THE WETLANDS OF FULLERTON COVE, HUNTER RIVER, NEW SOUTH WALES

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INTRODUCTION

Fullerton Cove (lat. 32°50' long. 151°48') is a broad shallow embayment on the northern shore of the Hunter River estuary (Fig. 1). Extensive areas of estuarine wetlands in the Hunter have been reclaimed for heavy industry and Fullerton Cove is one of the few large remaining areas. Kooragang Island, downstream from Fullerton Cove, was originally a group of low swampy islands which have been linked by reclamation. Although further extensive reclamation is planned for wetlands south of the railway on Kooragang Island, it is intended that the northern and eastern parts of the island and Fullerton Cove will eventually be gazetted as a Nature Reserve by the National Parks and Wildlife Service.

Between 1975 and 1977 the Australian Littoral Society (NSW Division) (now the Coast and Wetlands Society) conducted a survey of Fullerton Cove to determine the present status of the vegetation and the benthic infauna and epifauna. The aim was to establish baseline data against which future changes could be examined.

ENVIRONMENT

Fullerton Cove is a shallow protected estuarine lagoon about 3 km wide with an area of 9.5 km^2, the Quaternary sedimentary history of which has been described by Roy (1980). The tidal range at the mouth of the cove is 1.16m (springs) and 0.82 m (neaps) (New South Wales Department of Public Works, unpublished data).

Some 5.5 km^2 of mangroves (*Avicennia marina*) fringe the cove, with trees 15-17 m in height on the seaward margins. The average canopy cover is 80% with the lowest foliage occurring at a height of 12 m. A few seedlings, about 30 cm high are scattered throughout most of the community. The pneumatophores and the trunk bases, to a height of about 20 cm, are covered with tufts of predominantly red algae. Both algae and mangrove seedlings are absent from the extreme seaward margins of the mangroves.

At the salt marsh/mangrove interface, *Aegiceras corniculatum* occurs with *Avicennia*. In this zone the *Aegiceras* trees are about 3 m high and the *Avicennia* about 4 m, and patches of the saltmarsh plant *Suaeda australis* occur between the mangroves.

The well developed salt marsh has been extensively modified. Grazing cattle have had local effects while flood mitigation works, involving construction of levee banks, have altered the original reticulate drainage patterns. The saltmarsh is delineated by the mangroves to seaward and by a zone of She-oaks (*Casuarina glauca*) on the landward side.

Six species of saltmarsh plants were recorded: *Suaeda australis, Sarcocornia quinqueflora, Sporobolus virginicus, Samolus repens, Triglochin striata* and *Atriplex* sp. aff. *hastata*. All are common saltmarsh plants in central New South Wales. The dominant species over the saltmarsh is *Sporobolus virginicus* although *Samolus repens* is common in places. *Suaeda australis* occurs as scattered plants on the levee banks, *Sarcocornia quinqueflora* occurs on slightly higher ground, and *Triglochin striata* and *Atriplex* sp. occur on the landward margins of the saltmarsh. The rush *Juncus kraussii* occurs on the levee bank at the artificial junction of the mangrove and saltmarsh communities. In the damper areas the surface mud between the saltmarsh plants is covered by algae, but these were not investigated.

METHODS

Sampling took place on five occasions and four transects were studied (Fig. 1). Owing to poor weather neither all the transects nor all the replicates were sampled at each time (Table 1). Transect A ran from the mudflat to the saltmarsh. Sites A1-A5 on the mudflat are exposed at low water on spring tides and probably during most tidal cycles. Sites A6-A8 were in the fringing mangroves. In February 1977 the transect was continued beyond the mangroves to the broad saltmarsh/ mangrove transition (Sites A20-A22).

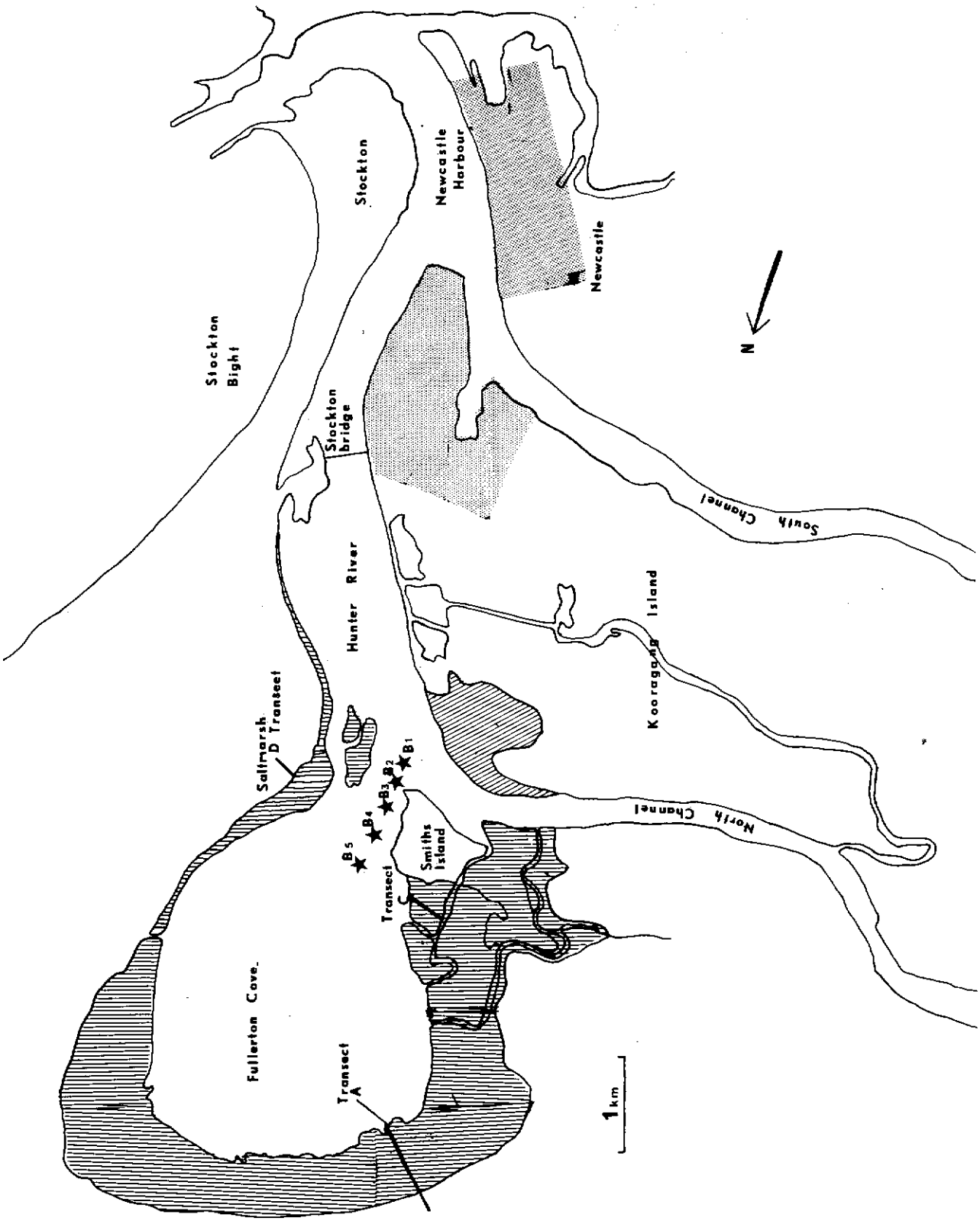

Fig. 1. Fullerton Cove and its environs, showing locality of mangroves, industrialised areas and sampling transects.

TABLE 1

Sampling Strategies

	Variables	Method	Replicates	Transects	Dates of Sampling
Vegetation	cover pneumatophore cover	$0.25m^2$ quadrats $0.25m^2$ quadrats	5 5	D A	Feb 1976; Feb, May; Nov 1977. Feb 1976; Feb 1977.
Epifauna	number of species	$0.25m^2$ quadrats	5	A(sites 6-8) A(sites 20-22) D	Feb 1976;Feb,May,Nov 1977 Feb 1977. Feb 1976; Feb, May, Nov 1977.
Infauna	number of species	9 dm^3 of sediment	5	A(sites 1-5)	June 1975; Feb 1976; Feb, May, Nov 1977.
		van Veen grab ($0.1m^2$)	5	B	June 1975; Feb 1976; Feb 1977.

1. All benthic samples sieved through 2 mm sieve, animals preserved in 7% neutralised formalin. Representative collection of fauna deposited in the Australian Museum.
2. Transect C, only qualitative observations on the fauna and flora were made.

Transect B was sited across the mouth of the cove. The sediment here varied from shell fragments to solid mud and the grab did not bite consistently into the substrate. Transect C, on which only qualitative observations were made, crossed the mangroves of Smiths Island in the west corner of the Cove. Transect D traversed the saltmarsh from the landward side of the mangroves to a small creek just seaward of the *Casuarina glauca* swamp forest zone. The uneven distribution of the transects, sites and sampling periods reflects the practical difficulties of surveys dependent upon enthusiastic volunteer workers.

RESULTS

Vegetation

In Figure 2 the percentage cover of the three dominant species of saltmarsh plants along Transect D is shown. *Sporobolus* was consistently present at all sites throughout the sampling period except at D2 in May 1977, when it was completely absent. *Sarcocornia* was mostly restricted to D1 and D2, the seaward sites. The percentage cover of *Triglochin* varied considerably; for example, at D3 it occupied 16% and 18% in February 1976 and November 1977 respectively, but was absent in February and May 1977. The total percentage cover of the saltmarsh vegetation varied, with the highest cover adjacent to the mangroves at D1. Despite the temporal changes, no obvious seasonal variation was apparent.

Fauna

Table 2 lists all the macrofauna collected during the survey and indicates the zone in which they occurred.

Infauna

Infauna was recorded on the intertidal mudflat portion of transect A (sites 1-5) and from the subtidal portion of transect B. The polychaete fauna was similar on the two transects but additional mollusc species were present on transect B (see Table 2).

On transect A twenty-six species were recorded but five species dominated: 3 polychaetes, 1 bivalve mollusc and 1 amphipod. The mean number of the individuals of these 5 species is shown in Figure 3 and the species are discussed below.

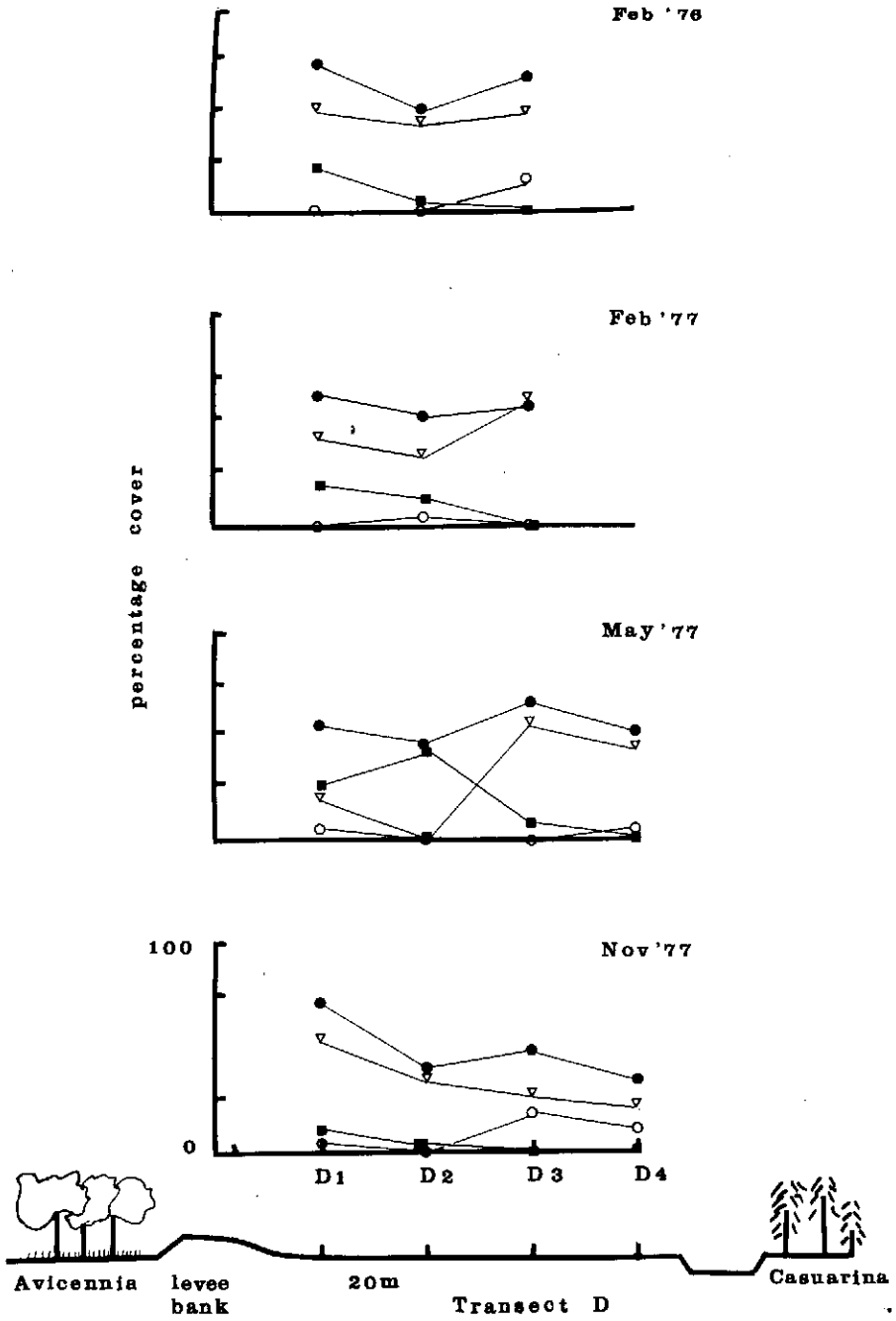

Fig. 2. The % cover of the 3 dominant saltmarsh plants, ▽ *Sporobolus*, ■ *Sarcocornia* and o *Triglochin* together with • % cover of plants, along Transect D, during the survey.

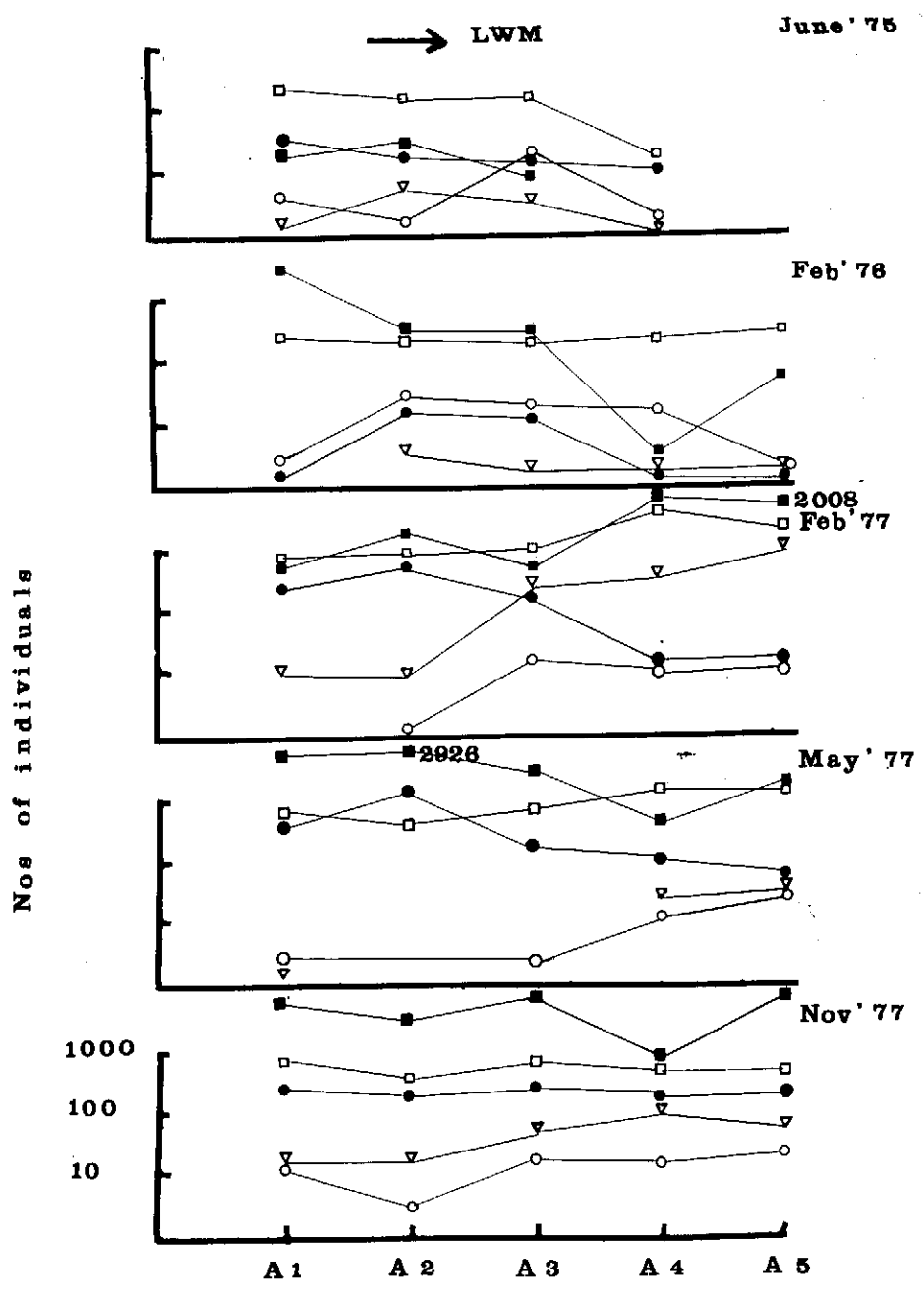

Fig. 3. The total number of the five common species • *Ceratonereis* sp., o *Nephtys australiensis*, ▽ *Leitoscoloplos normalis*, ■ *Arthritica helmsii* and □ *Victoriopisa australiensis* collected at each site along Transect A1-A5 during the survey.

Ceratonereis sp. (F. Nereididae, Polychaeta). This species has been misidentified in the past as *C. erythraeensis*, but is a new species being described by Hutchings and Turvey (1982). It was present in very low numbers at sites 1, 2, 3 and 4 in June 1975 and February 1976 but then recruited very successfully at sites 1, 2 and 3 between February 1976 and 1977. In addition, recruitment also occurred at sites 3, 4 and 5 between May 1977 and November 1977.

Nephtys australiensis (F. Nephtyidae, Polychaeta). Exhibited some variation in number of individuals both within a site over time and along the transect during one sampling period. This species, although consistently present, never reached the large numbers exhibited by the other dominant species.

Leitoscoloplos normalis (F. Orbiniidae, Polychaeta). Fullerton Cove is the type locality of this species (Day 1977). This species had a very large successful recruitment to sites 3, 4 and 5 prior to February 1977 compared with the same period in the previous year. Recruitment to the two inshore sites (A1, A2) was low.

Arthritica helmsi (F. Leptonidae, Bivalvia). This small bivalve showed distinct bursts of settlement which occurred at different times of the year along the transect. At sites A1, A2 and A3, maximum recruitment occurred between February to May 1977, whereas it appears to have occurred later (between May to November 1977) at the two offshore sites A4 and A5. At sites A1-A5 (site A5 was not sampled until February 1976) recruitment prior to June 1975 was very low and numbers gradually built up and reached their maximum in 1977.

Victoriopisa australiensis (F. Gammaridae, Amphipoda). This amphipod was present in large numbers along the entire transect, with some variations in numbers occurring at a site over time. At sites A4 and A5, there was evidence of a very successful recruitment prior to February 1977. This, however, did not occur at the inshore stations at this time.

The only other animal occasionally occurring in large numbers was the mysid *Neomysis japonica*, which was abundant at sites A2 and A3 in February 1977, but then completely disappeared.

The fauna of sites C7 and C1, which were on either side of Smiths Island at low water mark, was similar to the sites along Transect A. The nereid polychaete *Ceratonereis* sp. was found at site C5, where the sediment was dry during sampling, indicating that this species can survive for a limited period in relatively dry substrates as well as occurring in much wetter inter-tidal and sub-tidal areas. The capitellid *Notomastus* sp. represents an undescribed species (Hutchings and Murray, in prep.) which is common in upper estuarine areas in New South Wales.

Epifauna

Epifauna were collected from the mangrove zone on transect A (A6-A8; A20-A23) and from the saltmarsh zone on transect D.

The number of individuals recorded from the mangrove sites A6-A8 are shown in Table 3. Considerable differences in the fauna occurred between February 1976 and February 1977. Species which were common in 1976, such as the gastropod *Tatea ballinensis* and the crab *Paragrapsus laevis* were apparently absent in 1977. The sparse epifaunal counts may be explained by the lack of an encrusting faunal community at the bases of the tree trunks or on the pneumatophores.

TABLE 3

Numbers of individuals occurring at sites A6-A8 in the mangroves

	February 1976			February 1977	
	A6	A7	A8	A6	A8
Corbicula nepeanensis			1		
Ophicardelus quoyi					5
Salinator solida		3	61		12
Tatea ballinensis	3	26	73		
Australoplax tridentata		2			
Heloecius cordiformis		9	16	6	1
Macrophthalmus punctualatus			3		
Paragrapsus laevis	1	13	24		
Penaeus sp.				1	
Sesarma erythrodactyla	3	27	53		2
Sphaeroma quoyanum			2		

Sites A20-A23 at the saltmarsh margins of the mangroves have a much richer mollusc epifauna than the frontal sites. The gastropods *Salinator solida* and *Ophicardelus quoyi* were common. Their presence may have been correlated with sparse patches of *Sarcocornia* and seedlings of *Avicennia* which provide some shade for these animals.

The number of individuals occurring at each site along the saltmarsh transect D are shown in Table 4. The fauna consists of gastropod molluscs, crabs and a talitrid amphipod *Orchestia* sp. which is undescribed. In February 1976, the gastropods *Ophicardelus quoyi* and *Salinator solida* dominated the fauna at all sites sampled (sites 1, 2 and 3). A year later, *S. solida* was still common at all sites but the numbers of *O. quoyi* were seen to have fallen drastically. Unfortunately these vials have been mislaid, so actual numbers of each species of *Ophicardelus* are unknown. This fall in numbers of *Ophicardelus* was maintained for the rest of the sampling period. *Ophicardelus* tends to occur at the base of the saltmarsh plants whereas *Salinator* occurs on the surface of the mud. However, the decline in numbers cannot be correlated with a fall in the percentage cover of saltmarsh plants (Fig. 2) so other factors must be responsible.

TABLE 4

Numbers of individuals occurring along Transect D through the saltmarsh

	Sites	February 1976			February 1977			May 1977				November 1977			
		1	2	3	1	2	3	1	2	3	4	1	2	3	4
Assiminea tasmanica						2							10		
Littorina scabra					1										
Ophicardelus quoyi		428*	86	103	X	X	X		1	X	21	X			
Ophicardelus sulcatus		11	1		X	X	X			X		X			
Salinator solida		146	110	119	180	221	240	141	5	123	165	304	73	109	206
Tatea kesteveni						2					1				
Helograpsus haswellianus		11	4	1											
Orchestia sp.		2													
Paragrapsus laevis			2	2							1				
Sesarma erythrodactyla		1			2		13	4	1		5				

*The number of individuals occurring in the 5 replicate quadrats each 0.25m^2 has been combined.

XPresent but the 2 species of *Ophicardelus* not differentiated.

DISCUSSION

The fauna of the mangroves, saltmarsh and the mudflats of Fullerton Cove appears to be typical of similar areas in central New South Wales (Hutchings *et al.* 1977). Relatively few species occur, but some of these are extremely abundant. This may be explained in part by the large salinity range experienced in the Cove. At low tide on 14 February 1976 surface salinities along transect B were 1°/$_{oo}$, whereas, bottom salinities in the channel were 14°/$_{oo}$. During periods of high rainfall and runoff, salinity may be very low for long periods of time.

This wide range must affect the fauna severely. Low salinity will limit the number of species recruiting into the Bay as pelagic larvae from the Hunter River, for many pelagic larvae are unable to osmoregulate. Of the five dominant species occurring on the inter-tidal mudflats three are brooders. The bivalve *Arthritica helmsi* broods and small crawling veligers are released onto the substrate. The reproductive strategy of this species is currently being investigated by Dr Fred Wells of the West Australian Museum. Similarly, the amphipod *Victoriopisa australiensis* broods, like all other gammarids, and is a common species occurring in estuarine and lagoon situations along the New South Wales coast (Gibbs, pers. comm.). Of the polychaetes, only *Ceratonereis* sp. broods, and immature worms are found in the parent tube. However, where fertilisation occurs is unknown. This brooding behaviour eliminates the pelagic larval stage and is often found amongst estuarine species. The other two polychaete species, *Nephtys australiensis* and *Leitoscoloplos normalis* probably produce pelagic larvae.

These dominant animals showed considerable fluctuations in numbers during the sampling period. *Leitoscoloplos normalis* and *Arthritica helmsi* exhibited variations between years. Recruitment was most successful in 1977, however, more intensive sampling would be necessary to establish the range of temporal variation and to determine if distinct seasonal recruitment occurs.

The mysid *Neomysis japonica* has not previously been recorded in the literature from Australian waters although its Australian distribution is currently being described by Williams and Griffith (in prep.). It seems that this species, which until now has only been known from Japan, where it is common along the Pacific coast in brackish water, has been introduced into the Hunter River in ballast water discharged from Japanese ships. Other unpublished records from the east coast of Australia can also be correlated with the discharge of ballast water in the vicinity. The species is successfully breeding in Fullerton Cove.

The well developed mangrove community consists of healthy mature *Avicennia marina* trees. However, the marine faunal community is fairly sparse. The encrusting epifaunal community is poorly developed, consisting only of barnacles; this poor development of the encrusting fauna and the complete lack of an oyster (*Saccostrea commercialis*) zone can, perhaps, be explained by the low salinities at low tide. These may be caused by fresh water runoff or ground water, as no major creeks flow into the Cove. Whether an encrusting fauna occurs lower down the Hunter in more saline areas is not known.

Another contributing factor may be that the pneumatophores and bases of the mangroves are only covered for limited periods during each tidal cycle. From casual observations in areas such as Careel Bay in Pittwater, New South Wales, where there is a well developed *Saccostrea* community (Hutchings and Recher 1974), the pneumatophores and bases of the mangroves are exposed to the air for much shorter time periods. If the immersion time is reduced as in Fullerton Cove, perhaps there is insufficient feeding time for the filter feeding *Saccostrea*. Without the oysters to provide protection from predation and desiccation, the rest of the community will not develop.

The saltmarsh zone appears well developed although it has been considerably modified by grazing and flood mitigation works. The habitat is rapidly disappearing on the central coast of New South Wales, and this is a particularly large area. No attempt was made to estimate the total area of saltmarsh in Fullerton Cove but we suspect that a large percentage of saltmarsh has already been converted to terrestrial habitats by changes in the pattern of water flow and by reclamation. More detailed sampling of the saltmarsh plants is needed to document the phenology of the species. This should be carried out in conjunction with detailed salinity studies. During periods of prolonged heavy rain, high mortality of the saltmarsh fauna may occur, especially if they coincide with neap tides when tidal flooding of the marsh does not occur.

In Fullerton Cove seasonal changes in the macrofauna may be masked by local catastrophic events such as floods. Further sampling over long periods would be necessary to confirm any such effects, but the occurrence of some such catastrophic events may explain the inter-year variations in recruitment shown by *Leitoscoloplos normalis* and *Arthritica helmsii*.

RECOMMENDATIONS FOR FURTHER STUDY

The scale of development in the lower Hunter poses many threats to the remaining natural communities. All the communities in Fullerton Cove are likely to be vulnerable to man induced changes.

This preliminary survey has shown that under 'normal' circumstances large fluctuations in the abundances of the five dominant organisms occur in the inter-tidal area. To evaluate any impact on the fauna, the amplitude of naturally occurring fluctuations must first be established. Attempts should be made to investigate variation in ecological factors, such as salinity and temperature, to determine whether they can be related to the variation in faunal abundance.

At a minimum, sampling every two months for two years would be required to document the environmental and biotic variability of the system. Similarly, such sampling should also take place in the saltmarsh.

Each wetland system has its own characteristics so that generalisations on the impact of development should be made with extreme caution. Instead each major system should be studied in its own right. We suggest that Fullerton Cove is a major system on the Hunter and worthy of future monitoring studies.

Although the New South Wales Government announced, in May 1981, its intention of establishing a nature reserve including the northern part of Koorangang Island, thus following the recommendations of the Coffey Enquiry (SPCC 1973), there remains considerable need for the preservation of other wetland areas in the Hunter. Fullerton Cove represents one of the last remaining, relatively intact, fully developed wetland areas in the Hunter and, in the Society's opinion, is worthy of protection. It may be that without the protection and management of the remaining wetlands in the Hunter the present viable fishing and oyster industry in the estuary will disappear.

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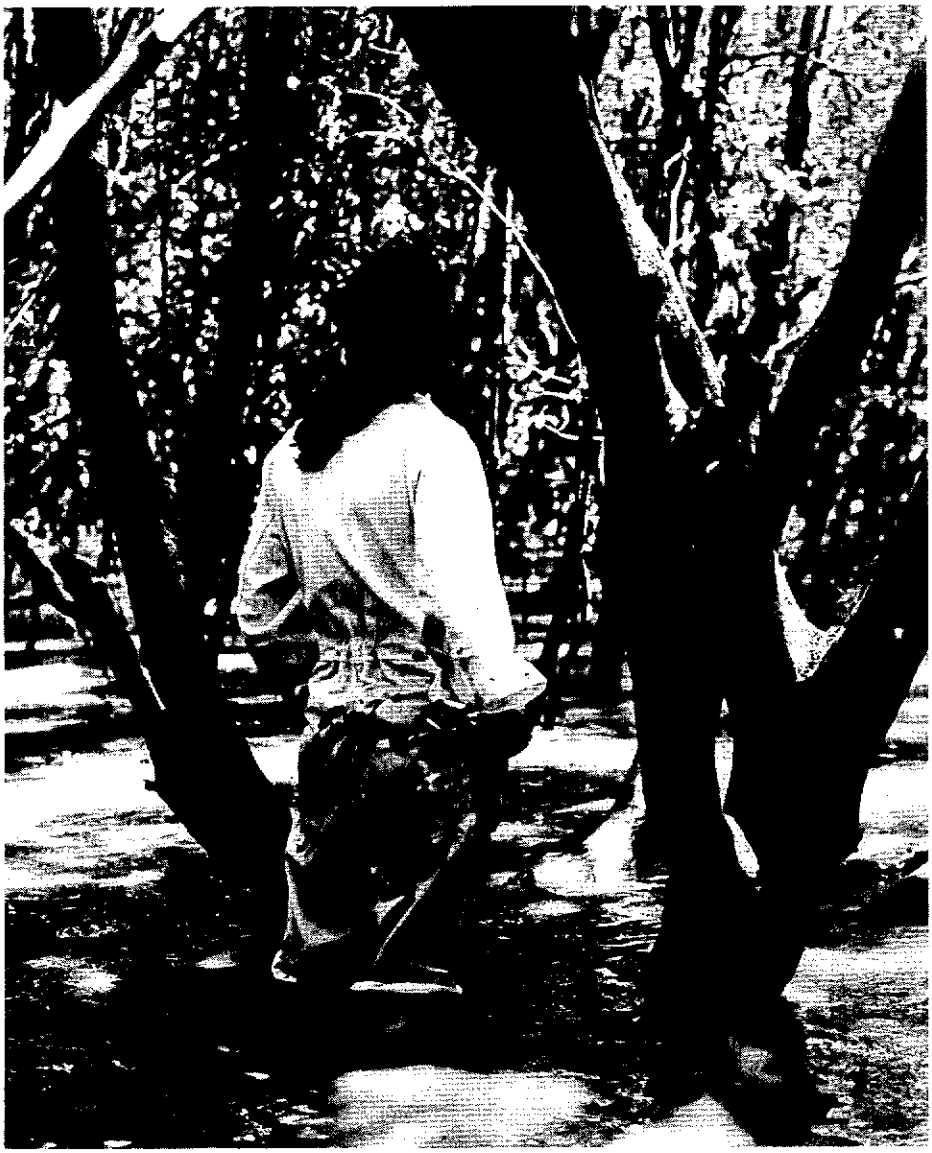

Fieldwork at Fullerton Cove

TABLE 2

Invertebrate Faunal List of Fullerton Cove

	Mudflat	Mangroves	Saltmarsh	Channel
Phylum Mollusca				
F. Littorinidae				
Littorina scabra			X	
F. Rissoidae				
Tatea ballinensis	X	X		
Tatea kesteveni	X		X	
Tatea rufilabris	X			
F. Assimineidae				
Assiminea tasmanica			X	
F. Nassariidae				
Nassarius jonasi				X
Nassarius burchardi				X
F. Ellobiidae				
Ophicardelus quoyi		X	X	
Ophicardelus sulcatus			X	
Ellobiidae (juv.)			X	
F. Amphibolidae				
Salinator fragilis	X			
Salinator solida		X	X	
F. "Leptonidae"				
Arthritica helmsi	X			X
F. Mactridae				
Notospisula trigonella				X
F. Tellinidae				
Tellina deltoidalis				X
F. Psammobiidae				
Sanguinolaria jonacioides				X
F. Corbulidae				
Corbicula nepeanensis		X		
Phylum Arthropoda				
Class Crustacea				
F. Balanidae				
Balanus amphitrite		X		
F. Mysidae				
Neomysis japonica	X			
F. Anthuridae				
Anthurid sp.	X			
F. Sphaeromatidae				
Sphaeroma quoyanum	X	X		X
F. Gammaridae				
Victoriopisa australiensis	X			X
F. Oedicerotidae				
Oedicerotid sp.	X			
Exoediceros sp.	X			
F. Talitridae				
Orchestia sp.			X	
F. Penaeidae				
Penaeus sp.	X	X		
Penaeus sp. (juv.)	X			
F. Sergestidae				
Acetes sp.	X			
Acetes sp. (juv.)	X			

Table 2 (continued)

	Mudflat	Mangroves	Saltmarsh	Channel
F. Alpheidae				
Alpheus sp	X			X
F. Palaemonidae				
Palaemon sp.	X			X
F. Grapsidae				
Helograpsus haswellianus			X	
Ilyograpsus paludicola	X			
Paragrapsus laevis		X	X	
Sesarma erythrodactyla	X	X	X	
F. Hymenosomatidae				
Hymenosomatid sp. 1				X
Hymenosomatid sp. 2				X
F. Ocypodidae				
Australoplax tridentata		X		
Heloecius cordiformis		X		
Macrophthalmus punctulatus		X		
M. setosus	X			X
F. Xanthidae				
Pilumnopeus serratifrons				X
Phylum Nemertinea				X
Phylum Annelida				
Class Polychaeta				
F. Phyllodocidae				
Phyllodoce novaehollandiae	X			X
F. Nereididae				
Ceratonereis n. sp.	X			X
F. Nephtyidae				
Nephtys australiensis				X
F. Eunicidae				
Eunice australis				X
Marphysa sanguinea				X
F. Lumbrineridae				
Lumbrineris latreilli				X
F. Orbiniidae				
Leitoscoloplos normalis	X			X
Scoloplos (S.) simplex	X			
F. Capitellidae				
Notomastus torquatus				X
Notomastus n. sp.	X			
F. Serpulidae				X
Phylum Phoronidae				
Phoronis sp.				X