal and spatial change in *Posidonia* cover and density. Local changes will be more difficult to detect.
- Faunal data showed no clear patterns, with the exception of gastropod abundance which was greater at the rear of the banks.
- Fish were not numerous enough for statistical analysis.
- Seining reduced the height and cover of *Posidonia* and the abundance of some of the associated fauna. As this disturbance can't be easily predicted or measured, it will make correct interpretation of long term data problematic, particularly for data collected during summer.

Figure 2. ***Posidonia australis*** **seagrass with a gastropod (*Thalotia conica*) and majid crab (*Trigonoplax longirostris*).**

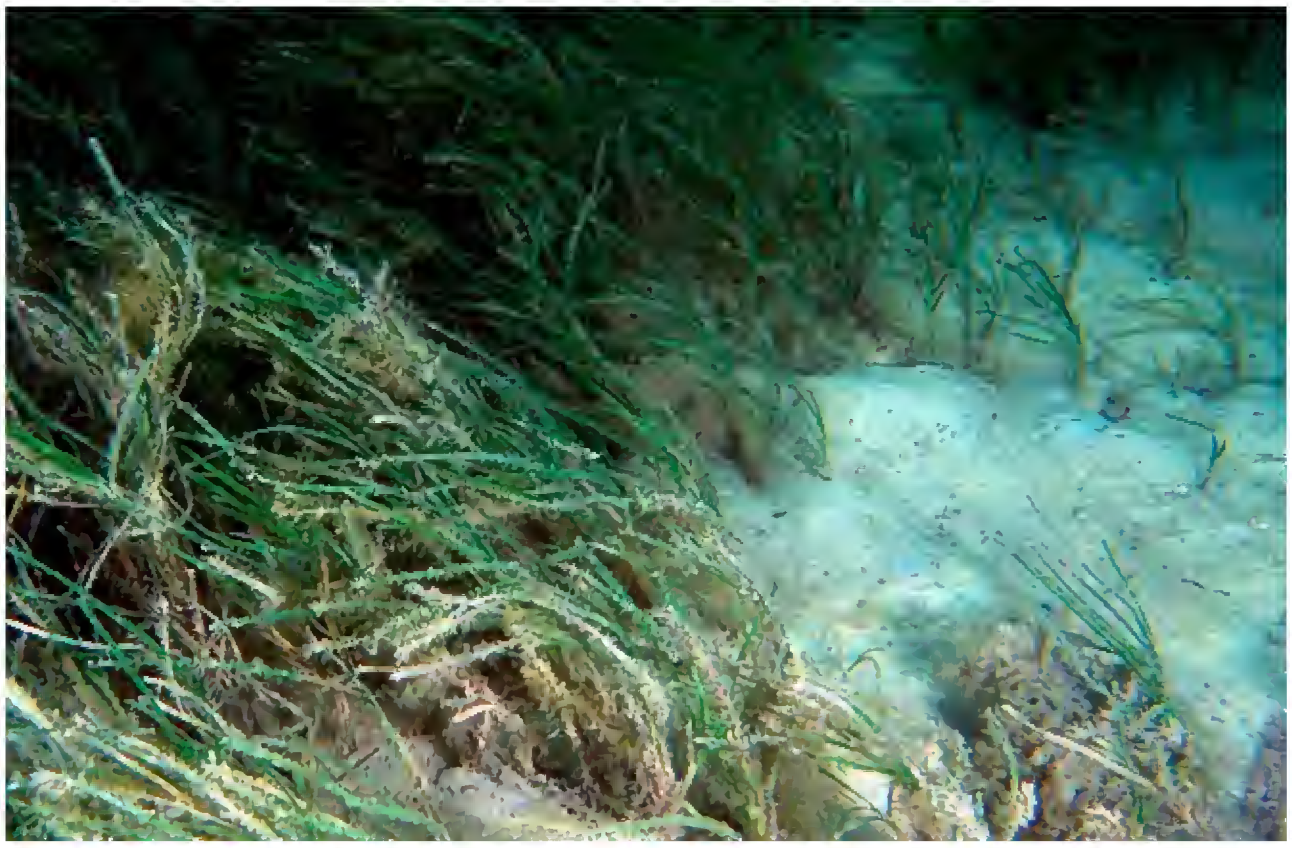

Figure 3. ***Heterozostera tasmanica*** **seagrass bed**

Figure 4. ***Halophila australis*** **seagrass.**

3. Descriptive overview

Corner Inlet is a large submerged plain. Bordered to the west and north by geological faults, it is very slowly sinking over time as South Gippsland rises. However, this subsidence is more than matched by the steady accumulation of sediment, washed down from surrounding valleys. Today large sand or mud banks cover most of the Inlet. Some of the banks can become exposed at low tide; others remain permanently submerged. On an ebbing tide, a radiating system of deeper channels drain the banks towards the entrance on the eastern side. It can take over an hour and a half for the peak of low or high tide to reach the far reaches of the Inlet; tidal ranges vary from 1.5 m near the entrance to almost 3 metres near the Port Albert.

The diverse landscape is matched by the profusion of animal and plant life. From the seagrass meadows, mudflats, mangroves and deeper channels, the quiet sheltered waters of Corner Inlet host an amazing variety of sea-life. No less than four of Victoria's five main species of seagrass form meadows here. The short eelgrass (*Zostera muelleri*) forms dense mats around the fringes and frequently lies exposed at low tide. The long eelgrass (*Heterozostera tasmanica*) prefers slightly deeper water, and is common on the top and around the base of submerged banks, places where it is not out-competed by the larger and more vigorous Broad-leaf Seagrass or Strapweed (*Posidonia australis*). Broad-leaf Seagrass is the dominant seagrass on the submerged banks. The long flat fronds sprout from a thick rhizome lying deep within the sediment. The fourth seagrass is the diminutive Southern Paddleweed (*Halophila australis*), which appears as pairs of small oval leaves snaking out along long slender rhizomes. It occurs sparsely around Broad-leaf Seagrass beds or across sandy patches, although it can be locally common.

The dense Broad-leaf Seagrass beds are one of the reasons that Corner Inlet is so special. It is the only place in Victoria where it forms large meadows. The nearest substantial beds are far away in the South Australian Gulfs, New South Wales or around Flinders Island in Tasmania. This isolated colony may be a remnant from a warmer climate when meadows could form all along the Victorian coastline, or perhaps originated from a fortuitous immigrant. Either way, colonies of Broad-leaf Seagrass establish infrequently. Seedlings are rarely observed, only one was observed in the current survey. Instead the plant spreads vegetatively via rhizomes. It reinvades disturbed areas very slowly. Sand "blow-outs" are a regular feature of Broad-leaf Seagrass beds and may persist for decades.

The life history of the eelgrasses is somewhat different. These species regularly sprout from seed and, provided enough light can filter through the water, can quickly recolonise bare sediment. Once established these species will also spread from rhizomes.

Broad-leaf Seagrass is a "keystone" species that provides shelter and food for many other creatures. Fish and large crabs find refuge under the long fronds. It is one of the few "hard" substrates available to smaller plants and animals in the expanse of sand and mud. The leaf tips become covered in a fuzz of filamentous algae and encrusting invertebrates, such as a bright red sea-moss and a smooth white colonial ascidian. The base of the leaf shoot supports larger organisms such as a bright orange finger sponge, a hard knobbly sea-squirt and some small red and green algae. The rhizomes of the seagrass play a fundamental role in stabilising the fine sediment, keeping the waters of the Inlet relatively clear. Finally the seagrass is itself an important source of food. Not so much when it is alive, when the indigestible tannins keep most herbivores away. But when it decomposes, it provides the bulk of the organic matter for the animals that burrow through the silt and for those that filter the water as it streams past.

However, the animals and plants that live on the seagrass become a burden. They reduce the amount of light reaching the seagrass blade and prevent it from growing. The Broad-leaf Seagrasses' response is to grow from the base, ensuring a constant supply of fresh green leaf that is free (at least for a while) of other species. In contrast the encrusted tips of the leaves are allowed to die and break free. Thus there is a constant cycle during spring and summer of leaf growth from the base and death at the end. You will rarely find a Broad-leaf Seagrass leaf that has an unbroken tip. Nevertheless the leaves can reach over one metre in length, and the seagrass bed is dense and luxurious. In winter growth is much reduced, storms rip off much of the leaf, leaving less than 300 mm remaining. The seagrass bed looks like it has been mown; dead leaves become piled up along the shoreline.

Seagrass beds shelter numerous other animals and plants. Under the Broad-leaf Seagrass leaves in Corner Inlet, there is a sparse understorey of green algae, sponges and sea-squirts. The main green algae are the beautiful *Caulerpa trifaria* with its characteristic three rows of tiny branchlets. *Codium fragile*, commonly known as Dead Man's Fingers after the thick fleshy fronds, grows here and there. The larger animals include two crabs, the aggressive Red Swimmer Crab (*Nectocarcinus integrifrons*) which will readily bite unwary fingers, and the long-limbed decorator crab (*Naxia aurita*). An occasional shy Blue Ringed Octopus (*Hapalochlaena maculosa*) is present.

There are several common seastars including the purple six-armed *Patiriella brevispina* and the multi-coloured eight-armed *Patiriella calcar*. These are the garbage disposal units of the seagrass bed devouring plant and animal debris. Less common are the large eleven-armed seastar (*Coscinasterias muricata*) which preys on molluscs and the seven-armed *Luidia australiae* with long mottled black and white arms that usually lies buried in the sediment. Sea-urchins are present, although rarely seen. *Amblypneustes ovum* with a spherical body and short black and white spines lives on filamentous algae. The elongate heart urchin *Echinocardium cordatum* lives buried deep within the sediment.

Numerous snails live on the seagrass. The most common species are the turban shells *Thalotia conica* and *Astralium aureum*. These species do not live on the seagrass itself, but on the epiphytes and micro-organisms that cover the leaves, and thus they help keep the seagrass clean. These species are very common on sheltered banks further into the inlet. The most brilliant snail is the Pheasant Shell (*Phasianella australis*), which can grow up to 60 mm long and is covered in stripes of brown, pink, cream, purple and red. There are also numerous smaller shells living in the foliose epiphytes and amongst the debris on the seafloor. Old shells are readily snapped up by hermit crabs.

Smaller fish and squid can be seen hiding amongst the seagrass. These include Weed and Rock Whiting (*Haletta semifasciata*, *Neoodax balteatus*), Southern Gobbleguts

(*Vincentia conspersa*), Cobblers (*Gymnapistes marmoratus*), Woods Siphon Fish (*Siphaemia cephalotes*), Marine Gobies (*Tasmanogobius gloveri*), Toadfish (*Tetractenos glaber*), Globefish (*Diodon nicthemerus*), Bridled and Pygmy Leatherjackets (*Acanthaluteres spilomelanurus* , *Brachaluteres jacksonianus*)and various pipefishes (eg *Stigmatopora argus*). Many of these fish are difficult to see. However, if you are patient they will emerge and investigate your presence. Larger fish can be regularly spotted by divers, particularly on patches of sand, including Sparsely-spotted and Cross-Backed Stingarees (*Urolophus paucimaculatus*, *U. cruciatus*), Southern Fiddler Rays (*Trygonorrhina guanerius*), Rock and Sand Flatheads (*Platycephalus laevigatus*, *P. bassensis*), and Greenback founders (*Rhombosolea tapirina*). Small schools of juvenile Silver Trevally regularly swim past (*Pseudocaranx dentex*). The commercially important fish such as King George Whiting, Australian Salmon, Southern Garfish, School and Gummy Sharks are rarely seen.

Two tiny squid are regular inhabitants of the Broad-leaf Seagrass beds. The Southern Pygmy Squid (*Idiosepius notoides*), with a tiny row of blue dots, hovers above the seagrass leaves, while the iridescent Southern Dumpling squid (*Euprymna tasmanica*), although mainly active at night, can occasionally be seen sitting motionless near the seafloor.

The deep channels that drain the seagrass beds support a different animal community. The sides of the banks can be covered in a field of brittle-star arms (*Amphiura elandiformis* and *Ophiocentrus pilosa*). Two to four of their five long arms are held up to catch plankton streaming past with each tide. Food is relayed back to the mouth, which is kept hidden deep in the sediment.

The bases of the channels (5-20 m) support large clumps of sponge and sea-squirts. Typically these 'mini-reefs' appear to start as a sea-squirt (*Pyura stolonifera*) that attaches to one of the many dead oyster shells that lie just beneath the surface of the sediment. Other sedentary animals then settle, attach and grow on the sea squirt. These include many different coloured sponges, such as the pink spiny *Dendrilla rosea*, encrusting ascidians, soft-corals, fragile lace-corals, large orange anemones, some red seaweeds and various hydroids. The mini-reef then provides shelter to many other mobile animals, including the Banded (*Ophionereis schayeri*) and Sponge Brittle-stars (*Ophiothrix spongicola*), the brown knobbed sea cucumber (*Stichopus mollis*), the Doughboy Scallop (*Chlamys asperrimus*), the Eleven-armed seastar and the Large Biscuit Seastar (*Tosia magnifica*).

The waters of Corner Inlet and Nooramunga are unique in many ways. They are situated in a region of Victoria where the cool waters of the south and west meet the warm waters of the east and north. Some animals and plants, preferring cooler waters, are at the very east of their range. A good example is the Little Scorpion Fish (*Maxillicosta scabriceps*) which ranges from Western Australia to Corner Inlet. On the other hand, some warm-water species, for example the White Mangrove (*Avicenna marina*), are at the southern tip of their range. Other species, such as Broad-leaf Seagrass itself, only occur within Victoria in this region. Some species depend directly on the Broad-leaf Seagrass, for example a small boring isopod (*Lynseia annae*). For other rare species the link is not so clear. The occurrence in Corner Inlet of the small black sea-cucumber (*Trochodota shepherdi*) and the seagrass brittlestars (*Ophiocomina australis* and *Amphiura triscantha*) is probably not directly related to Broad-leaf Seagrass but their preference for similar ecological conditions.

There is evidence that humans have interacted with the inlet for at least 5000 years. Aboriginal middens are plentiful along the southern shore. Europeans settled South Gippsland in the 1850s. By the 1860s, once regular steamship services to Melbourne commenced, fishing became an important industry. The majority of fishers used small wooden boats to hand haul nets over shallow seagrass beds or set mesh nets in the deeper channels. This technology persisted until the 1980s when powered aluminium boats and new seine net designs allowed fishers to target deeper seagrass beds. In the meantime land practices in the catchment changed the Inlet is subtle ways. The hills were cleared of forest by the early twentieth century and levee banks and seawalls were constructed along the northern coastline. The Broad-leaf Seagrass beds to the north of the inlet gradually disappeared, perhaps the result of increased sedimentation or nutrient run-off. Ricegrass (*Spartina anglica*) was introduced around Foster in the 1930s, which altered the shape of the estuaries.

Figure 5. Typical mini-reef on the floor of the deeper channels.

Figure 6. The eleven armed sea-star, *Coscinasterias muricata*.

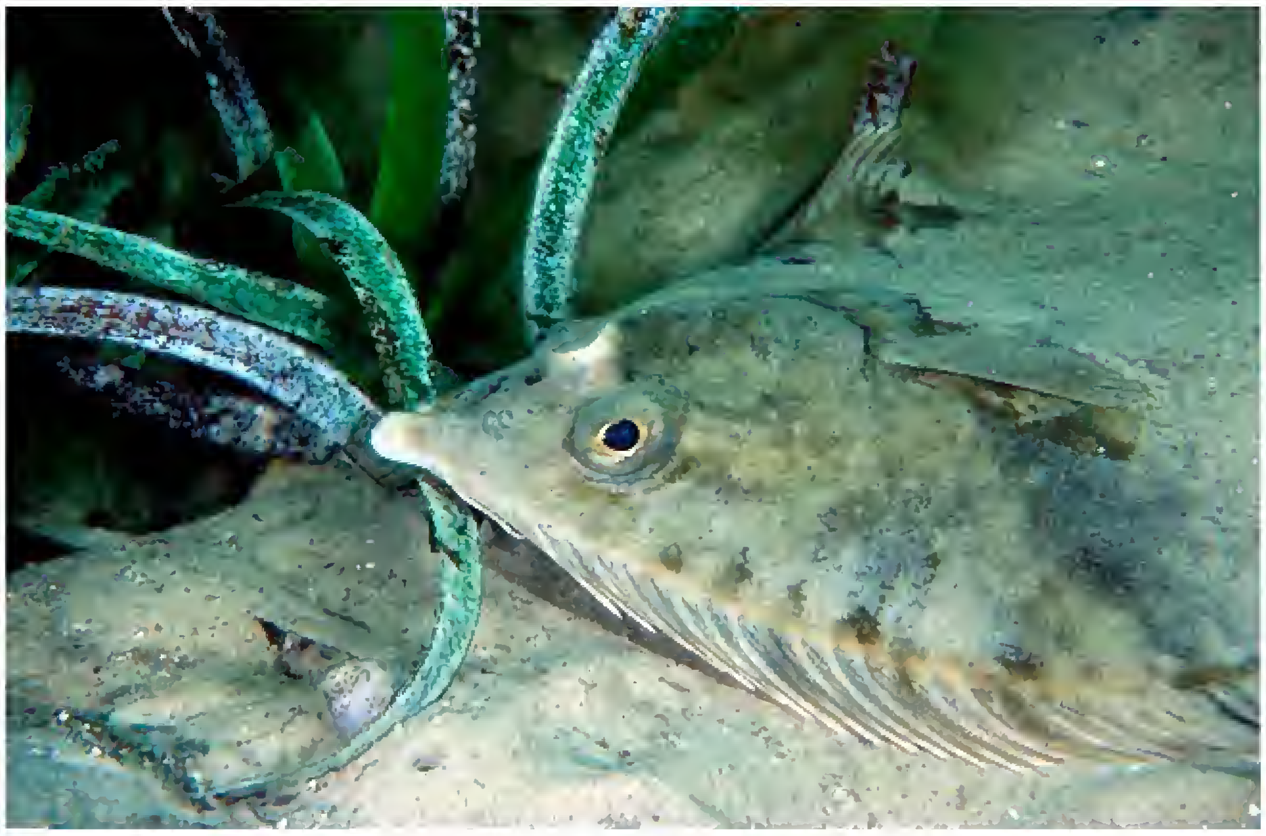

Figure 7. Greenback Flounder (*Rhombosolea tapirina*)

Figure 8. Southern Gobbleguts (*Vincentia conspersa*).

4. Study methodology

4.1 Data collection

Sites

Sites were selected along two banks at the southeastern end of Corner Inlet (Figure 12). This area was chosen on the basis that 1) it was known to possess extensive *Posidonia australis* beds and 2) encompassed the area recommended as a marine national park (Environment Conservation Council 2000). The two banks selected for study were Bennison and Middle Banks. Sites were randomly selected from along the southern and northern sides of each bank, from the apex of each bank westward for a distance of 8 km. Once a site was chosen, 1-2 50 m transects were run from the edge of channel north-south into the bank (either north or south depending on the side of the bank) using a compass (Figure 11). The location of the site was determined using standard GPS. The base of each transect was marked by a buoy tied to a small star-picket. The star-picket was completed buried into the seafloor ensuring that fishing nets and boats would not become snagged or damaged. Pair of divers worked together along each transect, one diver surveying the flora, the other surveying the fauna. The same team of divers consistently surveyed eastern and western transects in order to account for observer bias.

Four field trips were conducted to the study area. The first in July 2000 was limited to spot sampling off Manns Beach in Nooramunga because of adverse weather conditions. The second in December 2000 established the survey methodology. Transects were established at six sites. The third trip in February 2001 established transects at a further 11 sites, and visual surveys of the channels were conducted. This completed the summer sampling. The fourth trip in June 2001 resurveyed 10 sites for the winter sampling. Buoys were located for nine of the ten resurveyed sites. The sites and transects are summarised in Table 1.

Abundance data

Six sets of data were collected from each transect.

1. A qualitative description of the transect and associated flora and fauna.

2. Seagrass/algal cover abundance. One 1.0 m^2 quadrat was sampled every 5 meters along the transect (beginning at the 5 m mark). The quadrats were divided up into eight 0.25x50cm sub-quadrats based on the methodology of Provancha & Scheidt (2000) in order to minimise observer bias. Percentage cover abundance was estimated in each of the sub-quadrats for the three seagrass species (*Posidonia australis*, *Heterozostera tasmanica*, *Halophila australis*), algae (predominantly *Caulerpa trifaria*, *Codium fragile* and filamentous epiphytes), and sessile invertebrates.

3. Faunal abundance. The abundance of major macro-invertebrates was measured for each of the ten 1.0 m^2 quadrats established above. Invertebrates included large seastars, sea-urchins, crabs, gastropods, ascidians and sponges. Ascidians and sponges were identified to colour 'morpho-species'. Surveying for these species included searching by hand amongst the seagrass shoots and across the upper layer of sediment. Other large invertebrates were noted.

4. Seagrass shoot density. Seagrass density was measured by counting shoots by hand in three 25x25cm sub-quadrats randomly placed within the main 1.0m^2 quadrat. Shoot density was measured every second quadrat along each transect.

5. Seagrass height. Maximum leaf height was determined by 'combing' three clusters of shoots in the 1.0 m^2 quadrat. Shoot density was measured every quadrat along each transect.

6. Fish presence/absence. The presence and absence of fish and cephalopod species was noted along each transect. Observed fish numbers were too low to justify quantitative measurements.

Biomass data

The relationship between biomass and shoot height was investigated along a single transect in summer. Ten 0.25x0.25 cm quadrats spaced 5 m apart were destructively sampled by removing all shoots and rhizomes down to 20 cm depth. The rhizomes were cut along the edge of each quadrat. The samples were returned to the laboratory, separated into above and below ground material, dried in an oven at 60°C for 5 days, and weighed.

4.2. Analytical techniques

This study primarily used the multivariate statistical framework outlined by Clarke (1993) and Clarke & Warwick (1994) and implemented by the PRIMER software package.

Transformation and similarity coefficient

The floral cover abundance data was effectively standardised (as a percentage of a metre square quadrat) and thus was not transformed. Abundance of faunal species was size dependent with the smaller gastropods being much more numerous than the seastars or crabs. Consequently, the faunal data was fourth square root transformed to overcome the potential dominance by smaller animals.

The Bray-Curtis similarity measure was used, as it is particularly suitable for ecological applications. It does not include joint absences of species and is not dependent on the scale of measurement (Clarke & Warwick 1994).

Environmental variables

The analyses were interpreted by reference to the following environmental data: bank (Bennison or Middle Banks), aspect (north or south side of the Bank), neighbouring channel (Bennison, Middle and Franklin), distance in metres from the easterly tip of the bank, season (summer and winter), depth and transect (east or west).

Cluster dendrograms

Clustering techniques are designed to find "natural groupings" of samples, ie those samples that are more similar to each other than samples in other groups (Clarke & Warwick 1994). The output of hierarchical agglomerative clustering is a dendrogram (a tree) that groups samples into progressively larger clusters (branches). The clustering technique used in this study was hierarchical agglomerative clustering using group-average linking (Clarke & Warwick 1994).

Ordinations

Ordination techniques map similarities between samples in a two or three-dimensional diagrammatic representation. The distance between sample points on the diagram reflects the similarity between samples. Ordinations display interrelationships between samples on a continuous scale rather than by creating discrete clusters. The ordination technique primary used in this study is Multi-Dimensional Scaling (MDS) a non-parametric technique suitable for ecological analyses (Clarke & Warwick 1994). Ordination points were superimposed by environmental and biological variables to assist in the interpretation of the pattern.

ANOSIM

Analysis of Similarity (ANOSIM) is the non-parametric multivariate equivalent of the univariate Analysis of Variance (ANOVA). The similarities of samples within groups are compared to similarity of samples between groups to determine the statistical significance of the overall difference between groups. The similarity between samples is calculated by the Bray-Curtis measure and then ranked. Averaging the ranked similarities generates a test statistic. A test statistic of 1.0 indicates complete dissimilarity; 0.0 indicates that the variability of in-group samples is equal to the variability of between-group samples; a negative statistic indicates greater within group variation than between group variation. This statistic is then compared to numerous simulations where the samples are randomly re-labelled. The hypothesis that there is no difference between the groups is rejected if fewer than 5% of random simulations generate a statistic greater than the test statistic. Tests are computed "globally" on all groups and then on each pair of groups separately. (Clarke & Warwick 1994)

In this study, two sets of groups were defined from position variables. One set of groups was based on the bank and aspect (south Bennison Bank, north Bennison Bank, south Middle Bank, north Middle Bank). Another was based on distance from the apex of the bank (0-1500 m; 1500-3500 m; 3500+ m).

BIOENV

Environmental variables can be matched against using the BIOENV procedure outlined by Clarke & Warwick (1994). This procedure computes ranked similarity co-efficients for samples based on various combined groups of environmental variables. These co-efficients are then compared against samples ranked by species similarity co-efficients by using the weighted Spearman-Rank correlation. The highest rank correlation indicates which group of environmental variables best reflects the species composition of the samples.

In this study both environmental and biological variables were used in the BIOENV procedure. The faunal similarity matrix was correlated with the physical variables and cover abundance values for each species. The floral similarity matrix was correlated with the physical variables and abundance values for faunal species.

RELATE

The RELATE procedure correlates similarity measures from two matrices using a Spearman Rank procedure. A ρ-value is then calculated by comparing this correlation with a large number of random (Monte Carlo) simulations. In this study the similarity matrices for flora and fauna were compared to see if the overall patterns were the same.

Correlations

Various untransformed physical and biotic variables were correlated using the Pearson Moment Correlation. The significance (at alpha=0.05) of each correlation was determined after the probability values were adjusted for multiple comparisons using the sequential Bonferroni correction (Peres-Neto 1999).

Analysis of Variance

The temporal variability of *Posidonia* cover, height and density was analysed using Analysis of Variance, using sites as a fixed factor and the survey (summer, winter) as a fixed repeated measure. Height and density data were $\mathrm{Log}_e(x+1)$ transformed and percent cover data arcsine square root transformed. The Statistica 5® software package was used to perform these analyses.

Power was calculated using the multi-factor ANOVA (F-test) procedure of the G-Power software. The repeated measure calculation was not used, as the assumption of Sphericity (equal variances across groups) was unlikely to be met. Alpha was set at 0.05. A 'medium' effect size (f=0.25) was assumed (Cohen 1977).

5. Survey results

5.1. Description of the study sites

Posidonia beds

Bennison and Middle Banks support a mosaic of *Posidonia australis* seagrass beds, *Heterozostera tasmanica* beds and bare patches of sand. *Posidonia* beds dominate much of the banks from 0.5 to 4 m at low tide. It grew longer and denser near the apex of the banks. *Heterozostera* forms beds in shallow water, along the margins of the *Posidonia* beds at the edge of the channel, and in places where *Posidonia* is sparse or not present. *Heterozostera* was more common towards the western end of the inlet away from the entrance. *Halophila australis* was sparsely present throughout the inlet, never forming continuous beds.

The seagrass beds recorded as present in 10-15 m near the apex of the banks on the Corner Inlet/Nooramunga Coastal Resource Atlas (MAFRI 1998) maps were not found. However, there were extensive exposed shell beds in these areas, predominantly dead valves from the native flat oyster, *Ostrea angasi*. Presumably the digital image for these beds was misinterpreted.

Two species of green algae were common. *Caulerpa trifaria* occurred frequently throughout the *Posidonia* beds and areas without seagrass. *Codium fragile* was found less frequently. Both species attached themselves to the base of a seagrass shoot, to sessile invertebrates, or shell fragments in the sediment. It could not be determined whether the *Codium* was the exotic subspecies '*tomentosoides*'. Both these species formed only a minor component of the seagrass assemblage. The tips of the seagrass supported a heavy load of epiphytes in summer. This included various filamentous and foliose brown and red algae.

The *Posidonia* beds underwent a clear seasonal cycle. During summer (December to February) the *Posidonia* leaves were long (to 1000 mm) and densely overlapping. With algal epiphytes, *Posidonia* often formed a closed canopy of 100% cover. The fragile senescent tips of the leaves supported numerous floral and faunal epiphytes. By winter the senescent tips of the leaves were gone, leaving shorter (300 mm) leaves composed mainly of healthy green tissue. This cycle has been described from other *Posidonia* beds, with winter storms being held responsible for detaching the leaf ends (Larkum *et al.* 1989). On the other hand, *Heterozostera* beds showed little change over the study period, and remained approximately 200-300 mm in length. *Heterozostera* plants also supported numerous epiphytes, including some larger species such as the brown foliose alga, for example *Lobospira bicuspidata*.

Posidonia inflorescences and fruit were present in December. Many isolated plants were examined for an attached hypocotyl to see if they were seedlings, however, the majority were derived from sub-surface rhizomes approximately 100 mm deep. Only one small *Posidonia* seedling was observed over the entire study (in February). This is consistent with studies in Western Australia that show the maintenance of *Posidonia* beds depended on vegetative growth not seedling colonisation (Kuo & Kirkman 1996). Conversely, numerous *Heterozostera* seedlings were observed. A successional sequence of bare sand, to *Halophila* or *Heterozostera* and then *Posidonia* is likely for Corner Inlet. This is broadly similar to successional sequences observed in South

Australia (Clarke & Kirkman 1989), although systems in that state are more complicated, involving *Amphibolis antarctica* and *Posidonia sinuosa* which are absent from *Corner Inlet*.

Seagrass fauna

Larger invertebrates included seastars (*Patiriella calcar, P. brevispina, Coscinasterias muricata*), urchins (*Amblypneustes ovum*), crabs (*Naxia aurita, Nectocarcinus integrifrons*), gastropods (predominantly *Thalotia conica* and *Astralium aureum*), ascidians (predominantly a brown knobbly species) and various bryozoans and sponges. The inconspicuous hydroid *Lineolaria spinulosa* was present as an epiphyte on *Posidonia*. Less commonly seen were other seastars (*Tosia australis, T. magnifica, Uniophora granifera, Luidia australiae, Allostichaster polyplax*), brittle stars (*Ophiopeza cylindrica, Ophiacantha alternata, Ophiothrix spongicola*), holothurians (*Paracaudina* sp, *Trochodota shepherdi*), gastropods (*Phasianella australis, Cacozeliana granaria*), mussels, the Dough-boy Scallop (*Chlamys asperrimus*), pycnogonids (*Anoplodactylus evansi*) and the Blue-ringed Octopus (*Hapalochlaena maculosa*).

Trochodota shepherdi, a rare holothurian, only known within Victoria from Corner Inlet/Nooramunga (O'Hara & Barmby 2001), was observed during the survey. *Trochodota shepherdi* was present on foliose algae (*Lobospira bicuspidata*), epiphytic on *Heterozostera* seagrass adjacent to the *Posidonia* beds.

Channel fauna

The banks slope away into the channels quite steeply at their margins. The sides of the banks sometimes supported large numbers of brittle-stars (*Amphiura elandiformis* and *Ophiocentrus pilosa*) that feed of the tidal flows. Large clumps of sponge and sea-squirts were present at the base of the channel (6-15 m). Typically these 'mini-reefs' were based on a sea-squirt (*Pyura stolonifera*) attached to one of the many dead oyster shells that lay just beneath the surface of the sediment. Other sedentary animals that were growing on the sea squirt included a variety of sponges, such as the pink spiny *Dendrilla rosea*, encrusting ascidians, soft-corals, orange bryozoans, large orange anemones, some red algae and various hydroids. Mobile invertebrates sheltering on the reefs included the Banded (*Ophionereis schayeri*) and Sponge Brittle-stars (*Ophiothrix spongicola*), the brown knobbed sea cucumber (*Stichopus mollis*), the Doughboy Scallop (*Chlamys asperrimus*), the Eleven-armed seastar and the Large Biscuit Seastar (*Tosia magnifica*).

Fish and squid

Numbers of observed fish and cephalopods were low. This may be because fish numbers are low or due to predator avoidance strategies by the larger fish. Large predators such as dolphins, penguins and cormorants were common, and the fish may react to the presence of divers in relatively shallow water. The fish observed during the survey are listed in Table 2. A few larger fish were observed in the bare patches of sand, sparse seagrass or within the channels, including the Sparsely-spotted and Cross-Backed Stingarees (*Urolophus paucimaculatus*, *U. cruciatus*), Southern Fiddler Rays (*Trygonorrhina guanerius*), Rock and Sand Flatheads (*Platycephalus laevigatus*, *P. bassensis*), and Greenback founders (*Rhombosolea tapirina*).

Smaller fish and squid were seen amongst the seagrass. The most common included Weed and Rock Whiting (*Haletta semifasciata*, *Neoodax balteatus*), Southern

Gobbleguts (*Vincentia conspersa*), Cobblers (*Gymnapistes marmoratus*), Woods Siphon Fish (*Siphaemia cephalotes*), Marine Gobies (*Tasmanogobius gloveri*), Toadfish (*Tetractenos glaber*), Globefish (*Diodon nicthemerus*), Bridled and Pygmy Leatherjackets (*Acanthaluteres spilomelanurus*, *Brachaluteres jacksonianus*) and various pipefishes (eg *Stigmatopora argus*). Two small squid were regularly seen amongst the seagrass, the Southern Pygmy Squid (*Idiosepius notoides*), and the Southern Dumpling squid (*Euprymna tasmanica*). The main pelagic fish observed were small schools of juvenile Silver Trevally (*Pseudocaranx dentex*).

Large fish species targeted by commercial fishers in Corner Inlet were not generally observed. These larger species are difficult to assess on SCUBA surveys due to diver avoidance and limited visibility. Night dives on these sites would be worth investigating in future monitoring. Many targeted species are easier to monitor at night.

Visual assessment of the effects of seining

This survey did not set up to examine the effects of haul seining. The dive sites were chosen on the basis of geographic position. However, during summer, two transects (site 15) were surveyed in *Posidonia* beds that appeared to have been recently seined. Evidence of seining included tracks in the sediment and large rolls of detached *Posidonia* leaves and epiphytes remaining on the seafloor. These rolls measured 0.3 m in diameter and 2-3 meters long. The affected seagrass beds were relatively open, composed of short leaves (300 mm) severed at their tips, which were generally free of larger epiphytes. This was in contrast to other beds surveyed nearby (site 4 and 5) that were composed of long (to 1000 mm) densely overlapping leaves supporting a crown of foliose and filamentous epiphytes. The seined site contained reduced numbers of gastropods and no crabs compared to the other sites. The abundance of seastars (mainly flattened cushion stars of the genus *Patiriella*) and sponges, however, was approximately the same.

Sites 13 and 14 also were also characterised by short leaf length. Possibly these sites had also been seined at some point. No evidence of detrital rolls or tracks was observed at these sites, however, the seining could have happened weeks beforehand.

5.2. Statistical interpretation

Macrophyte and sessile invertebrate cover

There was considerable variation at various spatial and temporal (summer/winter) scales in cover abundance for seagrasses, algae and sessile invertebrates, including between quadrats, between transects, between sites, and between sites in summer and winter. Variation in *Posidonia* cover between quadrats at each site can be seen in the spread of values in Figure 19. Typically many sites had quadrat values ranging from 0 to 100 % cover. *Posidonia* beds are not uniform at this scale, but include 'blow-out' areas with bare sand, and sparse areas with other seagrass species, large sponges or macroalgae.

Mean cover values for each transect are given in Table 3. For *Posidonia*, values range from 2 to 90% in summer and from 0 to 60% in winter. The lower winter values were caused by the shedding of leaf tips (see above). *Heterozostera* dominated some transects with relatively low *Posidonia* cover, and was almost completely absent when *Posidonia* dominated; mean cover values ranged from 0 to 60%. *Heterozostera* was particularly abundant at the rear of the banks, furthest into the Inlet. There were significant differences between summer and winter values for some transects. This was usually a decline, but in one case (Transect 4b) there was a substantial increase. *Halophila* was present at only four sites where *Posidonia* was relatively sparse (<40% cover). Although locally common, the small leaves and sinuous rhizomes ensure low mean cover abundance values (< 2%).

Macroalgae ranged from 0 to 30 % cover. At no sites did filamentous epiphytes dominate the seagrass beds. Quadrats with relatively large cover abundance values tended to have *Caulerpa* or *Codium* plants attached to the base of seagrasses or onto other hard substrata (eg sponges, ascidians or dead shell). *Codium fragile* (possibly the introduced subspecies) did not dominate any quadrats. The mean algal cover values for winter were higher than summer, although this was not statistically significant. Sessile invertebrates occurred intermittently at many sites. Mean transect cover abundance for sessile invertebrates was generally low (<2.5%.)

Ordinations and dendrograms generated from the summer cover abundance data reflected the relative cover of *Posidonia* and *Heterozostera*. On the dendrogram (Figure 13) transects from sites 2 and 13 formed an outlying cluster, being predominantly *Heterozostera* beds with scattered *Posidonia* plants. The main cluster on the dendrogram was divided into two secondary clusters, one with dense to medium *Posidonia* beds and the other with sparse *Posidonia* beds. This pattern is repeated on the ordination (Figure 14). The dense-medium *Posidonia* transects form a tight group on the upper left of the ordination; the sparse *Posidonia* transects are split into those that support dense *Heterozostera* beds and those that do not. The sparse beds include the two transects that were recently seined (15a & 15b).

Transect points superimposed by bank, aspect, neighbouring channel, date or transect position did not form consistent groupings on the ordination or dendrogram (not shown). This was confirmed by 1) non-significant one-way ANOSIM tests using bank/aspect groups (Table 6) and 2) low correlation coefficients when these variables were compared to the flora similarity matrix using a BIOENV procedure (R<0.2) (Table 7)

However, there was a relationship between the floral assemblage pattern and distance into the inlet. *Heterozostera* cover was positively correlated with distance into the inlet and *Posidonia* cover is negatively correlated (Table 3). This was confirmed by a one-way ANOSIM (R=0.101, p=0.031) using three distance categories (0-1500, 1500-3500, 3500+ m) (Table 6). Distance was the best-matching BIOENV variable (R=0.420) (Table 7).

Motile invertebrate abundance

The abundance of motile invertebrates per transect also differed considerably between sites (Table 4), particularly for the more abundant species, *Patiriella* spp and the gastropods. Between the summer and winter surveys there was a general increase in seastars, a decrease in *Naxia* crabs, an increase in *Nectocarcinus* crabs and mixed results for gastropods.

On a dendrogram (Figure 15) and ordination (Figure 16) produced from summer abundance data (excluding site 7 with very low abundance data), transects from site 8 form an outlying group due to the low numbers of animals overall. The ordination points show some geographical pattern. When the ordination points are superimposed by bank (Figure 17), sites from Bennison Bank group at the base of the ordination. This pattern reflects the abundance of gastropods, which were present in high numbers towards the rear of Bennison Bank (Figure 17). The abundance of gastropods was correlated with bank, channel or distance variables (Table 5), particularly for the winter survey.

One-way ANOSIM tests were significant for groups of faunal transects defined by both location and distance from the bank apex (Table 6). This was confirmed by a BIOENV procedure in which a combination of bank, side, channel and distance variables best matched the faunal pattern (Table 8). Possible collection biases due to differences in sampling personnel or time were not emphasised. The correlation between abundance of an individual species and collection time was for *Naxia aurita* that was found predominantly in December, although collection numbers overall are low (n=28).

The correlation between the similarity matrices formed from the motile invertebrate and floral assemblages was not significant (ρ=-0.134, p=67.7).

Macrophyte height, density and biomass

There was much variation in average shoot density per m^2 (Table 9, Figure 21) and (Table 10, Figure 20) and between quadrats at the same site. Mean shoot density per site was not significantly correlated with bank, aspect, channel, distance from the bank apex, or mean shoot height. Mean shoot height per site was not correlated with bank, aspect or channel, however, there was a significant negative correlation between mean height and distance from the bank apex (r=-0.6269, p=0.016), although many points lie outside 95% confidence levels (Figure 18). Sites with low mean height (13,14 and 15) were characterised by short, sparse *Posidonia* shoots with broken tips. These may have resulted from recent seining activities (see section 1). There was evidence of seining tracks at site 15.

Stem and rhizome biomass per 0.25x0.25 mm quadrat was not correlated with maximum shoot height or each other (Table 11); although these results were only taken from a single transect.

The difference between summer and winter quadrat abundance measurements was analysed using Analysis of Variance, with sites as a fixed factor and the survey (summer, winter) as a fixed repeated measure. There was a significant difference between summer and winter values for height and percent cover but not for density. Both height and cover reflect the seasonal leaf growth cycle, whereas density (shoots per m^2) only declined slightly from 116 shoots/m^2 to 97 shoots/m^2. The interaction term (survey x site) was also significant for both cover and height, indicating that differences between seasons differed from site to site making generalisations difficult. This may have been due to the confounding effects of seining at some sites during summer.

A Post Hoc Power calculation (using a 'medium' effect size = 0.25, alpha = 0.05, 20 groups (2 surveys over 10 sites), sample size=400 (10 quadrats x 2 transects x 10 sites x 2 seasons)) was equal to 0.87.

Figure 9. Roll of broken leaves and epiphytes left by a seining operation (site 15).

6. Discussion

6.1. Principal findings

1. The Corner Inlet *Posidonia* beds supported a single faunal and floral community. There were few significant differences between Middle and Bennison Banks. Distance from the inlet entrance has an effect on some species, presumably derived from differences in tidal flow rates.

2. There was substantial spatial and temporal variation. This variation would need to be measured over a number of years for clear patterns to emerge.

3. The experimental design has enough power to detect a large, widespread temporal and spatial change in *Posidonia* cover and density. Local changes will be more difficult to detect.

4. Faunal data showed few clear trends, with the possible exception of gastropod abundance.

5. Fish were not numerous enough for statistical analysis.

6. Qualitative evidence suggests that haul seining has the potential to reduce the height and cover of *Posidonia* and reduce the abundance of some of the associated fauna. As this disturbance can't be easily predicted or measured, it will make correct interpretation of long term data problematic, particularly for data collected during summer.

7. The rare invertebrate found during this survey was not associated directly with *Posidonia*. This makes the nomination of a '*Posidonia*' community to the Flora and Fauna Guarantee Act 1988 problematic. It may be more accurate to focus on the unique position and ecology of Corner Inlet/Nooramunga as a whole, which includes *Posidonia* seagrass beds of state significance.

6.2. Effects of Haul Seining.

This object of this study was not to quantify the affects of seining. However, by comparing sites that were recently seined (definitely site 15, possibly also sites 13, and 14) with others, it appeared as it the seining operation removed the senescent ends of the seagrass leaves and associated epiphytes. This thinned the seagrass bed and removed the epiphytes, reducing the potential amount of shelter and food available to animals. Crabs and gastropods were reduced in number.

There are obvious parallels with the removal of seagrass tips by storms, which occurs naturally at the onset of winter. However, seining operations occur at different times and frequency than storms. The effect of seining on the invertebrate and fish assemblages in different seasons requires further study.

Seining techniques in Corner Inlet have changed in comparatively recent times. For most of last century, wooden boats and hand-hauled nets restricted seining to the shallow banks. The introduction of powered boats and boat-drawn nets in the 1980s opened up deeper (eg., *Posidonia*) seagrass beds and channels to seining operations.

The draft Fisheries Management Plan for Corner Inlet (1995) noted concern at the hauling of weighted-nets in Corner Inlet and called for an assessment of the impact of haul seining on the seagrass beds. The results from this study suggest that this assessment should examine the affects of seining on a seasonal basis. Moreover, the affects of seining on *Heterozostera* beds that have been conducted elsewhere, cannot be necessarily extrapolated to *Posidonia* because of their different anatomy and life history.

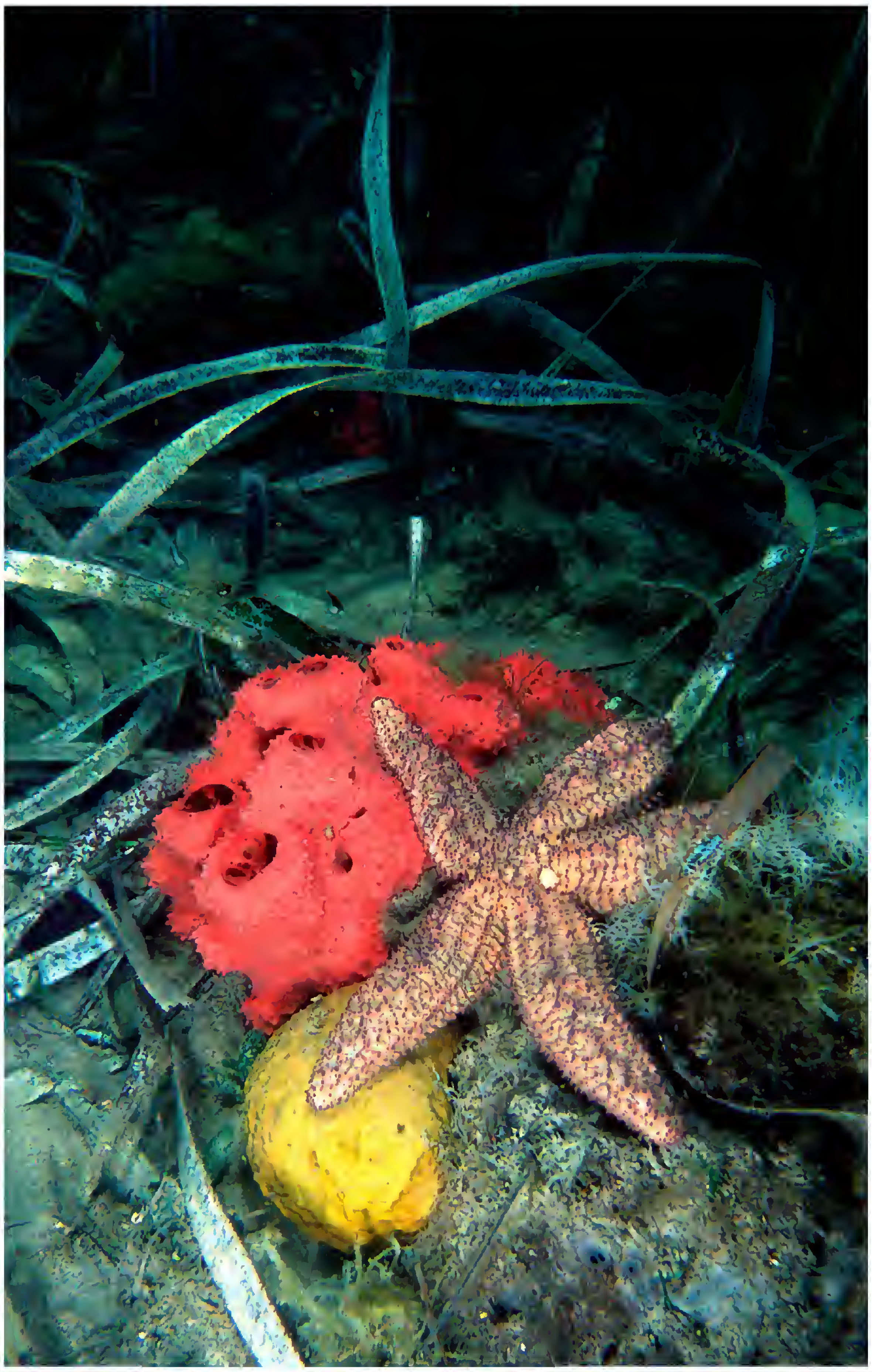

Figure 10. Seastar (*Uniophora granifera*) and sponges in *Posidonia* seagrass bed.

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Table 1. Site data.

Site	Bank	Side	Channel	Lat/Long	Distance from apex of bank (m)	No. Transects Summer Survey	No. Transects Winter Survey	Notes
2	Bennison	South	Bennison	38°50.421"S, 146°21.01"E	6224	1	2	*Heterozostera* bed
3	Middle	South	Middle	38°49.237"S, 146°20.329"E	7178	1	-	
4	Bennison	south	Bennison	38°48.29"S, 146°24.507"E	1198	2	2	Sparse *Posidonia*
5	Bennison	south	Bennison	38°48.77"S, 146°23.316"E	2909	2	-	
6	Bennison	north	Middle	38°47.733"S, 146°22.741"E	3735	2	2	
7	Bennison	north	Middle	38°47.2"S, 146°24.1"E	1781	1	2	*Heterozostera* patches
8	Middle	north	Franklin	38°46.241"S, 146°24.679"E	924	2	-	
9	Middle	north	Franklin	38°46.194"S, 146°24.378"E	1357	2	2	Sand patches
10	Middle	south	Middle	38°46.703"S, 146°24.16"E	1671	2	2	
11	Middle	south	Middle	38°46.859"S, 146°23.725"E	2296	2	-	Sand patches
12	Middle	south	Middle	38°47.047"S, 146°23.208"E	3039	2	-	
13	Middle	south	Middle	38°47.499"S, 146°21.538"E	5440	2	-	*Heterozostera* patches
14	Bennison	south	Bennison	38°49.877"S, 146°21.591"E	5389	2	-	
15	Bennison	south	Bennison	38°48.914"S, 146°22.566"E	3987	2	2	Evidence of seining just prior to survey 1
16	Bennison	south	Bennison	38°47.724"S, 146°25.303"E	72	2	2	
17	Middle	north	Franklin	38°46.19"S, 146°23.483"E	2643	1	2	
18	Middle	south	Middle	38°47.495"S, 146°21.765"E	5114	1	2	

Table 2. Fish recorded from Corner Inlet in the survey.

Common name	***Species name***	**Family**
Southern Fiddler Ray	*Trygonorrhina guanerius*	Rhinobatidae
Sparsely Spotted Stingaree	*Urolophus paucimaculatus*	Urolophidae
Banded Stingaree (cross-backed)	*Urolophus cruciatus*	Urolophidae
2-barbed Stingaree	*Trygonoptera* sp.	Urolophidae
Big Belly Seahorse	*Hippocampus abdominalis*	Syngnathidae
Spotted pipefish	*Stigmatopora argus*	Syngnathidae
Pipefish	[various undetermined species]	Syngnathidae
Cobbler	*Gymnapistes marmoratus*	Scorpaenidae
Little Scorpionfish	*Maxillicosta scabriceps*	Scorpaenidae
Sand Flathead	*Platycephulus bassensis*	Platycephalidae
Rock (Grassy) Flathead	*Platycephalus laevigatus*	Platycephalidae
Southern Gobbleguts	*Vincentia conspersa*	Apogonidae
Woods Siphon Fish	*Siphaemia cephalotes*	Apogonidae
Silver Trevally	*Pseudocaranx dentex*	Carangidae
Goat Fish	*Upeneichthys vlamingii*	Mullidae
Weed Whiting	*Haletta semifasciata*	Odacidae
Little Rock Whiting	*Neoodax balteatus*	Odacidae
Weedfish	*Heteroclinus* sp.	Clinidae
Marine Goby	*Tasmanogobius gloveri*	Gobidae
Bass Strait Flounder	*Arnoglossus bassiensis*	Bothidae
Greenback Flounder	*Rhombosolea tapirina*	Pleuronectidae
Bridled Leatherjacket	*Acanthaluteres spilomelanurus*	Monacanthidae
Southern Pygmy Leatherjacket	*Brachaluteres jacksonianus*	Monacanthidae
Smooth (Common) Toadfish	*Tetractenos glaber*	Tetraodontidae
Globefish	*Diodon nicthemerus*	Diodontidae

Table 3. Mean transect cover abundance for seagrasses, algae and sessile invertebrates, calculated by averaging 10 1.0 m^2 quadrats; sessile invertebrates include sponges, ascidians and bryozoans.

Transect	Mean % Cover (n=10 1m^2 quadrats per transect)									
	Posidonia		*Heterozostera*		*Halophila*		Algae		Sessile inverts	
	Summer	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**
2a	1.69	0	55.94	42.56	0	0	0.25	22.06	0	0
2b	-	0	-	36.81	-	0	-	19.75	-	0
3a	25.96	-	0.01	-	0.25	-	0.40	-	0	-
4a	26.88	11.60	5.04	0.75	0.55	0.23	4.94	4.03	0	0.13
4b	35.75	9.28	0.58	11.61	0	0.03	9.93	4.69	0	0
5a	81.56	-	0	-	0	-	2.13	-	0.31	-
5b	82.44	-	0	-	0	-	6.06	-	0.50	-
6a	74.31	49.69	0	0.20	0	0	0.44	3.61	0	0.06
6b	87.20	40.88	0	0	0	0	1.33	6.75	0	0.88
7a	32.09	33.84	12.39	0.03	0	0	29.64	27.45	0	0
7b	-	34.38	-	0.88	-	0	-	24.19	-	0
8a	89.64	-	0	-	0	-	3.03	-	0	-
8b	84.00	-	0	-	0	-	12.63	-	0	-
9a	76.05	60.25	0	0	0	0	4.54	14.69	0	0.38
9b	79.81	45.88	0	0	0	0	10.56	22.50	0	0
10a	80.68	51.68	0	0	0	0	5.90	2.69	0.44	1.19
10b	59.00	56.50	0	0	0	0	8.75	15.25	0.63	0
11a	57.94	-	10.03	-	0	-	5.90	-	0	-
11b	47.69	-	1.50	-	0	-	5.41	-	0	-
12a	85.30	-	0	-	0	-	0.80	-	0	-
12b	74.88	-	0	-	0	-	1.56	-	0.63	-
13a	5.94	-	59.79	-	0	-	2.93	-	0.13	-
13b	13.50	-	25.43	-	0	-	0.31	-	0	-
14a	17.25	-	1.98	-	0	-	13.74	-	0	-
14b	26.56	-	1.84	-	0	-	20.96	-	0	-
15a	36.25	16.41	0.13	0	1.59	1.06	2.58	1.51	1.13	1.96
15b	32.10	15.18	0.11	0.15	1.13	1.05	0.96	2.56	0.21	2.44
16a	65.81	47.25	0	0	0	0	0	1.88	0	0
16b	67.88	40.88	0	0	0	0	0.13	5.13	0	0
17a	71.31	55.94	0	0	0	0	7.06	15.31	0.06	0
17b	-	47.88	-	0	-	0	-	21.50	-	0
18a	34.31	20.38	2.58	0.50	0	1.00	0.69	9.88	0	0
18b	-	20.56	-	2.93	-	0	-	9.38	-	0

Table 4. Abundance of macro-invertebrates per transect, calculated by summing abundance from 10 1.0 m^2 quadrats.

Transect	Abundance													
	Asteroids						Echinoids		Decapods				Gastropods	
	Patiriella brevispina		*Patiriella calcar*		*Coscinasterias muricata*		*Amblypneustes ovum*		*Naxia aurita*		*Nectocarcinus integrifrons*		*Thalotia conica/ Astralium aureum*	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
2a	2	0	0	1	0	0	0	0	0	2	0	5	136	61
2b	-	2	-	0	-	0	-	2	-	1	-	1	-	161
3a	5	-	0	-	0	-	0	-	0	-	0	-	93	-
4a	9	21	5	10	1	0	0	0	2	0	0	1	22	2
4b	21	11	4	9	0	0	0	0	7	0	3	3	15	0
5a	22	-	0	-	0	-	2	-	2	-	1	-	229	-
5b	14	-	1	-	0	-	0	-	4	-	2	-	137	-
6a	7	4	12	31	0	0	0	0	2	0	0	3	16	3
6b	4	8	5	27	0	0	0	0	0	0	1	5	16	8
7a	0	0	0	0	0	0	0	0	0	0	0	2	0	0
7b	-	1	-	0	-	0	-	0	-	0	-	3		0
8a	0	-	0	-	0	-	0	-	0	-	2	-	6	-
8b	0	-	0	-	0	-	0	-	0	-	1	-	2	-
9a	6	1	0	0	0	0	0	0	0	0	1	3	3	40
9b	3	0	1	0	1	0	0	0	3	0	0	5	0	20
10a	49	54	1	2	0	0	0	0	0	0	1	0	0	3
10b	27	40	3	2	0	0	0	0	0	0	1	2	0	2
11a	27	-	1	-	0	-	0	-	1	-	1	-	0	-
11b	65	-	0	-	1	-	0	-	1	-	0	-	11	-
12a	21	-	1	-	0	-	0	-	1	-	0	-	0	-
12b	24	-	0	-	0	-	0	-	0	-	0	-	0	-
13a	32	-	12	-	0	-	0	-	0	-	3	-	4	-
13b	32	-	16	-	1	-	0	-	0	-	0	-	0	-
14a	3	-	11	-	0	-	0	-	0	-	0	-	302	-
14b	10	-	12	-	0	-	0	-	0	-	0	-	194	-
15a	26	87	9	8	0	0	0	0	0	0	0	0	33	209
15b	37	39	6	35	0	0	0	0	0	0	0	0	48	45
16a	46	49	0	0	0	0	0	1	0	0	0	0	28	24
16b	10	28	0	1	0	0	1	0	1	0	0	0	13	33
17a	5	6	0	0	0	0	0	0	0	0	2	1	6	0
17b	-	0	-	0	-	0	-	0	-	0	-	1	-	13
18a	5	18	27	5	0	0	0	0	0	0	2	2	11	21
18b	-	8	-	12	-	0	-	1	-	0	-	0	-	7

Table 5. Pearson correlation coefficients between invertebrate abundance, floral cover abundance, and physical factors. Only significant relationships are shown. Significance is determined after a sequential Bonferroni correction for multiple comparisons (n=128).

		Summer survey			Winter survey		
Variable 1	**Variable 2**	**r**	**p**	**Significant**	**r**	**p**	**Significant**
Bank side	*Patiriella brevispina*	0.56	0.00	s	0.57	0.00	s
Sessile invertebrates	*Halophila* cover	0.55	0.00	s	0.58	0.00	s
Distance	*Patiriella calcar*	0.52	0.00	s	0.37	0.01	
Heterozostera cover	Distance	0.47	0.01		0.50	0.00	s
Gastropod	Distance	0.44	0.02		0.45	0.00	s
Gastropod	Channel	0.40	0.03		0.49	0.00	s
Sessile invertebrate cover	*Patiriella brevispina*	0.28	0.15		0.52	0.00	s
Sessile invertebrate cover	*Patiriella calcar*	-0.05	0.79		0.41	0.00	s
Patiriella brevispina	Algal cover	-0.18	0.37		-0.43	0.00	s
Posidonia cover	Channel	-0.38	0.05		-0.48	0.00	s
Posidonia cover	*Patiriella calcar*	-0.50	0.01	s	-0.33	0.02	
Naxia	Days	-0.51	0.01	s	-0.40	0.00	
Gastropod	Bank	-0.53	0.00	s	0.41	0.00	s
Posidonia cover	*Heterozostera* cover	-0.61	0.00	s	-0.56	0.00	s
Posidonia cover	Distance	-0.65	0.00	s	-0.53	0.00	s

Table 6. Results of 1-way ANOSIM tests

Similarity matrix	Groups	Global	Significant pairwise combinations
Floral cover abundance	Location groups (Bennison south, Bennison north, Middle south, middle north)	not significant	None
	Distance groups (0-1500, 1500-3500, 3500+ m)	r=0.101	1500-3500 x 3500+ (r=0.208)
Faunal abundance	Location groups (Bennison south, Bennison north, Middle south, middle north)	r=0.435	Middle south x Middle north (r=0.5) Bennison south x Middle north (r=0.57) Bennison south x Middle south (r=0.51)
	Distance groups (0-1500, 1500-3500, 3500+ m)	r=0.293	1500-3500 x 3500+ (r=0.40) 0-1500 x 3500+ (r=0.32)

Table 7. BIOENV comparison between the floral similarity matrix and the physical variables and faunal abundance (fourth root transformed) variables. Only the three best overall matches and the five best faunal matches are shown.

R	Variables
0.420	Distance
0.316	Distance, Days
0.314	Bank, Distance
	…
0.305	*Naxia*, *Nectocarcinus*
0.297	*Naxia*, *Nectocarcinus*, *Amblypneustes*
0.289	*Naxia*, *Nectocarcinus*, *Coscinasterias*
0.280	*Naxia*, *Nectocarcinus*, *Amblypneustes*, *Coscinasterias*
0.233	*Nectocarcinus*

Table 8. BIOENV comparison between the faunal similarity matrix and the physical variables and floral cover variables. Only the six best overall matches and the six best single variables are shown.

R	Variables
0.372	Bank, Side, Channel, Distance
0.365	Bank, Channel, Distance
0.362	Channel
0.357	Bank, Side, Distance
0.349	Side, Channel, Distance
0.342	Bank, side, Channel, Distance, *Posidonia*
	…
0.220	Bank
0.210	Side
0.144	Distance
0.111	*Posidonia*
0.068	Algae
0.016	Days

Table 9. Mean density per m^2 of *Posidonia* shoots for each site. Quadrats without *Posidonia* are omitted from the measurements.

Site	Cover %	Summer survey			Winter survey		
		No. quadrats	Mean	St. dev.	No. quadrats	Mean	St. dev.
2	1.69	-	-	-	-	-	-
3	25.96	6	73.78	26.94	-	-	-
4	31.31	10	44.53	22.82	10	44.00	18.74
5	82.00	9	121.19	39.56	-	-	-
6	80.76	9	168.89	70.90	10	136.00	54.98
7	32.09	2	180.00	25.99	9	87.40	53.26
8	86.82	12	154.22	56.31	-	-	-
9	77.93	10	126.93	47.77	12	108.22	34.03
10	69.84	10	145.07	36.98	10	113.33	45.45
11	52.81	8	137.00	47.13	-	-	-
12	80.09	10	122.40	23.54	-	-	-
13	9.72	2	69.33	40.17	-	-	-
14	21.91	8	94.67	23.71	-	-	-
15	34.17	10	86.13	37.04	9	88.00	25.19
16	66.84	10	112.80	34.84	10	81.07	14.56
17	71.31	5	106.67	50.36	10	111.2	29.54
18	34.31	4	93.33	57.19	7	102.10	27.87

Table 10. Mean height of *Posidonia* shoots (mm) for each site. Quadrats without *Posidonia* are omitted from the measurements.

Site	Cover %	Summer survey			Winter survey		
		No. quadrats	Mean	St. dev.	No. quadrats	Mean	St. dev.
2	1.69	1	306.67	-	-	-	-
3	25.96	10	492.50	48.42	-	-	-
4	31.31	14	779.05	54.10	10	307.33	34.95
5	82.00	15	746.67	122.65	-	-	-
6	80.76	14	602.98	130.47	10	247.67	26.58
7	32.09	-	-	-	6	236.67	59.44
8	86.82	-	-	-	-	-	-
9	77.93	-	-	-	10	218.67	42.64
10	69.84	10	620.33	169.59	10	216.33	41.77
11	52.81	6	442.78	91.71	-	-	-
12	80.09	10	684.00	83.11	-	-	-
13	9.72	3	293.33	36.16	-	-	-
14	21.91	8	219.58	40.41	-	-	-
15	34.17	10	312.00	72.02	10	202.67	32.61
16	66.84	10	626.50	113.47	10	271.33	37.85
17	71.31	10	712.67	162.79	10	215.00	27.45
18	34.31	8	594.58	286.79	8	276.25	46.31
Total		**129**					

Table 11. Correlations of *Posidonia* height and biomass.

Variable	Mean ± SD	Correlation coefficient	
		Stem biomass	Rhizome biomass
Max shoot height	92.3 ± 11.6	r=0.78, p=0.22	r=0.83, p=0.17
Stem biomass	10.4 ± 3.2		r=0.62, p=0.14
Rhizome biomass	29.2 ± 8.4		

Table 12. Analysis of Variance for *Posidonia* variables, using sites as a fixed dependent factor and survey as a fixed repeated measure. * Indicates significant results.

	Df Effect	MS Effect	Df Error	MS Error	F	p-level
Height (mm) ($\log_e$ transformed)						
Site	6	0.82082	58	0.069729	11.7717	*0.000000
Survey	1	23.26495	58	0.044095	527.6133	*0.000000
Site x Survey	6	0.28290	58	0.044095	6.4157	*0.000032
Density per m^2 ($\log_e$ transformed)						
Site	8	2.596595	58	0.355836	7.297163	*0.000001
Survey	1	.220176	58	0.219933	1.001108	0.321199
Site x Survey	8	0.199608	58	0.219933	0.907587	0.516657
Cover % (arcsin √ transformed)						
Site	9	2.675912	149	0.089805	29.79679	*0.000000
Survey	1	3.458927	149	0.063658	54.33635	*0.000000
Site x Survey	9	0.142362	149	0.063658	2.23636	*0.022642

Figure 11. Schematic diagram of a collecting site, showing the 50 m transects and associated quadrats.

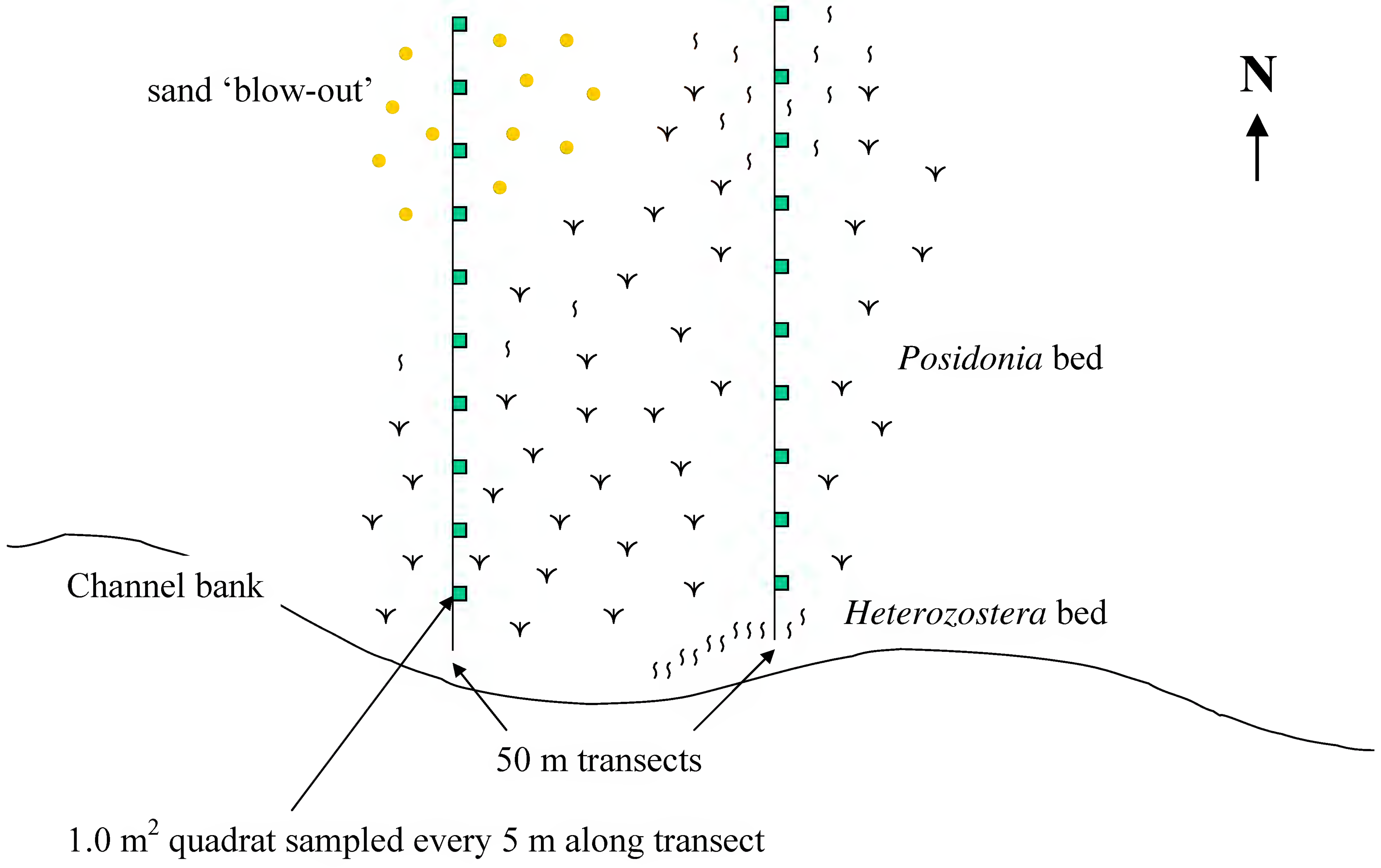

Figure 12. Map of southern Corner Inlet, Victoria showing the numbered study sites spread over Bennison and Middle Banks (see Table 1).

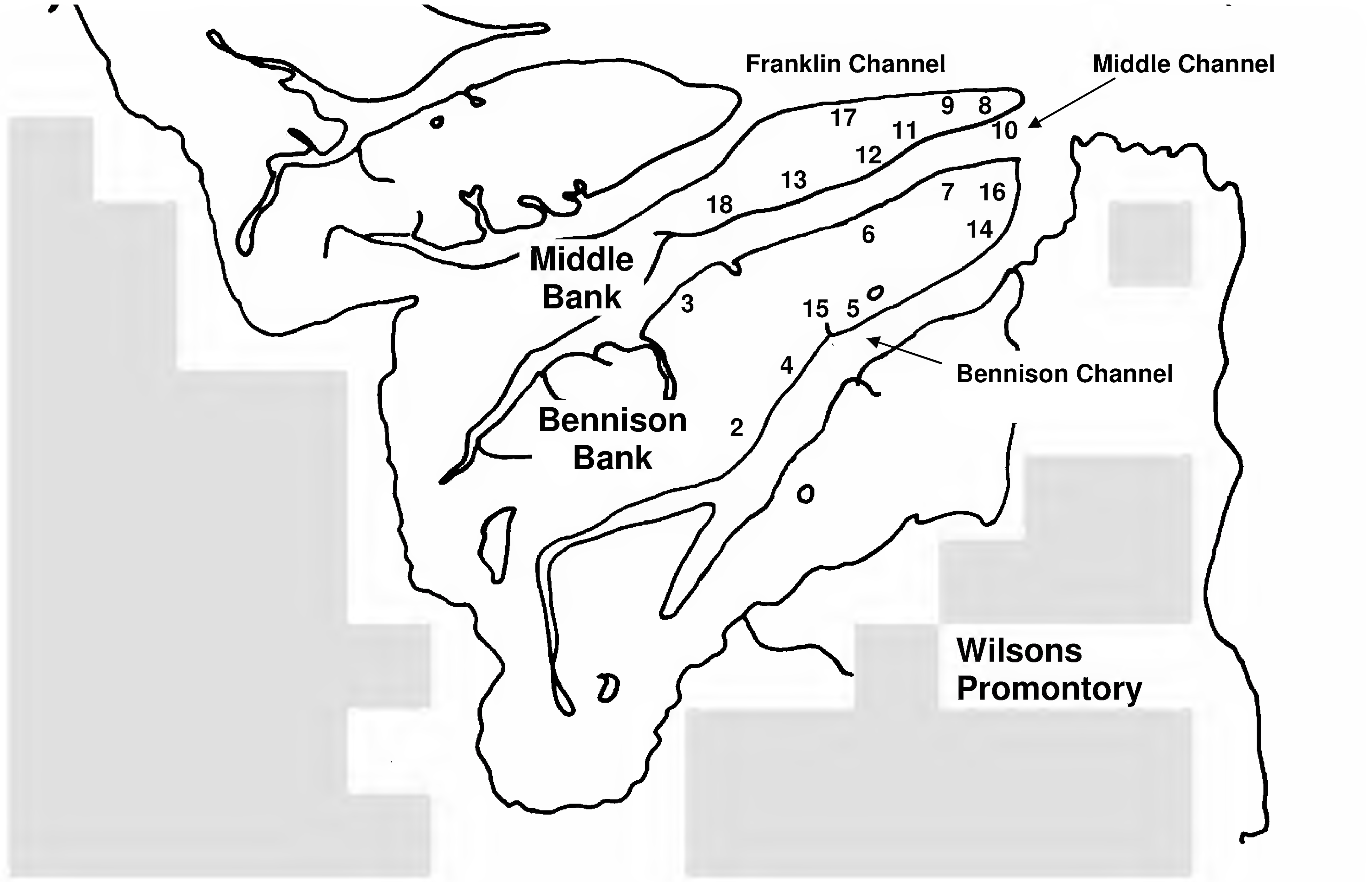

Figure 13. Cluster dendrogram of average cover abundance for each transect in the summer survey, showing clusters characterised by the abundance of *Posidonia*.

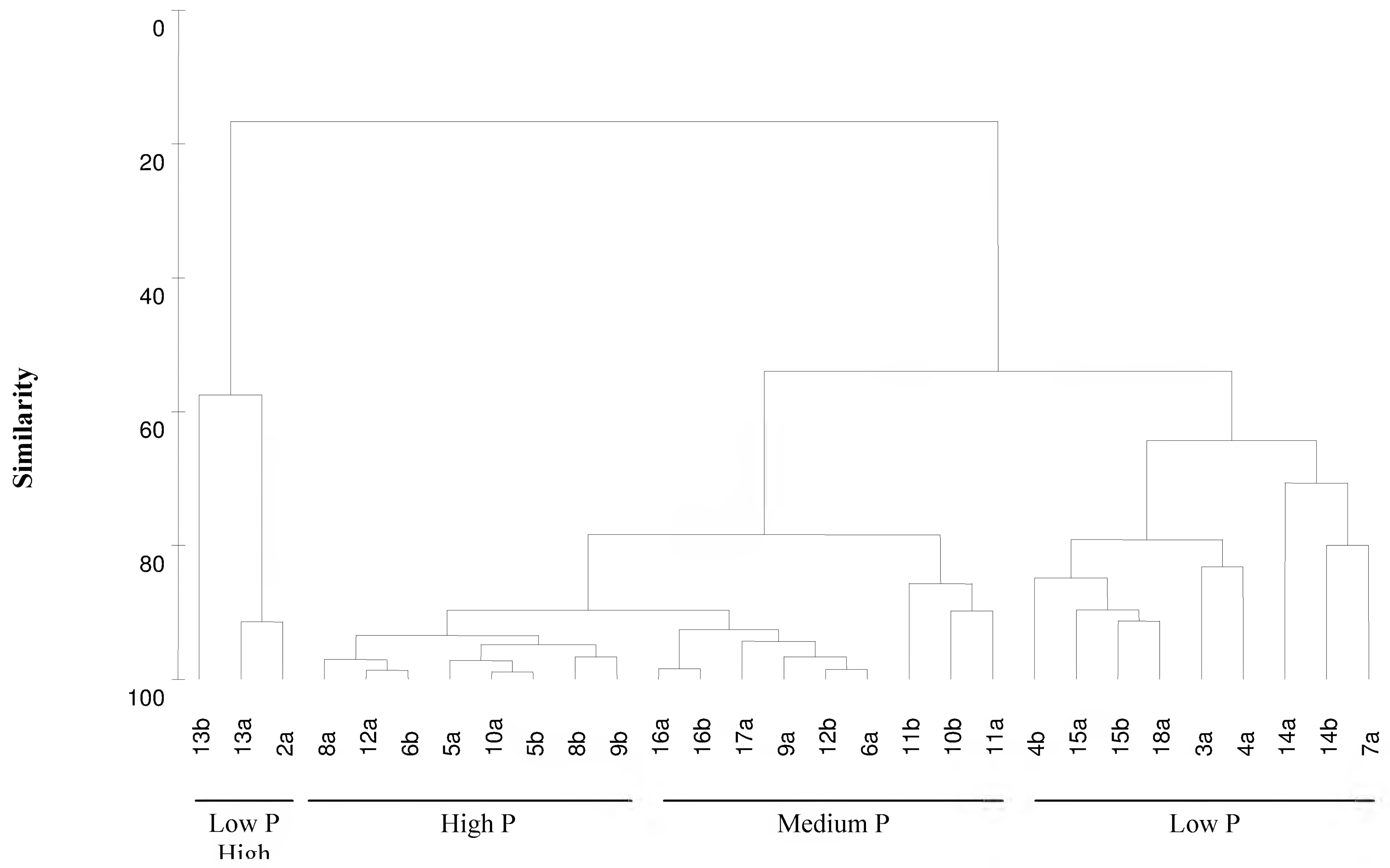

Figure 14. MDS ordination of average cover abundance for each transect in the summer survey, superimposed by transect number (see Table 3.1, a= east, b=west transect).

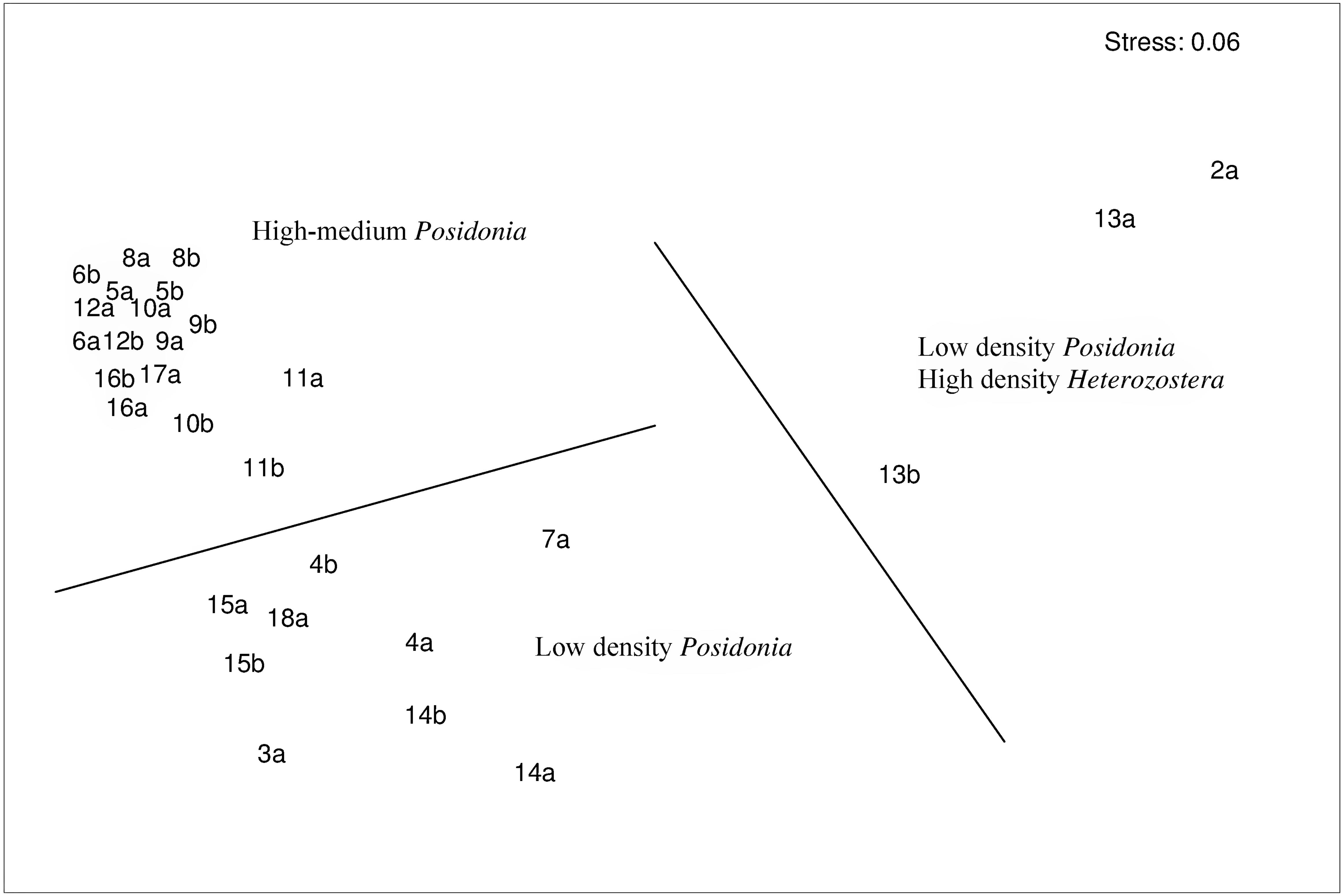

Figure 15. Cluster dendrogram of total faunal abundance for each transect in the summer survey, fourth root transformed.

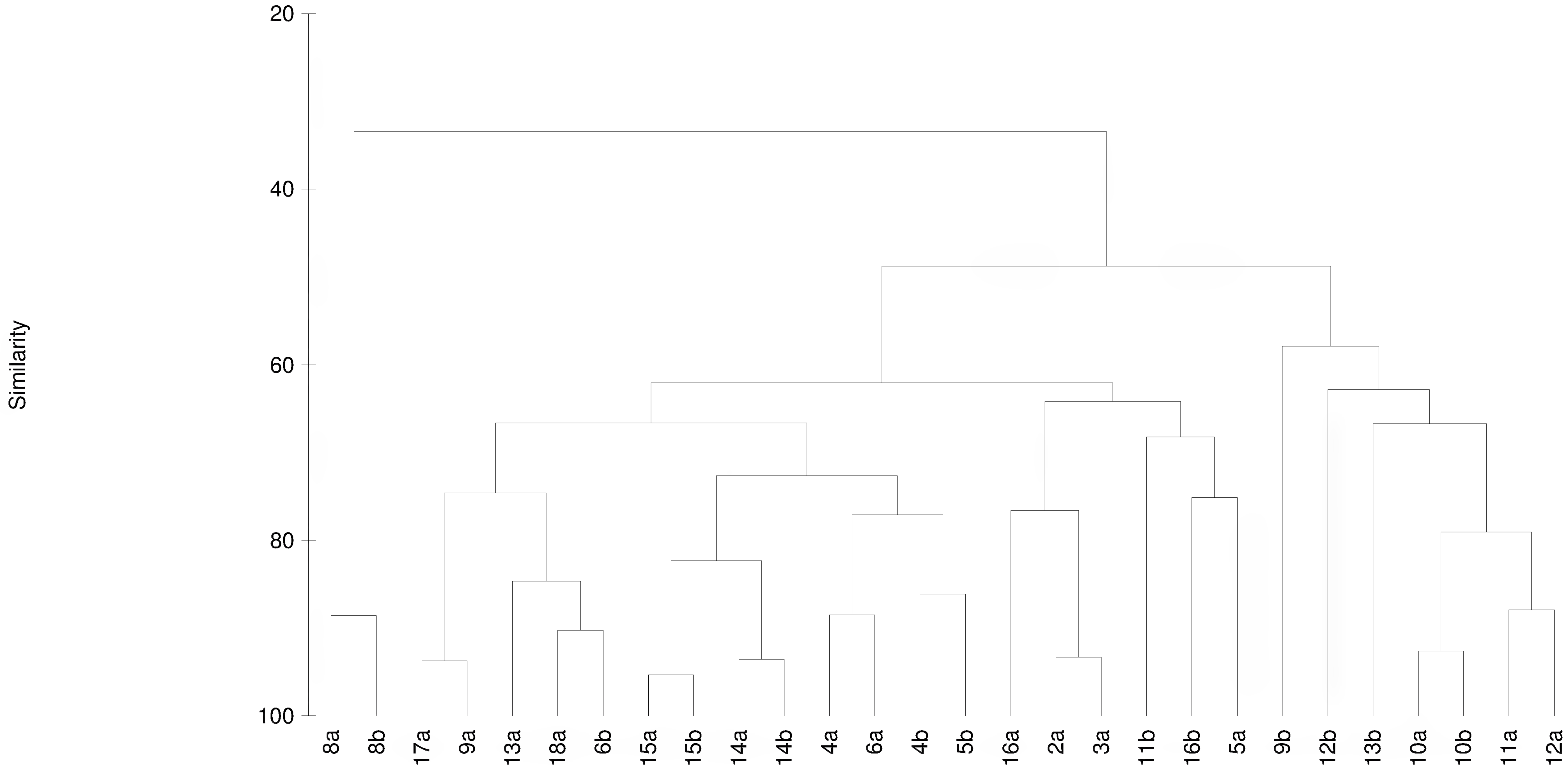

Figure 16. Ordination of faunal abundance per transect in the summer survey, superimposed by transect number (see Table 3.1, a= east, b=west transect). Abundance data was fourth root transformed.

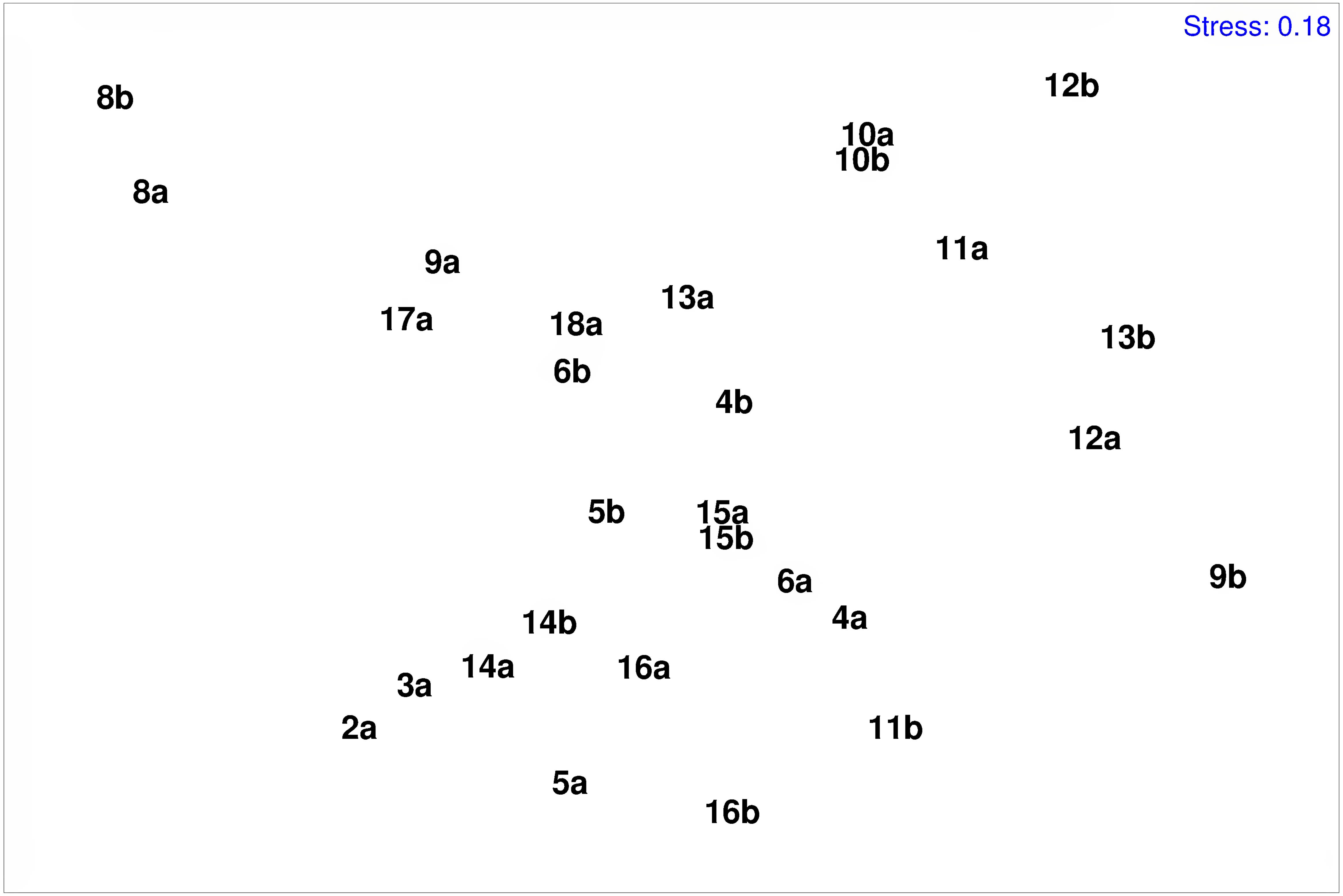

Figure 17. Ordination of faunal abundance per transect in the summer survey, superimposed by the bank (B=Bennison Bank, M=Middle Bank), the relative radius of the circle indicates the number of gastropods from each transect. Abundance data was fourth root transformed.

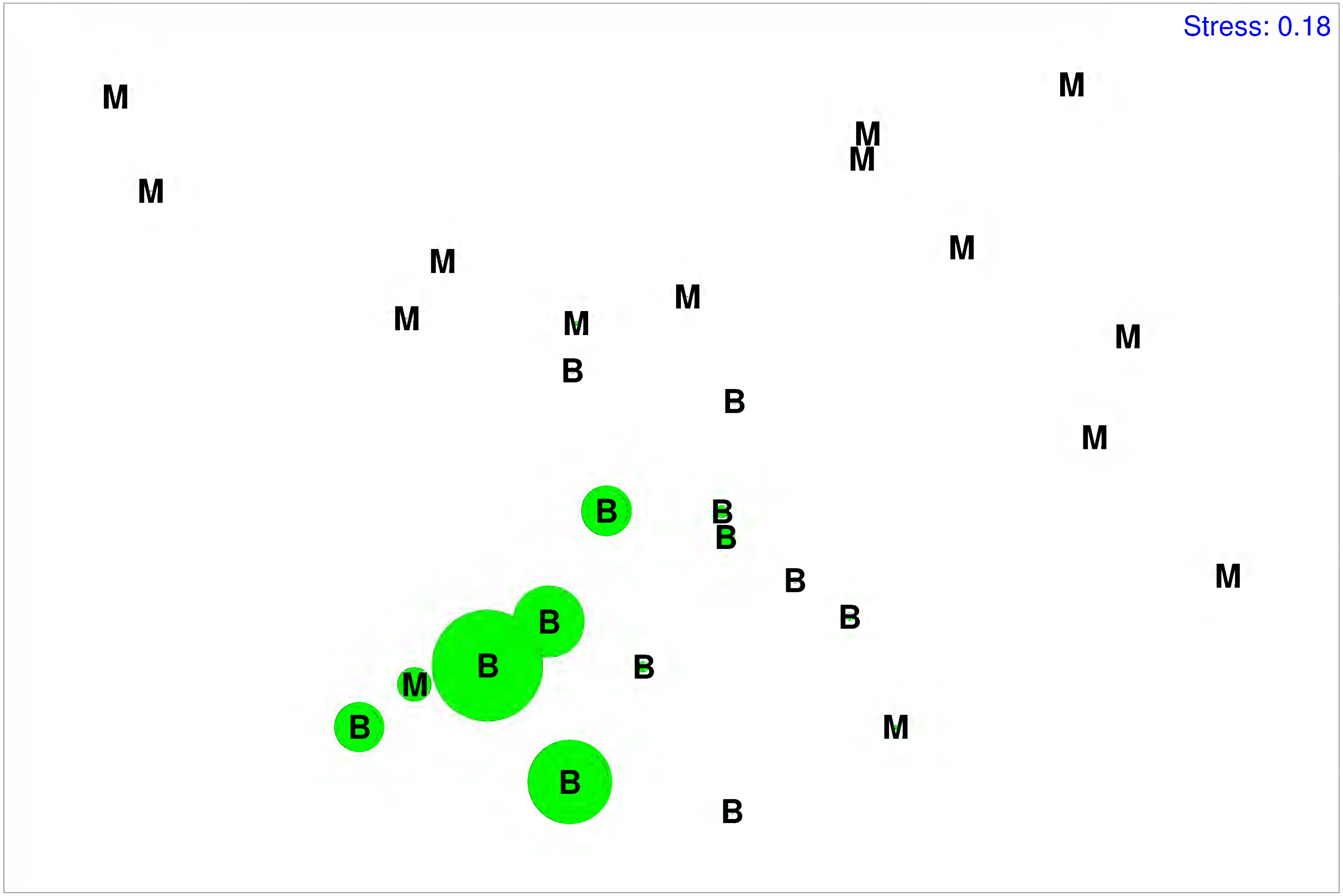

Figure 18. Correlation between the maximum height of *Posidonia* leaves per transect in the summer survey and distance from the apex of the banks.

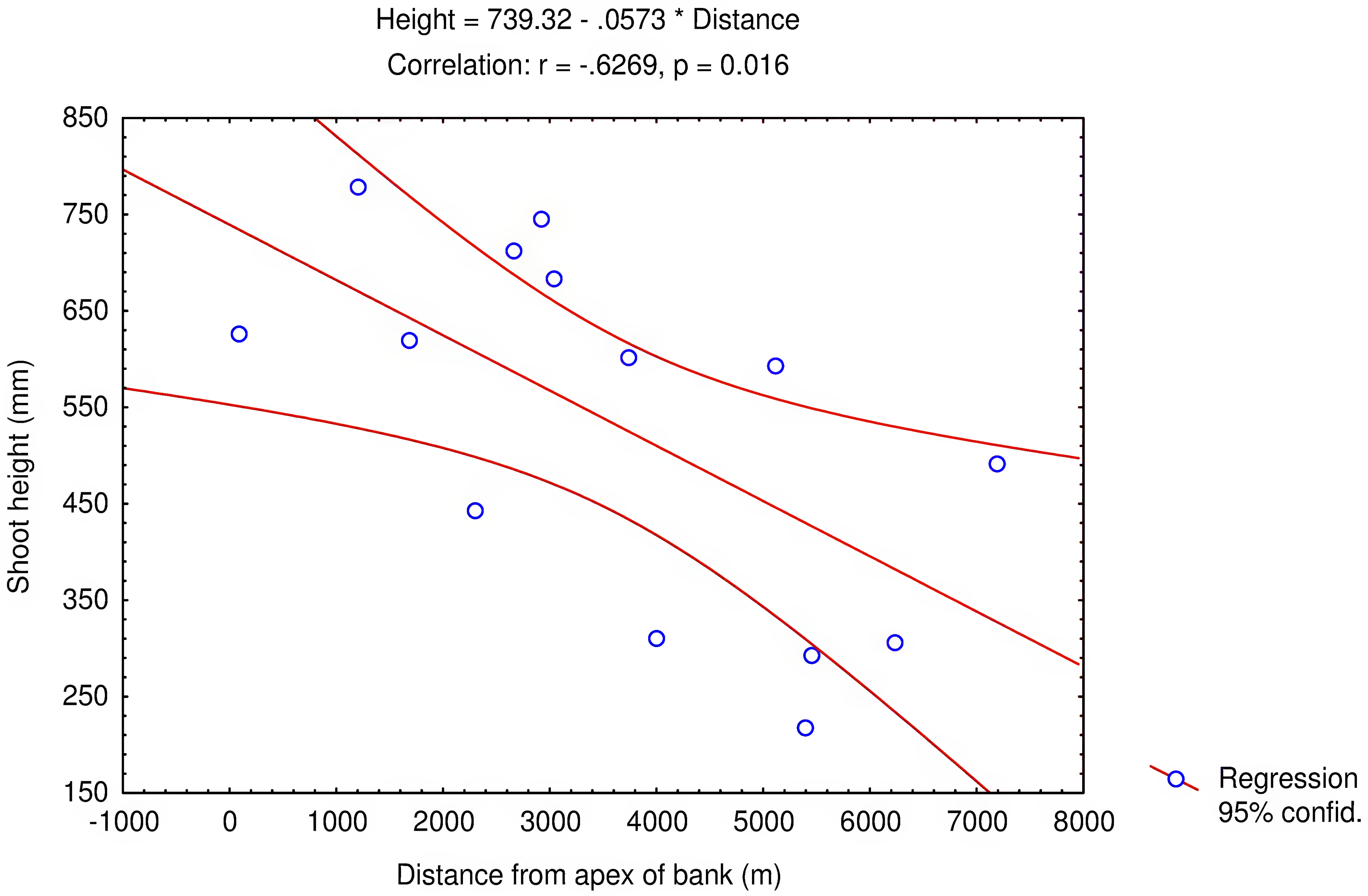

Figure 19. Box plot of percent cover of *Posidonia* per 1.0 m^2 quadrat for each site.

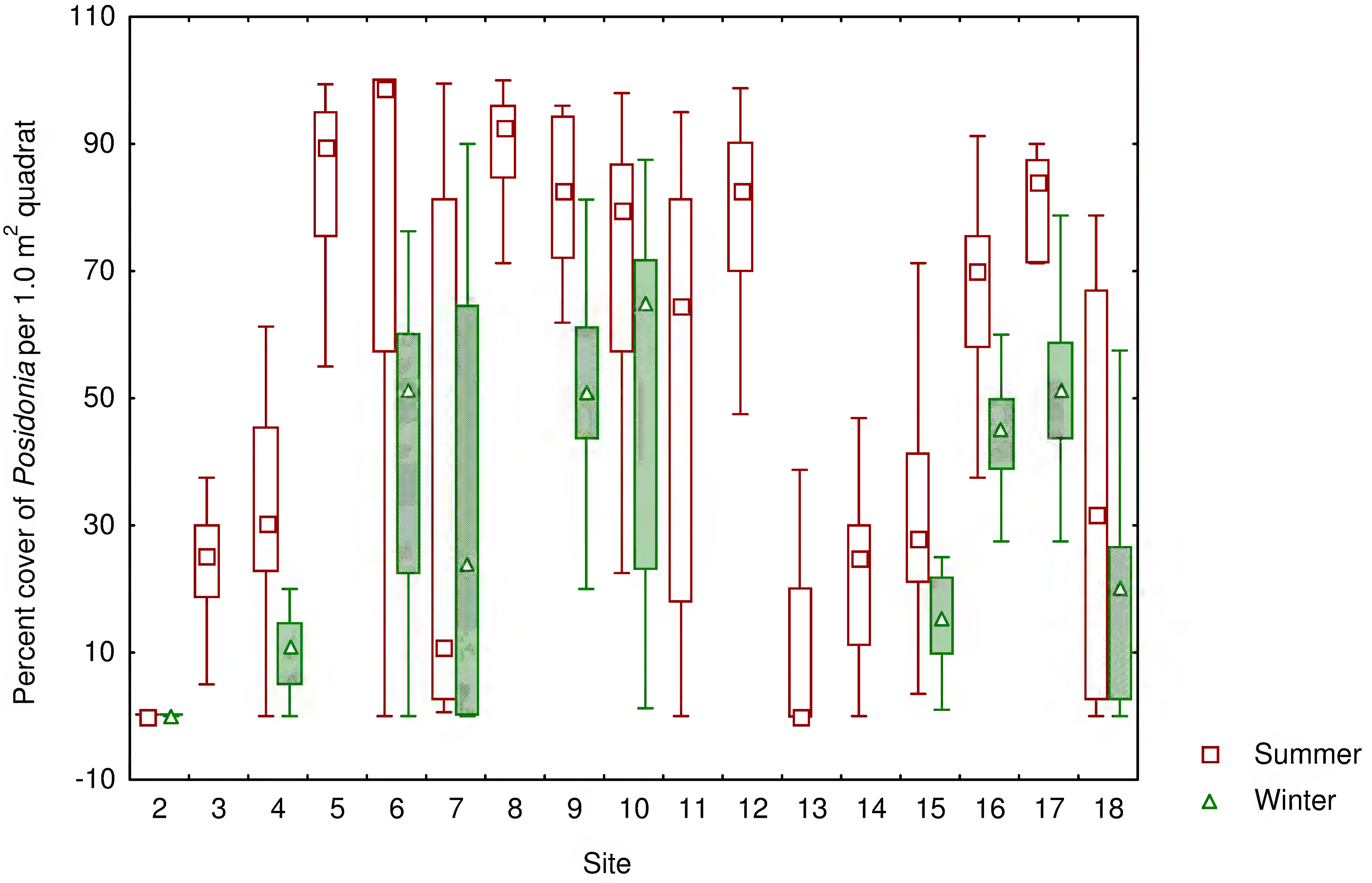

Figure 20. Box plot showing *Posidonia* leaf height (mm) per 1.0 m^2 quadrat for each site.

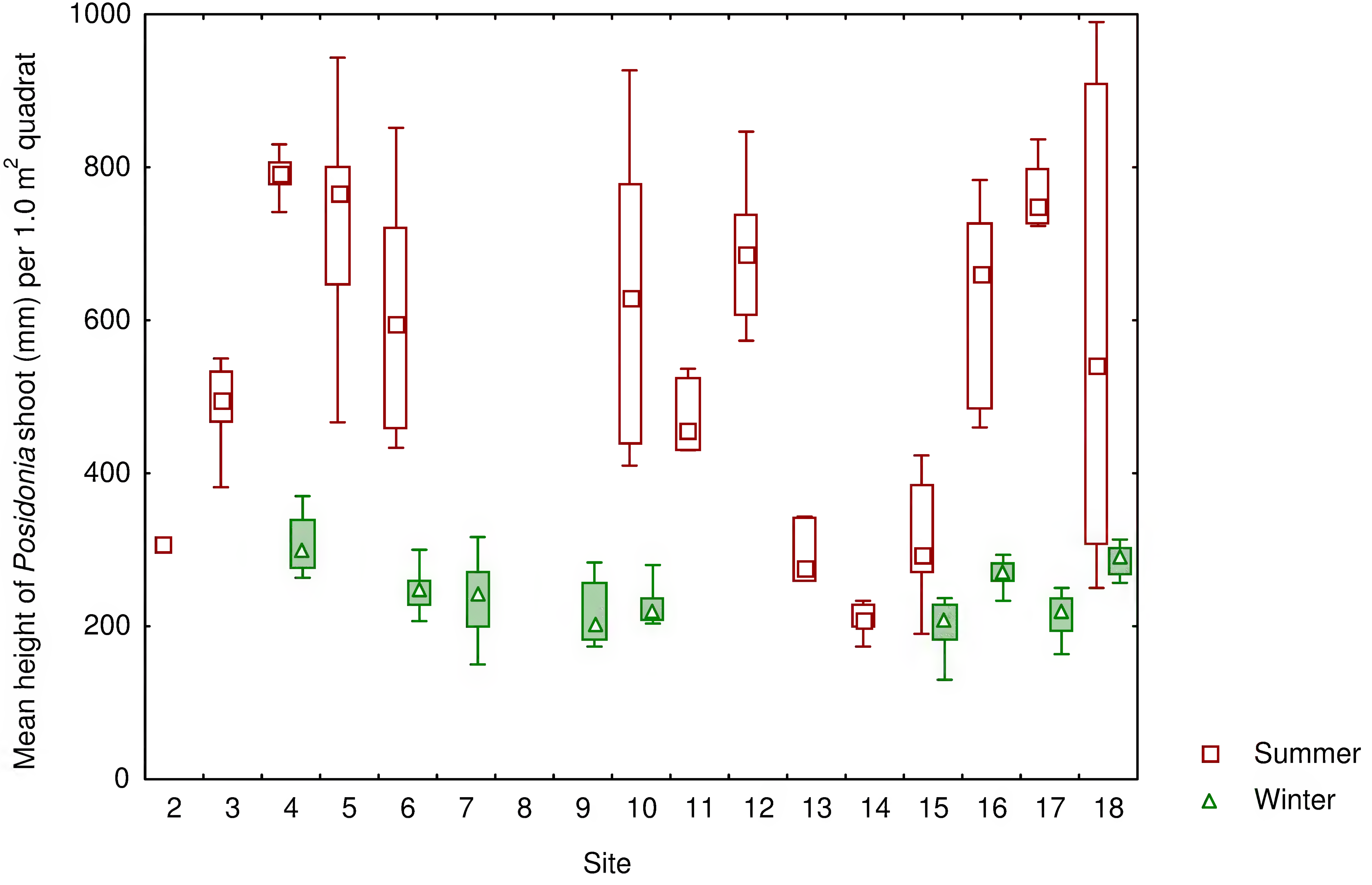

Figure 21. Box plot of the density of *Posidonia* shoots per 1.0 m^2 quadrat for each site.