TEMPORAL CHANGES IN THE ESTUARINE BENTHIC FAUNA OF TOWRA POINT, BOTANY BAY

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INTRODUCTION

The estuarine wetlands in the Towra Point region of Botany Bay, New South Wales, represent one of the few large remaining such systems near Sydney. They are probably the major contributor of organic material to the food web within Botany Bay and provide habitats and nursery areas for many important fish and invertebrate species of the Bay.

Botany Bay has been converted to a major port facility to serve Sydney. As well as heavy shipping usage (and its associated dredging activities), it is also fringed by considerable industrial development and a major airport complex. Research done on the estuarine flora of Towra Point includes a major study on the physical and biological factors that control the structure of the mangrove and saltmarsh plant communities (Clarke and Hannon 1967, 1969, 1970, 1971; Kratochvil *et al.* 1973), distribution and biomass determinations of the seagrasses *Posidonia australis* (Larkum 1976; West and Larkum 1979) and *Zostera capricorni* (Larkum, Collett and Williams, in preparation) and comparisons of the epiphytic algae communities on both species of seagrass (May *et al.* 1978).

Faunal studies, however, have been less extensive. McCormick (1978) compared seasonal changes in the invertebrate fauna of the mangrove habitat in Towra Bay with other mangrove systems along the New South Wales coast. The Australian Littoral Society (1978) sampled seagrass and mud flat habitats quantitatively once only in the winter of 1977, and also provided a species list for molluscs and crustacea from other habitats studied at the same time, and Collett, Hutchings, Gibbs and Collins (in preparation) have sampled invertebrate fauna of the *Posidonia australis* beds once only as part of a study of *Posidonia* beds along the New South Wales coast.

It is apparent that the studies on estuarine fauna communities have not been extensive. All habitat types have not been quantitatively sampled, nor with the exception of McCormick's (1978) work, have seasonal variations or longer term changes been assessed. This, unfortunately, is the case in many estuarine benthic studies in Australia. This lack of seasonal and longer term data means that the assessment of any impact on a community is difficult due to the inadequate information on natural fluctuations over time.

The paper therefore aims to:

a) Determine any major seasonal changes in the community structure of estuarine habitats in the region, i.e. seagrass, mangroves, saltmarsh and sub-tidal sandbar; and
b) determine longer term changes in those areas that have been sampled previously.

A subsidiary experiment was also carried out. Severe oil spills have occurred in Botany Bay, the most noticeable being in September 1979 and just prior to the commencement of this study in February 1980. These resulted in the oiling of areas of Towra Point and Quibray Bay (Allaway 1982). Two mangrove sites were chosen to determine if the oil spill had any immediate effects on the mangrove fauna. One site was within the oiled region on the eastern side of Towra Point. The other site was within Towra Bay, away from any oil spill.

THE TOWRA POINT REGION

The Towra Point area occupies 600 ha of land about 16 km from the centre of Sydney. Towra Peninsula joins Kurnell Peninsula, and they form the southern and eastern boundaries respectively of Botany Bay (Fig. 1).

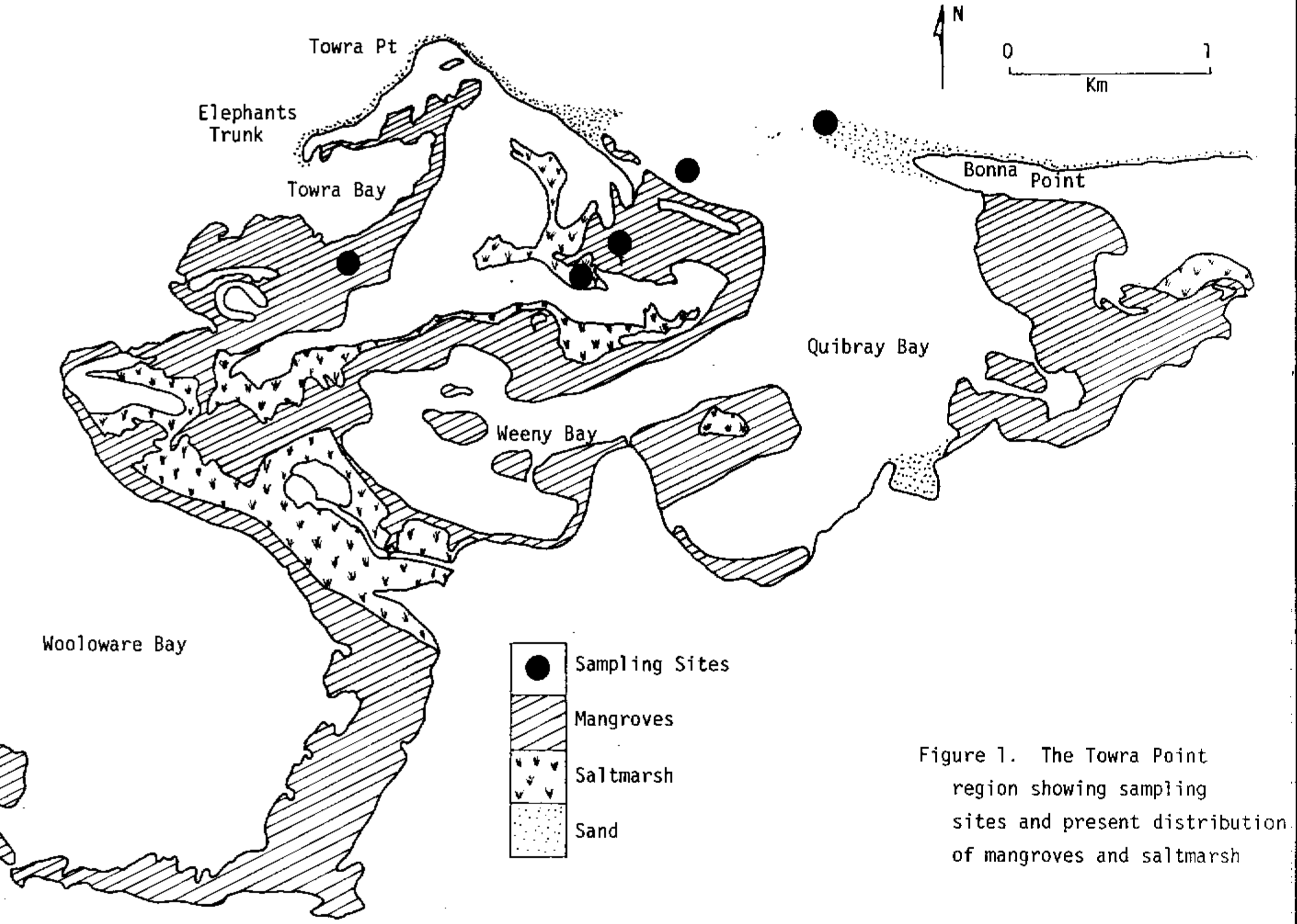

Figure 1. The Towra Point region showing sampling sites and present distribution of mangroves and saltmarsh

Towra Point is a low lying peninsula made up of Holocene sandy sediments. This peninsula and other parts of the sandy foreshore of Botany Bay are prone to storm erosion, the severity of which has increased in recent years, particularly at Towra Point. There is concern that this acceleration in erosion has resulted from the re-direction of ocean waves caused by dredging in Botany Bay (Roy and Crawford 1982).

Towra Point is fringed by extensive tidal wetlands, including seagrasses, mangroves and saltmarshes. The most recently published seagrass distribution maps (ALS 1978, SPCC 1978) indicate extensive beds (approximately 600 ha) of *Posidonia australis* and *Zostera capricorni* extending to well below ELWM (Extreme Low Water Mark) from Wooloware Bay to Silver Beach, including Quibray and Weeney Bays. *P. australis* is generally found between 1 and 3 m below ELWM, whereas *Z. capricorni* is usually found in shallow water in the region. Two other species of seagrass found in the area are *Halophila ovalis* and *H. decipiens*.

There are two mangrove species found in the Towra Point region — *Avicennia marina* and *Aegiceras corniculatum*. *A. marina* is the taller, occasionally reaching heights of 10-12 m. *A. corniculatum* seldom reaches more than 2.5 m in height and, at Towra Point, is usually distributed in small patches amongst the *Avicennia*. It may be found in areas where freshwater runoff has caused lower salinities (ALS, 1978). Approximately 400 ha of mangroves are found in the Towra Point region, from Wooloware to Quibray Bays, but they are generally absent in the exposed areas of Towra and Quibray Beaches (SPCC, 1979) (Fig. 1). Detailed maps of the mangrove distribution are shown in ALS (1978) and SPCC (1979).

At least 12 species of saltmarsh plants (listed in ALS, 1978), consisting of low succulent herbs and rushes, cover large areas of Towra Point (up to 161 ha). *Sarcocornia quinqueflora* is the most abundant species in the saltmarsh areas that are most frequently inundated by the tides. *Sporobolus virginicus* usually occurs less extensively in pure stands on slightly elevated ground among the *Sarcocornia*, while pure stands of the brackish water rush *Juncus kraussii* occupy the terrestrial margin of the saltmarsh. The Towra Point saltmarshes are the last major stands remaining in the Sydney region, as all other large areas have been reclaimed for industry or sporting fields.

MATERIALS AND METHODS

Five sampling sites were chosen as follows (Fig. 1).

(1) Seagrass: in *Zostera capricorni* (1 m depth at low tide) 50 m east of Mangrove Creek. The sediment was sandy/mud.

(2) Sandbank: westward extension of Bonna Point, across the mouth of Quibray Bay (1.5 m depth at low tide). The sediment was mobile sand.

(3) Inter-tidal mud flat within *Avicennia* forest in Towra Bay adjacent to the Elephants Trunk. This site was located as close as possible to the transect area used by McCormick (1978). The habitat was similar to that of Area 2 (McCormick 1978), where oysters are found only on the tree trunks, never on the pneumatophores. The sediment was mud.

(4) Mud flat within the mangrove forest, 15 m south of Mangrove Creek. The habitat type chosen was similar to that chosen above.

(5) Saltmarsh area, behind mangroves of Mangrove Creek on the eastern side of the water course. The marsh was subject to regular tidal inundation.

All sites were sampled five times at approximately 12 weekly intervals between 10 February 1981 and 17 January 1982. Fauna samples were collected by the following means;

(1) Seagrass and sand — 12 cores (0.03 m^2 surface area x 10 cm depth) were taken on each occasion at each site and the contents washed through a 1 mm diameter sieve. The residue was preserved in 10% formalin, sorted and identified.

(2) Mangroves and saltmarsh sites — 12 x 0.25 m^2 quadrats were randomly placed within the area to be sampled. all epifauna was collected from each quadrat and crabs were removed from their holes by excavating burrows to a depth of approximately 15 cm. Mangrove pneumatophores were also examined and fauna removed. The algal growth on them often contained small molluscs and amphipods.

RESULTS AND DISCUSSION

(A) Seagrass Site

The species number and number of individuals for Site 1 on each sampling occasion are shown in Table 1. Also shown are the numerically dominant species ranked in decreasing order, the total number of individuals of that species, and the percentage of the overall total of individuals in the community.

TABLE 1

Species number (S), number of individuals (N), total and relative abundance of the dominant species in the *ZOSTERA* HABITAT on each sampling occasion

	FEB 1981			MAY 1981			JULY 1981			OCT 1981			JAN 1982		
S N	30 380			28 214			40 305			35 241			24 248		
		N	%		N	%		N	%		N	%		N	%
	N. burchardi	59	16	*N. burchardi*	48	22	*A. intermedia*	50	16	*N. torquatus*	38	16	*N. burchardi*	71	29
	Cymadusa sp.	55	14	*Cymadusa* sp.	36	17	*N. torquatus*	48	16	*A. intermedia*	28	12	*Cymadusa* sp.	37	15
	T. comtessei	48	13	*N. torquatus*	17	8	Nemertean	33	11	Nemertean	26	11	Nemertean	25	10
	A. constricta	36	9	*T. deltoidalis*	13	6	*Cymadusa* sp.	29	9	*Cymadusa* sp.	24	10	*A. trapezia*	20	8
	N. torquatus	35	9	*A. trapezia* } *Alpheus richardsoni*	12	6	*Lysilla pacifica*	18	6	*N. burchardi*	20	8	*A. constricta*	19	8
	Nemertean	24	6				*A. trapezia*	14	5	*A. trapezia*	14	6	*T. deltoidalis*	17	7
													N. torquatus	15	6

There is no seasonal pattern in terms of total numbers of species and individuals. However, some of the dominant species do display seasonal trends. In particular, the carnivorous gastropod *Nassarius burchardi* has its maximum numbers in summer and autumn, drops considerably during the winter, and begins to increase again in the spring.

The deposit feeding polychaete *Armandia intermedia* reaches its greatest abundance during the winter and its minima in summer. Other species such as the deposit feeding polychaete *Notomastus torquatus*, the amphipod *Cymadusa* sp., the filter feeding bivalve *Anadara trapezia*, and the nemerteans are relatively constant during the year. Other species listed in Table 1 were present in large numbers only once or twice throughout the year. Most of the 58 species collected over the year (see Appendix) are present in very low numbers on a few occasions. This low density/high variability is characteristic of most New South Wales estuarine benthic systems. Comparison with the data collected at approximately the same site in winter 1977 (ALS, 1978) indicates the presence of a similar species complement (a total of 52) with a number of the same species dominating – *N. burchardi*, amphipod (possibly *Cymadusa* sp.) *Thalotia comtessei*, *A. trapezia*, *N. torquatus* and *Tellina deltoidalis* are listed as dominant species during both studies. The mesogastropod *Pseudoliotia micans* was listed as the most dominant in 1977, but it only occurred in relatively small numbers early in the present study and then disappeared.

The fauna collected from the *Zostera* bed at Towra Point in 1977 and this study is typically estuarine in that most species listed have been collected in seagrass samples in other estuarine studies in New South Wales – Careel Bay, Pittwater (Hutchings and Recher 1974); Wallis Lake (Hutchings *et al.* 1978); Lake Macquarie (Robinson 1982), Lake Merimbula (Gibbs, unpublished data) – where the salinity has been almost fully marine.

The importance of seagrass to benthic fauna, which has been demonstrated elsewhere, is that it provides a greater habitat heterogeneity (Stoner 1980; Kikuchi 1980), a more stable sediment base (Orth 1977) and a direct and indirect source of food as detritus (SPCC, 1978). Comparison between vegetated and unvegetated areas within New South Wales estuaries have indicated both a higher faunal diversity (Powis and Robinson 1980; Robinson 1982; Robinson, Gibbs, Barclay and May, unpublished data) and biomass and production (Robinson 1982) in vegetated habitats.

(B) Sand Site

The species number and number of individuals for Site 2 on each sampling occasion are shown in Table 2. Also shown are the numerically dominant species ranked in decreasing order, the total number of individuals of that species and the percentage of the overall total of individuals in the community.

TABLE 2

Species number (S), number of individuals (N), total and relative abundance of the dominant species in the SAND HABITAT on each sampling occasion

	FEB 1981			MAY 1981			JULY 1981			OCT 1981			JAN 1982		
S	6			8			8			8			13		
N	28			102			23			41			89		
		%	N		%	N		%	N		%	N		%	N
	Nemertean	29	8	*G. americana*	58	59	*G. americana* / Nemertean	30	7	*G. americana*	37	15	*A. ehrlesi*	29	26
	Spio pacifica	25	7	Nemertean	20	20				Nemertean	24	10	*G. americana*	17	15
	N. longipes	21	6	*N. longipes*	10	10	*S. pacifica*	13	3	*S. pacifica*	22	9	*S. pacifica*	12	11
	A. ehrlesi	18	5	*A. ehrlesi*	5	5	*N. longipes*	9	2				Nemertean	11	10
				S. pacifica	4	4									

Both species number and numbers of individuals are consistently lower than the seagrass area discussed above. Total numbers of individuals fluctuate, although the numerically dominant species are relatively constant throughout the year. The dominant species are all carnivores and omnivores (with the exception of *Spio pacifica* which is probably a deposit feeder), suggesting an opportunistic way of life is needed to survive in such an unstable environment.

No samples have been taken previously at Site 2. A recent study (Jones and Candy 1981) had sampled sand substrates adjacent to Silver Beach (> 2 km north east of our sample site) in a study of the effects of dredging on the macro-benthos in Botany Bay. Jones and Candy (1981) found very much higher species and individual density than in this study, and the dominant species recorded from their work are very different from ours. This is probably related to the greater depths at which their samples were taken (4-21 m) compared with ours (1.5 m). The shallow water and high wind exposure in the present study resulted in a very unstable habitat. This presumably was reflected in the relative lack of fauna and the opportunistic life-styles of those present.

(C) Towra Bay and Mangrove Creek Mangrove Sites

The species number and number of individuals for Site 3 (Towra Bay) and Site 4 (Mangrove Creek) on each sampling occasion are shown in Tables 3 and 4 respectively. Also shown are the numerically dominant species at each site ranked in decreasing order, the total number of individuals of that species and the percentage of the overall total of individuals in the community.

TABLE 3

Species number (S), number of individuals (N), total and relative abundance of the dominant epifaunal species in the TOWRA BAY MANGROVES on each sampling occasion

FEB 1981			MAY 1981			JULY 1981			OCT 1981			JAN 1982		
S 12			10			8			7			10		
N 271			74			82			55			151		
	%	N		%	N		%	N		%	N		%	N
S. erythrodactyla	24	64	*A. tasmanica* }	23	17	*B. auratum*	30	25	*S. erythrodactyla*	29	16	*S. erythrodactyla*	45	68
B. auratum	19	51	*Orchestia* sp. 2 }			*H. cordiformis*	17	14	*B. auratum*	24	13	*H. cordiformis*	25	38
Orchestia sp. 2	17	45	*S. erythrodactyla*	20	15	*E. modestus*	13	11	*Orchestia* sp. 2	15	8	*B. auratum*	11	16
M. zonata	16	43	*B. auratum* }	12	9	*S. erythrodactyla*	12	10	*H. cordiformis*	13	7	*S. commercialis*	6	9
A. tasmanica	13	34	*M. zonata* }			*Orchestia* sp. 2 }			*A. tasmanica*	11	6	*A. tridentata*	5	8
						S. commercialis }	9	7				*M. zonata*		
						P. mimula }								
Total Number individuals														
Crabs		87			16			24			23			115
Molluscs		137			40			40			24			35

TABLE 4

Species number (S), number of individuals (N), total and relative abundance of the dominant epifaunal species in the MANGROVE CREEK MANGROVES on each sampling occasion

FEB 1981			MAY 1981			JULY 1981			OCT 1981			JAN 1982		
S 12			12			7			10			12		
N 315			232			65			83			234		
	%	N		%	N		%	N		%	N		%	N
S. erythrodactyla	23	72	*H. cordiformis*	27	63	*S. solida*	52	34	*M. zonata*	36	30	*S. erythrodactyla*	33	78
H. cordiformis	21	67	*B. auratum*	16	38	*B. auratum*	14	9	*S. solida*	27	22	*H. cordiformis*	32	74
S. solida	12	38	*S. solida*	13	30	*L. scabra* }	12	8	*S. erythrodactyla* }	8	7	*S. solida*	15	34
B. auratum	11	35	*S. erythrodactyla*	12	27	*M. zonata* }			*H. cordiformis* }			*M. zonata*	7	16
B. amphitrite	10	31	*M. zonata*	10	23	*S. erythrodactyla*	5	3	*B. auratum*	6	5	*A. tridentata*	4	10
M. zonata	6	20	*A. tridentata*	7	16							*B. auratum*	3	8
Total Number individuals														
Crabs		168			106			4			14			162
Molluscs		107			109			59			68			67

Both mangrove communities are dominated almost entirely by crabs and gastropod molluscs. At both sites the greatest number of species occurred in the summer months, although the difference in species number compared with winter is not great. However, total number of individuals underwent a reduction after the first summer sampling (at Mangrove Creek the reduction occurred after May; at Towra Bay before May 1981). These numbers remained low over winter and spring but by the following summer had returned to a level comparable with 11 months previously. The main feature of this phenomenon was the sharp decline in numbers of the dominant crabs *Sesarma erythrodactyla* and *Heloecius cordiformis* and some reduction in the mollusc numbers. Although the numbers vary considerably, the same species remain amongst the dominants at both sites throughout the year, i.e. *S. erythrodactyla, H cordiformis, Bembicium auratum, Melosidula zonata* and *Australoplax tridentata*. The gastropod *Salinator solida* is a dominant species at the Mangrove Creek site, but present only in low numbers at Towra Bay. The reasons for this are unknown, although the Mangrove Creek site was much closer to the saltmarsh zone, where *S. solida* is even more common.

(i) Changes over time at Towra Point: The ALS (1978) report listed the mollusc and crustacean species collected in the mangroves at Towra Point during 1977. The main species present then but absent now were the bivalves *Trichomya hirsuta* and *Xenostrobus securis* and the gastropods *Thalotia comtessei, Nerita atramentosa, Velacumantus australis, Pyrazus ebeninus* and *Tatea rufilabris*. All but the last of these species are generally found in seagrass areas or the seaward end of mangrove systems. This accounts for their absence from the habitat sampled in this study, towards the landward part of the mangroves. McCormick (1978) sampled the same habitat type in approximately the same area of Towra Bay between November 1972 and July 1973 and provided a very similar list of species to ours. According to McCormick (1978) this particular part of the mangrove habitat is dominated by the gastropod *Bembicium auratum* and the crabs *Sesarma erythrodactyla* and *Heloecius cordiformis*, all of which predominated during the present study. Two other crabs *Australoplax tridentata* and *Paragrapsus laevis* were also found in low numbers in both studies.

McCormick (1978) commented on the increase in abundance of molluscs to be found during the winter months. This was not evident during the present sampling. In fact, there was a general decline from 137 individuals in February 1981 to 35 in January 1982, with low numbers being found during the winter.

(ii) Comparisons with other studies: Although a number of studies have been done on mangrove systems along the New South Wales coast, exact comparisons are difficult because of variations in sampling technique and sampling zones within the mangroves. Qualitative reviews of Australian mangrove fauna have been conducted by MacNae (1968), Saenger *et al.* 1977, and Hutchings and Recher (1982).

McCormick (1978) provides a comparison of the fauna of six mangrove swamps, ranging from Goodwood Island, Clarence River, in the north to Pambula Lake on the south coast. Apart from Towra Point (already discussed above), he also sampled at Goodwin Island in Wallis Lake, Patonga Creek in the Hawkesbury River and Currambene Creek which flows into Jervis Bay. In general terms the dominant fauna at the equivalent zone (i.e. McCormick's Area 2) in the mangroves was similar at all locations. Of the gastropods *Assiminea tasmanica, Salinator solida* and *Ophicardelus* sp. were also common high in the mangrove zone. *Melosidula zonata* was present at all of the sites but in variable numbers. McCormick (1978) also found the tiny gastropod *Tatea rufilabris* at most sites, but its distribution was very patchy. This patchiness may account for its absence during our study.

The bivalve *Glauconome plankta* was common at most locations, including Towra Point (McCormick 1978), but was unaccountably rare during our study.

The four main crab species (*H. cordiformis, S. erythrodactyla, P. laevis* and *A. tridentata*) were present at all McCormick's (1978) sites, although their relative densities varied. In general, *H. cordiformis* and *S. erythrodactyla* were dominant, while the other two species were present in lower numbers. This results corresponds with the present study.

Due to inadequate sampling procedures, McCormick (1978) recorded few crabs during his seasonal study at Towra Point and unfortunately his more detailed study of crab fauna was not seasonal. However, a detailed temporal study of the crab population in Patonga Creek was conducted between 1974-1976 by Yates (1978), who found seasonal changes in their relative abundance. All species except *P. laevis*, were most abundant in the warmer months of the year. This corresponds with the results obtained for Towra Point.

Yates (1978) indicated that the changes in relative abundance of crab species at Patonga Creek corresponded with periods of greatest activity. He found that in most cases, crabs were more abundant during their breeding period. *S. erythrodactyla* breeds and is most abundant during the summer, whereas *P. laevis* breeds and is most abundant during the winter. There were insufficient numbers of *P. laevis* collected at Towra Point, however, the abundance data for *S. erythrodactyla* confirms Yates' (1978) suggestion. Yates (1978) found that *H. cordiformis* breeds throughout the year, but the lowest percentages of mature oocytes in the ovaries were present in summer, when relative abundance of crabs was greatest.

It would seem that for *H. cordiformis* the breeding season and the period of greatest activity are apparently unrelated, although in Tasmania the breeding season and the period of greatest activity for this species are both summer (Yates 1978).

Other New South Wales mangrove studies have provided distributional results comparable with Towra Point. Hutchings and Recher (1974) sampled an almost fully marine mangrove system at Careel Bay, Pittwater and provided a species list more extensive than ours. Many of the species collected by them, however, were from the front of the mangroves where the presence of seagrass affords an opportunity for more species to occur. At Brooklyn in the Hawkesbury River, the absence of seagrass beds and fluctuations in salinity have resulted in a reduced fauna compared with those mentioned above (Hutchings *et al.* 1977). Similarly, in the Myall River, Weate (1975) found fewer species in the mangrove system upstream as did Hutchings (1983) in the Fullerton Cove region of the Hunter River. In both of these studies it can be presumed that the wide salinity fluctuations recorded were an important factor responsible for this paucity. In all of the above examples, the dominant species were generally the same as those found during the present Towra Point survey.

(D) Saltmarsh site

The species number and number of individuals for Site 5 on each sampling occasion were shown in Table 5. Also shown are the numerically dominant species ranked in decreasing order, the total number of individuals of that species, and the percentage of the overall total of individuals in the community.

TABLE 5

Species number (S), number of individuals (N), total and relative abundance of the dominant species in the SALTMARSH HABITAT on each sampling occasion

	FEB 1981			MAY 1981			JULY 1981			OCT 1981			JAN 1982		
S	7			4			8			6			7		
N	162			251			104			147			244		
		%	N		%	N		%	N		%	N		%	N
	O. quoyi	65	106	*O. quoyi*	43	109	*O. quoyi*	57	59	*O. ornatus*	51	75	*O. ornatus*	67	163
	S. solida	19	30	*O. ornatus*	31	79	*S. solida*	27	28	*O. quoyi*	30	44	*O. quoyi*	12	29
	O. ornatus	11	18	*S. solida*	25	62	*O. ornatus*	10	10	*S. solida*	16	23	*S. solida*	9	21

The sample site was in a part of the saltmarsh zone that was often covered with seawater at high tide. The area was dominated by *Sarcocornia quinqueflora*. Other species present were *Sporobolus virginicus*, *Samolus repens*, *Suaeda australis* and *Juncus kraussii*, the latter two in very low densities.

As can be seen, three pulmonate gastropods dominated the fauna in the saltmarsh site during the course of this study. The numbers of *Ophicardelus quoyi* gradually diminished through the year and it was replaced as the dominant species by *O. ornatus*. *Salinator solida* remained fairly constant throughout the year. All other species were present occasionally in very low numbers.

The species list from the 1977 survey (ALS, 1978) is more extensive than the present study. However, no attempt was made during that study to explain the methods or extent of collecting. As both of these factors are important in determining species number, comparisons over time are difficult.

Although a qualitative review of Australian saltmarsh fauna exists (Saenger *et al.* 1977) only two other studies of saltmarsh areas on the New South Wales central coast, Careel Bay, Pittwater (Hutchings and Recher 1974) and Fullerton Cover, Hunter River (Hutchings 1983) are available to provide comparison. These indicated more extensive communities than the one described in this study. In both cases the pulmonate gastropods *Salinator solida* and *Ophicardelus* spp. dominated the fauna, but many other species were recorded as well.

Even allowing for differences in sampling methods, the relative absence of species at the Towra Point saltmarsh site in 1981/82 is worthy of note. The reasons for this paucity are, unfortunately, not apparent, although the considerable distance from the mangroves reducing the prospect of mangrove species straying into the area is likely to be a contributing factor.

GENERAL DISCUSSION

The four habitat types sampled displayed considerable differences in community structure. The seagrass beds had a community of consistently high diversity with a mix of gastropods, bivalves, worms and crustacea dominating. The sandbar had a much lower diversity, dominated entirely by worms. Some of these species were in common with the seagrass area. Crabs and gastropod molluscs were the dominant species in both mangrove swamps, while a few gastropod species dominated the saltmarsh.

Seasonal changes were apparent at all sites, these changes generally relating to the changes in abundance of particular species rather than an increase or decrease of species number.

Where such comparisons were possible, longer term changes in the benthic communities were assessed qualitatively. In general, both the seagrass and mangrove communities appeared to be similar in terms of species presence/absence, although there were changes in abundance. The saltmarsh area has relatively fewer species than before, although this phenomenon may be a result of sampling only one part of the saltmarsh zone during this study. If one is eventually to be able to distinguish natural fluctuations in community structure from those induced by man, it will be necessary to sample quantitatively over very long time periods.

The comparisons between the oiled and the unoiled mangrove sites suggest there is no difference between them that could be attributed to the oil spills. Allaway (1982) was able to indicate changes in the mangrove vegetation that could be attributed to recent spills. However, the site sampled for fauna was not subject to the dieback reported by him. It is possible that any subsequent changes in faunal community may be a delayed reaction to existing spills or a result of a gradual accumulation of small effects caused by a series of spills. This sort of information will only become apparent when long term monitoring is able to distinguish natural fluctuations from others.

We are only just beginning to understand the natural factors that control the structure of estuarine faunal communities. The importance of seagrasses in providing habitat diversity (Kikuchi 1980) and stabilising sediments (Orth 1977) enables a greater diversity of species to coexist than in unvegetated areas; although recent work, reviewed in Peterson (1979), has demonstrated the considerable importance of biological factors such as competition and predation in determining the structure of shallow water benthic communities. Similarly, envionmental parameters such as period of tidal inundation, salinity changes, shade and ground cover of vegetation, are thought to be the major controlling factors in mangrove and saltmarsh faunal communities, although recent work (Bell 1980) on saltmarshes has indicated the importance of species interaction in determining abundance.

The information on the production of seagrasses (SPCC, 1978), mangroves and saltmarshes (SPCC, 1979) and their influence on the Botany Bay estuary is limited, yet it is likely that they are important communities for preserving the quality of the estuary as well as providing habitat for many ecologically important benthic species. It is therefore necessary to ensure that the loss of these resources is minimised by careful management and monitoring.

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APPENDIX

Species collected from 5 sites* at Towra Point between February 1981 and January 1982.

*Seagrass– SG; Sandbar– S; Mangrove Creek mangroves– MC; Towra Bay mangroves– TM; Saltmarsh– SM.

Species	Site at which present				
	SG	S	MC	TM	SM
Phylum Cnidaria					
Edwardsia sp.	X				
Phylum Mollusca					
Class Bivalvia					
Anadara trapezia	X				
Tellina deltoidalis	X				
Ambuscintilla praemium	X				
Saccostrea commercialis				X	
Trichomya hirsuta				X	
Glauconome plankta			X	X	
Mactra pusilla		X			
Class Gastropoda					
Thalotia comtessei	X				
Austrocochlea constricta	X				
Bembicium auratum			X	X	
Nassarius burchardi	X				
Patelloida mimula				X	
Littorina scabra			X	X	
Pseudoliotia micans	X				
Bittium lacertinum	X				
Pyrazus ebeninus			X		
Ranella australasia		X			
Assiminea tasmanica			X	X	
Melosidula zonata			X	X	
Ophicardelus ornatus				X	X
Ophicardelus sulcatus			X		X
Ophicardelus quoyi			X		X
Salinator solida			X	X	X
Salinator fragilis					X
Onchidium sp.					X
Unknown slug		X			
Class Cephalopoda					
Squid species	X				
Phylum Annelida					
Class Polychaeta					
Paralepidonotus ampulliferaus	X				
Sigalion ovigerum		X			
Ceratonereis mirabilis n. sp.	X				
Ceratonereis	X				
Australonereis ehrlesi	X	X			
Naineris grubei australis	X				
Neanthes vaalii	X				
Lumbrineris latreilli	X	X			
Nephtys australiensis	X	X		X	
Nephtys longipes	X	X			
Marphysa sanguinea	X				
Notomastus torquatus	X				

Appendix (continued)

Species	Site at which present				
	SG	S	MC	TM	SM
Barantolla lepte	X	X			
Mediomastus californiensis	X				
Armandia intermedia	X				
Lysilla pacifica	X	X			
Scoloplos (Scoloplos) simplex	X				
Glycera americana	X	X			
Pista typha	X				
Rhinothelepus lobatus	X				
Owenia fusiformis	X				
Alustralospio trifida	X				
Spio pacifica		X			
Scolelepis towra		X			
Prionospio cirrifera	X				
Prionospio aucklandica	X				
Gyptis sp.		X			
Cirratulus sp.	X				
Cirriformia sp.	X				
Euchone sp.		X			
Branchiomma nigromaculata	X				
Class Hirudinea	X				
Phylum Nemertinea	X				
Phylum Arthropoda					
Class Crustacea					
Order Amphipoda					
Cymaduaa sp.	X				
Erichtonius sp.	X				
Birubius sp.	X	X			
Paralasmopus sp.	X				
Tozeuma sp.	X				
Maera sp.	X				
Corophium sp.				X	
Orchestia sp. 1					X
Orchestia sp. 2		X	X	X	
Isaeidae sp.	X				
Order Isopoda					
Sphaeromidae	X				
Eurydicidae		X			
Order Decapoda					
Latreutes sp.	X				
Alpheus euphrosyne richardsoni	X				
Callianassa arenosa	X				
Macrobrachium intermedium	X				
Metapenaeus macleayi		X			
Halicarcinus ovatus	X				
Amarinus laevis	X				
Pilumnopeus serratifrons	X				
Heloecius cordiformis			X	X	
Sesarma erythrodactyla			X	X	
Australoplax tridentata			X	X	
Paragrapsus laevis			X	X	X
Ilyograpsus paludicola	X				

Species	Site at which present				
	SG	IS	MC	TM	SM
Order Cirripedia					
Elminius modestus			X	X	
Balanus amphitrite			X		
Class Insecta					
Order Coleoptera					X
Order Orthoptera			X		X
Class Arachnida (Spider)					X
Class Chilopoda (Centipede)					X
Phylum Chordata					
Class Pisces					
Bathygobius kreftii	X				
Redigobius macrostoma	X				
Favonigobius exquisitus	X				
Favonigobius tamarensis	X