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CARBON FLUX THROUGH THE SOUTH WEST ARM POPULATIONS OF *CRASSOSTREA COMMERCIALIS AND TRICHOMYA HIRSUTA*

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INTRODUCTION

The construction of a successful ecosystems model is dependent upon the incorporation of all major components of that system. It is sometimes difficult however, to decide which components are really important. Initial work on South West Arm (SWA) of Port Hacking, for which the Ecosystems Group of the C.S.I.R.O. Division of Fisheries and Oceanography, has been attempting to construct a carbon based estuarine model, of hopefully general applicability (C.S.I.R.O., 1976) has thus far ignored the effect of the macro-invertebrate suspension feeders.

This report describes a study which attempts to partly rectify this omission by assessing the importance of two hard substrate bivalves; the Sydney rock oyster *Crassostrea commercialis* and the hairy mussel *Trichomya hirsuta*. These animals are very prominent members of the faunal component of SWA. They are found in distinct, easily discernible zones, *C. commercialis* forming an intertidal band and *T. hirsuta* a band immediately below. These bands are virtually continuous along the periphery of SWA and thus casual inspection leads to the conclusion that these two species may be of major importance to the Arm.

In order for any population data to be incorporated in the carbon model, the magnitudes of the major carbon fluxes of the population must be determined. For the purpose of this study it was assumed for these bivalves that, in comparison with feeding and biodeposition, all other carbon fluxes (e.g., excretion of soluble wastes) are negligible. Thus, by determining the magnitudes of these functions, the bivalves can be compared with other vehicles of carbon flux in the estuary, and their importance assessed. In order to determine values for feeding and biodeposition for the populations it was necessary to determine the total biomass of each species in SWA and to determine its feeding and biodeposition rates per unit weight.

MATERIALS AND METHODS

Biomass Estimation

For the purpose of this study, SWA was taken to be that area depicted in Fig. 1. The perimeter thus defined was measured from a chart (Scale : 1 inch = 300 ft.) and eight equally spaced sampling sites were selected *a priori*.

Sampling was conducted on 3-4 February 1976. At each sampling site a weighted shot line was laid out at right angles to the shore from the upper limit of the oyster zone. The line was carefully draped over the substrate in order to take surface irregularities into account. At 0 metres, the upper limit of the oyster zone, and then at intervals along the transect, a 0.25 m^2 square quadrat was placed over the centre of the shot line and all oysters and mussels occurring within the quadrat were removed, placed in labelled plastic bags and taken to the laboratory where they were deep-frozen for later inspection. It was necessary to employ SCUBA divers to remove the animals from the deeper quadrats. The intervals between the quadrats was generally 2 m but was sometimes larger where the total length of the transect exceeded 15 m (see appendices). For transect E, which was taken over mangrove flats, an interval of 10 m was employed.

On completion of the field programme, the frozen samples were thawed, the soft tissue was removed, rinsed in fresh water, patted dry and weighed. To determine the wet weight : dry weight relationships, five weighed samples of the oysters and five of the mussels were selected at random (table of random numbers),

dried to constant weight at 105°C and re-weighed. The ash-free weights were determined similarly by randomly selecting three of the dried oyster and mussel samples and ashing them for four hours in a muffle furnace at 500°C.

From the biomass values thus determined, the biomass of oysters and mussels per meter shore front, for each transect was determined by determining the midpoint between quadrats and assuming that the unsampled areas on either side of the midpoint shared the biomass of the closer quadrat. The biomass of the first and last quadrat was assumed to extend 1 m beyond the centre of the quadrats.

The total biomass for SWA was then calculated similarly by assuming that the biomass per meter of shore for each transect extended to the midpoint between it and the next transect. For transects A and H, their biomass was assumed to extend, on the oceanic side, to the mouth of SWA.

Feeding and Biodeposition Rates

The fundamental design of this experimental study was to maintain oysters and mussels in trays of flowing, natural sea water and to measure differences in the total particulate organic carbon (TPOC) entering and leaving the trays, in comparison with that of a control tray to determine a value for the actual feeding rates of the animals. Biodeposits in the animal trays were to be compared with those in the control tray due to settlement of suspended particles. It was intended that the experimental situation should approach the normal field conditions as closely as possible, especially with regard to food supply, temperature and salinity. The system (Fig. 2) is similar in various aspects to systems employed by Haven and Morales-Alamo (1970), Vahl (1972a) and Tenore and Dunstan (1973).

The experiments were carried out in the C.S.I.R.O. waterfront laboratory at Cronulla, N.S.W. during February and March 1976. Natural sea water was pumped from the jetty at Hungry Pt to a continually overflowing open air pool (volume approx. 1000 m^3). From the pool, water was pumped by a 0.5 h.p. 'Jabasco' electric pump into the laboratory. A 1 mm mesh sieve was placed over the inlet to prevent large particles entering the system. Within the laboratory the water first entered a constantly overflowing header tank from which the water flowed by gravity through the system. From the header the water entered a 2ℓ flask containing a magnetic stirrer which served to mix the suspended particles in the water. The water flow was then split into three and passed through flow meters and thence through three identical trays and then to an exit drain. The trays (Fig. 3) were made of plastic aged in sea water and were of 7ℓ volume. The animal chamber of the trays was 4.5ℓ volume. The flow rate through the trays was maintained at 300 ml/min in order to facilitate comparison with the study by Tenore and Dunstan (1973). Testing with fluorescein dye showed that the baffles in the trays ensured approximately laminar water flow. They also prevented mixing of water from the various chambers during the collection of water samples.

Four experimental trials were completed and, for each trial, fresh experimental animals were gathered from various locations and depths in SWA. Naturally occurring clumps and single animals were used in order to enable comparison with the biomass data. On returning to the laboratory, the animals were scrubbed to remove epifauna and then placed in the experimental trays. No specific number or weight of animals was employed. Instead, it was attempted to cover the bottom of the trays to a degree similar to that which the animals cover the substrate in their natural habitat. Less than two hours elapsed from collection to placement in the trays.

No acclimation period was employed because of the 'natural' conditions of the experimental system and because of the desire to test the animals in their field acclimatized state. Preliminary experiments indicated that the animals commenced feeding after one hour in the system and thus water sampling was commenced after two hours.

For each trial, 12 water samples were taken over 48 hours. For each sample approximately 600 ml of water was siphoned first from the outlet chamber of each tray and them from the inlet chamber. This procedure took about three minutes. Of the water thus collected, 500 ml of each was filtered through precombusted GF/C filters of effective pore diameter 1 µm according to the procedure described by Major *et al* (1972).

The filter pads were stored frozen until analysis. The carbon content of the entire filters was determined by combusting them and measuring the CO_2 evolved by infra-red spectrophotometry employing a modified "Total Carbon System" manufactured by Oceanography International Corp. (C.S.I.R.O. Divisional Report, in prep.). The accuracy of analyses is within $\pm$ 5% (P. Blomkamp, pers.comm.).

After the completion of each experimental trial, the deposits within the animal chambers of each tray were collected by suction, filtered and the carbon content determined as above.

RESULTS

Biomass Estimation

The raw data from the sampling programme are contained in the appendices. The calculated biomass of each transect and the total biomass hence calculated (as described above) for their adjoining zones are presented in Table 1.

On drying it was found that both oysters and mussels lost a mean 83.5% of their wet weight (standard deviations 1.35 and 2.52 respectively). Ashing, however, produced a subsequent weight loss of 77.4% (s.d. = 2.1) for oysters and 88.4% (s.d. = 2.0) for mussels. From these values, the total biomass of SWA is expressed in Table 2.

Feeding and Biodeposition Rates

With regard to temperature and salinity, the physical conditions of the experimental system remained fairly constant over the trials. Temperatures ranged from 22 to 26°C and salinities from 32.2 to 34.0‰. (No salinity measurements were made during Trial 1).

The carbon content of the water samples taken are given in Appendix II. From these values the percentage carbon removed from each tray at each sampling time was calculated (Table 3).

The carbon removal from the control tray was significantly greater than zero ($t = 7.15$, $df = 43$, $p<0.001$) and that from the oyster and mussel trays significantly greater than that from the control tray ($t = 9.14$, $df = 85$, $p<0.001$ for the oysters and $t = 7.81$, $df = 85$, $p<0.001$ for mussels). The t values were calculated from the formula

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\frac{Vx_1}{n_1} + \frac{Vx_2}{n_2}}$$

as n_1 and n_2 large and $n_1 \tilde{\sim} n_2$ (Croxton, 1953, p. 238).

Thus in order to calculate the feeding rates of the oysters and mussels, the control percentage carbon loss was subtracted from the experimental losses and the resultant values compared with the tissue masses of the experimental animals (Table 4). The resultant feeding rates are given in Table 5.

On grouping all results, the mean feeding rate for oysters was 3.88% C removed/g dry tissue weight (s.d. = 2.43) and for mussels, 1.28 (s.d. = 1.4). This difference is highly significant ($t = 6.31$, $df = 84$, $p < 0.001$). The 95% confidence limits of the means are $\pm$ 0.73 and $\pm$ 0.34 for oysters and mussels respectively. These carbon removal values were applied to the carbon content of the inflowing water (Table 6).

Again taking the mean of all values, the inlet water carbon content was 338 µgC/l. Since a flow rate of 300 ml/minute was employed, then an average of 146 mgC/day passed through each tray. From this value the following daily consumption rates were calculated:-

Oysters: 5.7 mgC/day/g dry weight soft tissue

Mussels: 1.9 mgC/day/g dry weight soft tissue

Since the carbon content of the inlet water was similar to that normally found in SWA (N. Bulleid, pers. comm.), the above consumption rates may be extrapolated to give values for SWA. It should be noted that, in the experimental system, both oysters and mussels were continually submerged. In the field however, only the mussels are continually submerged. The vast majority of the oyster population occurs intertidally and thus is exposed for approximately twelve hours each day. Thus for extrapolation to field data, the oyster consumption rate should be halved to give a value of 2.8 mgC/day/g dry wt soft tissue.

The biomass of oysters and mussels in SWA has been estimated (above) as 2.0 and 3.7 tonnes dry weight soft tissue, respectively. Applying these values to the feeding rates, total carbon consumption rates for SWA were calculated and are given in Table 7.

The carbon content of the deposits from the experimental trays are given in Appendix III. Biodeposition rates were calculated by subtracting the deposits in the control tray from those in the oyster and mussel trays (Table 8).

Applying the mean biodeposition rates to the biomass data the biodeposition for SWA can be calculated (Table 9). Again, the oyster rate is halved in order to account for aerial exposure in natural environment.

DISCUSSION

Due to topographical variation in SWA it is difficult to place confidence limits on the biomass data presented in Tables 1 and 2. However, a reasonable estimate may be obtained from the oyster data after a consideration of the biology of the two species and the geography of SWA.

Both *Crassostrea commercialis* and *Trichomya hirsuta* require hard substrates for successful larval settlement and subsequent growth and development. *C. commercialis* is virtually entirely intertidal in distribution. It can survive in deeper water, as was found in the sampling programme, but such occurrences are rare. Those oysters that were found subtidally were usually large and apparently healthy thus indicating that the selection probably occurs during the larval settlement stage of the life cycle. On the other hand, *T. hirsuta* is limited to subtidal water. It cannot seal its shell shut due to the gap for byssal attachment and thus it cannot prevent desiccation on aerial exposure. Its distribution extends from the beginning of the subtidal zone to a depth of approximately 3-4 m where ascidians and corals take over as the dominant hard substrate sessile macroinvertebrates. Within their zones, the oysters and mussels are by far the most

dominant species (at least in terms of biomass) and it can be stated that, in SWA, if a suitable substrate exists at an appropriate depth, then either mussels or oysters will be present. Accepting this premise, SWA can now be examined with regard to substrate variation.

South West Arm, as considered in this study, extends from a deep rock-banked basin downstream, to shallow mangrove flats upstream. Considering the mussel zone first, there is enormous subtidal substrate variation within SWA. For example, a very large biomass of mussels was found at transect H where large expanses of rock occurred below the oyster zone, while at transect E (on the mangrove flats) no mussels were found due to insufficient depth and lack of suitable substrate. Again, at transect D no mussels occurred because, although the depth was sufficient, the oyster zone terminated in anaerobic mud. Thus in no way can the mussel transects be regarded as replicates of each other.

For the oyster zone, however, a different picture is apparent. With the exception of the mangrove flats, virtually the entire intertidal perimeter of SWA consists of rock face suitable for oyster attachment. In the mangrove flats the oysters are found attached to the mangrove roots and in clumps on old shells, branches, etc. lying on the bottom. With the exception of the mangrove area virtually the entire perimeter of SWA can be regarded as comparable as an oyster habitat.

Thus, omitting transect E, the remaining seven transects can be regarded as replicates for oyster biomass. The mean of these values is 1146 g wet weight soft tissue/m shore front, and the 95% confidence limits of the mean are $\pm$ 36%. Assuming that the entire sampling programme shared the same accuracy, then the total biomass estimates should share the same confidence limits. A more accurate estimate of the total biomass could have been obtained by sampling a larger number of transects but the time spent would have become prohibitive as the processing time for each sample was 1-3 man/days. The biomass results may therefore be accepted as reasonably good estimates of the actual populations and can be applied with some confidence to the experimental data.

There have been very few studies reported in which the actual feeding rate of suspension feeding bivalves has been determined. Most studies of their feeding have been primarily concerned with either the efficiency of particle retention (e.g., Haven and Morales-Alamo, 1970; Vahl, 1972b), or with the measurement of water transport through the gills.

Water transport can be determined directly by measuring the volume of water that passes through the exhalent siphon, i.e. pumping rate (e.g. Bernard, 1974), or indirectly by measuring the rate of clearance of suspended particles from the medium on which the animals are feeding, i.e. filtration rate (e.g., Schulte, 1975; Walne, 1972). The early literature concerning these methods has been reviewed by Ali (1970). No matter which method is employed, however, difficulties arise if it is attempted to use the results to determine a normal field feeding rate. The pumping/filtration rate must be applied to ambient food levels of which the proportion retained by the filtration process is either unknown (e.g., Trevallion, 1971; McLusky and Stirling, 1975), or is calculated indirectly from other components of an energy budget (e.g., Bernard, 1974). Moreover, the results of many of the studies of filtration rate in experimental flowing systems are now in doubt due to the use of an incorrect formula for the calculation of filtration rate which does not take into account the dilution of inflowing water within the animal chamber (Hildreth and Crisp, 1976).

Tenore and Dunstan (1973) developed a flow through system in order to compare feeding and biodeposition of bivalves at different food levels. Their system enabled actual feeding rates (carbon consumption per unit weight) to be calculated. Their conclusions on the levels of food concentration affecting feeding rate are compromised by having ignored the dilution factor within the animal chambers, but their absolute feeding rates remain valid (Hildreth and Crisp, 1976). The experimental system used in this study was based on that of Tenore and Dunstan and was designed to produce results which could be compared with theirs. However, their main aim was to determine the effects of different food levels and thus they fed their animals on carefully monitored mixed algal cultures. The primary object of this study was to determine natural feeding rates and thus natural sea water was employed.

The results of the feeding rate experiments show large variation. Due to the thorough mixing applied to the incoming water, it had been expected that the inlet carbon values for all trays at each sampling time would have been similar. However, as can be seen from the raw data, large deviations occurred which were greater than could be accounted for by analytical variation. They are probably due to the use of natural sea water in which occasional large particles of high carbon content occur. Nevertheless, an obvious pattern is present of high inlet values, low outlet values for the oyster and mussel trays and intermediate values for the control outlet. As has been shown above, these differences were statistically significant.

The calculated feeding and biodeposition rates are compared with literature values in Table 10. The values employed from Tenore and Dunstan's study were taken from their graphical relationships of feeding and biodeposition rates versus food concentration, at the average level (340 µgC/l) used in this study. The biodeposition rates from Haven and Morales-Alamo were calculated from biodeposit dry weight data, assuming a carbon content of 5%. (Haven and Morales-Alamo found that mean carbon content for the bivalves varied from 4.4 to 6.1% of dry weight). The ranges shown for the biodeposition rates represent seasonal variation.

As can be seen from Table 10, the feeding and biodeposition rates determined in this study are low in comparison with the other cited values. They are of similar magnitude to those determined by Tenore and Dunstan (1973), but the biodeposition rates are considerably lower than those found by Haven and Morales-Alamo (1966). It should be noted that these studies derived greatly differing biodeposition rates for *Crassostrea virginica*, implying that the methodology may have been influential. It may be that the system employed by Tenore and Dunstan (and in this study) allowed some biodeposits to be lost. This is possible as, in this study, biodeposits were observed to be violently ejected and thus may not have settled before being carried over the baffles of the animal chamber.

The low rates determined in this study may have been a product of subnormal activity due, perhaps, to the lack of an acclimation period. It is difficult to subjectively assess how 'normally' a sessile bivalve is behaving. However, with regard to the mussels during field observation of feeding animals, it was noted that their shells gaped more widely and their siphons were further protruded than was the case with the experimental animals. No obvious difference was noted between the behaviour of field and experimental oysters.

A rough measure of the assimilation efficiency of the animals may be gauged the feeding and biodeposition rates:

$$\% \text{ Assimilation Efficiency} = \frac{\text{Feeding rate - Biodeposition rate}}{\text{Feeding rate}} \times \frac{100}{1}$$

It should be realized that the feeding rate is not a measure of food ingested, but of food retained by the gills. A proportion of this is ingested as pseudo-faeces before entering the alimentary tract. These pseudo-faeces and the faeces comprise the biodeposits. No account was taken of soluble excretory products. A variety of bivalve assimilation efficiences is presented in Table 11. Again the values from Tenore and Dunstan were calculated for the same food level as used in this study. It can be seen that, with the exception of the data of Bernard, the assimilation efficiences are very similar to those found by other workers on similar animals.

The extrapolation of the experimental rates to annual consumption values for SWA is somewhat questionable. Apart from the above discussed factors and the uncertainty of the biomass estimate, there is the lack of knowledge of seasonal variability, since all experiments were carried out in mid-summer. A considerable number of workers (e.g., Ali, 1970; McLusky, 1973; Schulte, 1975; Walne, 1972) has demonstrated that the filtration rate of bivalves is temperature-dependent. Further work determining feeding and biodeposition rates for the oysters and mussels during winter at least, would clearly be advantageous. Despite these deficiences, the extrapolation used is, the best available approximation and of considerable use.

Finally, the carbon fluxes determined for the oysters and mussels must be related to other known values in SWA. B. Scott (pers. comm.) has calculated the annual primary production of SWA as 147 tonnes particulate carbon per year. The carbon consumption of the oysters and mussels combined is approximately 3% of this value. Although this is not a high proportion, it should be remembered that the oysters and mussels comprise only one part of the sessile suspension feeding community. The sponges, ascidians, etc., may also remove a similar proportion. It can be compared with 25-30% for the grazing component of the zooplankton of SWA (Griffiths, Caperon and Smith, in press).

It is doubtful whether the figure of 3% can be regarded as typical for estuaries. Assuming that primary productivity is roughly proportional to volume, and that sessile suspension feeder biomass is proportional to suitable substrate, it is clear that, given equally suitable substrates, a shallow gently-banked estuary would exhibit a higher suspension feeder consumption to primary production ratio than for a deep steep-sided estuary. South West Arm is closer to the latter of these types and thus the consumption: production ratio should only be generalized to topographically similar estuaries.

SUMMARY

A study was made to determine the carbon flux through the SWA populations of the oyster *Crassostrea commercialis* and the mussel *Trichomya hirsuta*. From sampling eight transects around the perimeter of SWA, the total biomass of oysters and mussels was estimated at 2.0 and 3.7 tonnes dry weight of soft tissue respectively. Feeding and biodeposition rates were experimentally determined in a flow through system by monitoring the carbon content of the inlet and outlet water, and by collecting biodeposits. These rates were applied to the biomass estimates and it was calculated that the oysters and mussels together annually remove 4-6 tonnes of carbon from the waters of SWA and deposit 1.0 tonnes into the sediments.

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Table 1. Wet weight soft tissue of oysters and mussels from eight transects and their adjoining zones in South West Arm.

	Wet weight soft tissue			
	Grams per metre shore front at transect		Kilograms per transect	
Transect	Oysters	Mussels	Oysters	Mussels
A	610	1069	321	562
B	748	97	650	84
C	933	2583	810	2244
D	1093	0	949	0
E	5332	0	4632	0
F	1559	1112	1355	965
G	1215	6830	1055	5934
H	1862	9579	2427	12481
TOTAL			12198	22270

Table 2. Total biomass estimates for the South West Arm populations of the oyster *Crassostrea commercialis* and the mussel *Trichomya hirsuta*.

Biomass units	Biomass (tonnes)	
	Oysters	Mussels
Wet weight soft tissue	12.2	22.3
Dry weight soft tissue	2.0	3.7
Ash-free dry weight soft tissue	1.5	3.3

Table 3. Percentage carbon removed from oyster, mussel and control trays.

$$\%C = (100 - \frac{[\text{Outlet}] \times 100}{[\text{Inlet}]}$$

Trial			Sample 1	2	3	4	5	6	7	8	9	10	11	12
		O	51	49	64	66	76	52	-18	38	59	-	-	71
	1	M	15	18	55	51	11	71	83	29	11	-	-	69
		C	18	-43	28	60	32	38	18	40	7	-	-	31
		O	42	56	57	17	34	52	55	-	44	35	55	50
	2	M	52	23	47	55	73	62	56	-	44	35	51	53
		C	18	10	-4	15	31	8	-2	-	5	8	31	6
		O	36	71	64	80	61	51	74	71	57	37	39	71
	3	M	-	39	28	63	41	55	73	12	66	44	36	62
		C	3	14	16	28	20	29	20	25	31	5	9	30
		O	55	70	49	65	-	51	-	45	75	63	49	81
	4	M	79	66	69	49	40	58	-	68	45	54	73	62
		C	24	14	13	12	26	52	-	34	33	-5	0	48

Table 4. Masses of oysters and mussels employed in experimental trials

Trial	Dry weight (g) Oysters	Soft tissue (g) Mussels
1	9.6	15.5
2	8.3	28.4
3	9.1	29.1
4	9.4	22.5

Table 5. Feeding rates of oysters and mussels (% carbon removed/g dry tissue weight).

		Trial 1		2		3		4	
		O	M	O	M	O	M	O	M
Sample	1	3.44	-0.19	2.89	1.20	3.63	-	3.30	2.44
	2	9.58	3.94	5.54	0.46	6.26	0.86	5.96	2.31
	3	3.75	1.74	7.35	1.80	5.27	0.41	3.83	2.49
	4	0.63	-0.58	0.24	1.41	5.71	1.20	5.64	1.64
	5	4.58	-1.35	0.36	1.48	4.51	0.72	-	0.62
	6	1.46	2.13	5.30	1.90	2.42	0.89	-0.11	0.27
	7	-3.75	4.19	6.87	2.04	5.93	1.82	-	-
	8	-0.21	-0.71	-	-	5.05	-0.45	1.17	1.51
	9	5.42	0.26	4.70	1.37	2.86	1.20	4.47	0.53
	10	-	-	3.25	0.95	3.52	1.34	7.23	2.62
	11	-	-	2.89	0.70	3.30	0.93	5.21	3.24
	12	4.17	2.45	5.30	1.65	4.51	1.10	3.51	0.62
Mean		2.91	1.19	4.06	1.36	4.41	0.91	4.02	1.66
Standard Deviation		3.61	1.98	2.37	0.50	1.27	0.58	2.22	1.03

Table 6. Carbon content of inlet waters of experimental systems (µgC/l)

Trial	Mean	Standard Deviation
1	212	86
2	336	96
3	400	138
4	400	124

Table 7. Carbon consumption for the South West Arm populations of the oyster *Crassostrea commercialis* and the mussel *Trichomya hirsuta*.

	Daily (g)	Annual (tonnes)
C. commercialis	5,600	2.0
T. hirsuta	7,000	2.6

Table 8. Biodeposition rates of oysters and mussels for each trial.

Trial	Biodeposition (mgC/day/g dry wt soft tissue)	
	Oysters	Mussels
1	-	0.66
2	1.95	0.44
3	0.66	0.31
4	0.98	0.50
Mean	1.20	0.48

Table 9. Carbon biodeposited by the South West Arm populations of *Crassostrea commercialis* and *Trichomya hirsuta*.

	Daily (g)	Annual (tonnes)
C. commercialis	1,200	0.4
T. hirsuta	1,780	0.6

Table 10. Experimental feeding and biodeposition rates for various bivalves.

(mgC/g dry tissue/day)

Species	Feeding rate	Biodeposition rate	Source
Crassostrea commercialis	5.7	1.2	This study
Trichomya hirsuta	1.9	0.5	This study
Mercenaria mercenaria	7.5	1.5	Tenore and Dunstan (1973)
Mytilus edulis	11.5	2.5	Tenore and Dunstan (1973)
Crassostrea virginica	10.0	1.0	Tenore and Dunstan (1973)
Crassostrea virginica	-	6.4-14.3	Haven and Morales-Alamo (1966)
Mya arenaria		0.7- 1.4	Haven and Morales-Alamo (1966)
Modiolus demissus		8.6-10.7	Haven and Morales-Alamo (1966)

Table 11. Percentage assimilation efficiencies of various bivalves

Species	% Assimilation Efficiency	Source
Crassostrea commercialis	79	This study
Trichomya hirsuta	74	This study
Crassostrea virginica	90	Tenore and Dunstan (1973)
Mercenaria mercenaria	80	Tenore and Dunstan (1973)
Mytilus edulis	78	Tenore and Dunstan (1973)
Patinopecten yessoensis (1 yr old)	79*	Fuji and Hashizume (1974)
Patinopecten yessoensis (2 yr old)	65*	Fuji and Hashizume (1974)
Patinopecten yessoensis (3 yr old)	68*	Fuji and Hashizume (1974)
Crassostrea gigas	36*	Bernard (1974)

(* = derived from energy budgets)

APPENDIX I

Raw data from biomass survey

		Wet weight soft tissue of oysters and mussels per 0.25 m^2 quadrat (g)															
Transect		A		B		C		D		E		F		G		H	
Species		O	M	O	M	O	M	O	M	O	M	O	M	O	M	O	M
Distance from shore (m)	0	30.2	0	15.2	0	38.2	0	10.9	0	0	0	90.2	0	67.6	0	50.3	0
	2	24.8	0	9.2	0	21.1	0	48.7	0	-	-	0	0	32.3	0.5	28.6	0
	4	0	0	46.8	12.1	21.0	0	56.2	0	-	-	7.3	25.2	28.5	51.8	47.9	0
	6	9.1	0	22.3	0	20.4	14.5	20.8	0	-	-	79.5	109.9	-	-	4.7	0
	8	12.1	133.6	0	0	13.7	0	0	0	-	-	17.9	3.9	0	361.5	1.2	0
	10	0	0	-	-	0	0	-	-	6.0	0	0	0	-	-	33.4	27.2
	12	-	-	-	-	-	-	-	-	-	-	-	-	3.9	9.7	-	-
	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19.8	19.5
	14	-	-	-	-	1.1	97.5	-	-	-	-	-	-	-	-	-	-
	16	-	-	-	-	0	56.7	-	-	-	-	-	-	0.7	0	8.4	600.4
	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	20	-	-	-	-	0	0	-	-	6.9	0	-	-	0	16.6	6.9	41.7
	30	-	-	-	-	-	-	-	-	13.8	0	-	-	-	-	-	-
	40	-	-	-	-	-	-	-	-	106.6	0	-	-	-	-	-	-

APPENDIX II

P.O.C. values (µg/500 ml) determined for oyster, mussel and control inlet and outlet water from experimental system

Trial		Sample No. 1	2	3	4	5	6	7	8	9	10	11	12
1	Inlet O	189	110	159	136	192	81	40	73	90	163	-	58
	Inlet M	82	76	83	127	110	75	184	56	74	120	-	81
	Inlet C	136	107	99	161	154	102	49	118	98	132	38	52
	Outlet O	92	56	57	46	46	39	47	45	37	110	14	17
	Outlet M	70	62	37	62	94	22	32	40	66	91	23	25
	Outlet C	112	153	71	64	105	63	41	47	91	-	51	36
2	Inlet O	190	192	120	180	160	174	214	178	196	94	110	113
	Inlet M	145	102	106	202	230	203	216	-	215	100	110	109
	Inlet C	197	178	96	186	269	209	228	219	222	138	150	143
	Outlet O	110	84	52	150	106	83	96	112	110	61	50	56
	Outlet M	69	79	56	91	62	77	95	150	120	65	54	51
	Outlet C	162	160	100	158	185	143	233	-	212	96	104	134
3	Inlet O	202	251	179	302	130	134	173	190	190	100	169	76
	Inlet M	-	197	142	160	141	177	270	193	276	147	199	110
	Inlet C	286	331	258	235	148	212	230	287	374	194	227	107
	Outlet O	130	72	64	60	51	66	45	55	81	63	103	22
	Outlet M	127	121	102	60	83	80	73	169	94	82	127	42
	Outlet C	278	285	216	170	118	150	185	215	258	185	207	75
4	Inlet O	198	206	192	162	-	96	127	207	169	126	113	197
	Inlet M	356	223	214	185	158	147	125	356	171	158	222	199
	Inlet C	273	287	240	227	166	174	210	315	211	154	190	231
	Outlet O	90	61	47	57	46	47	125	114	42	46	58	37
	Outlet M	75	76	67	94	95	62	133	115	94	73	60	76
	Outlet C	207	247	209	200	123	84	-	207	142	161	190	121

APPENDIX III

Carbon collected from experimental trays after two days (mg)

		Oysters	Mussels	Control
Trial	1	-	26.36	5.91
	2	38.69	31.45	6.25
	3	18.75	24.89	6.66
	4	34.75	39.00	16.28

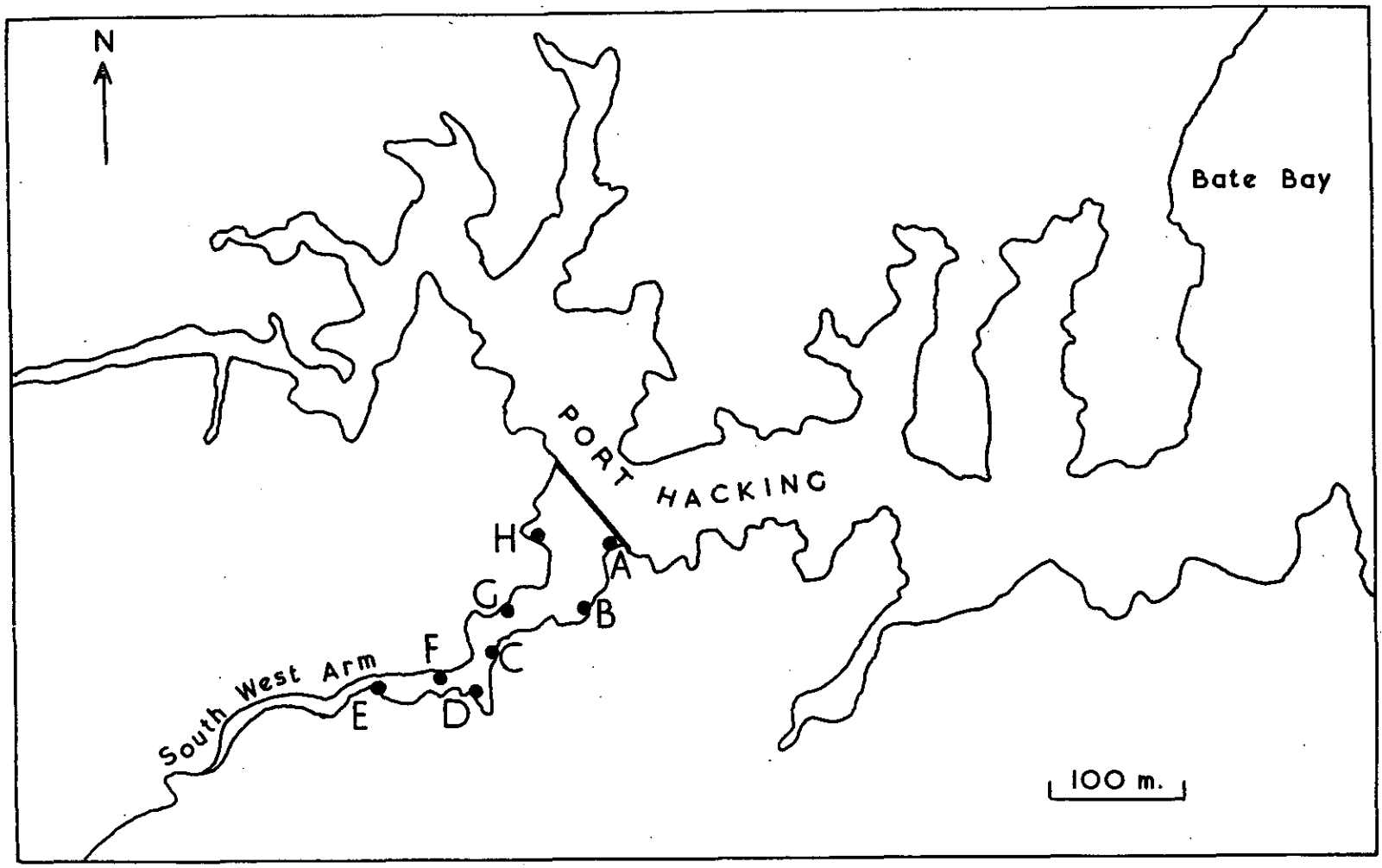

Fig. 1. Port Hacking and South West Arm indicating location of transects. The limits of South West Arm as considered in this study are shown with a solid black line.

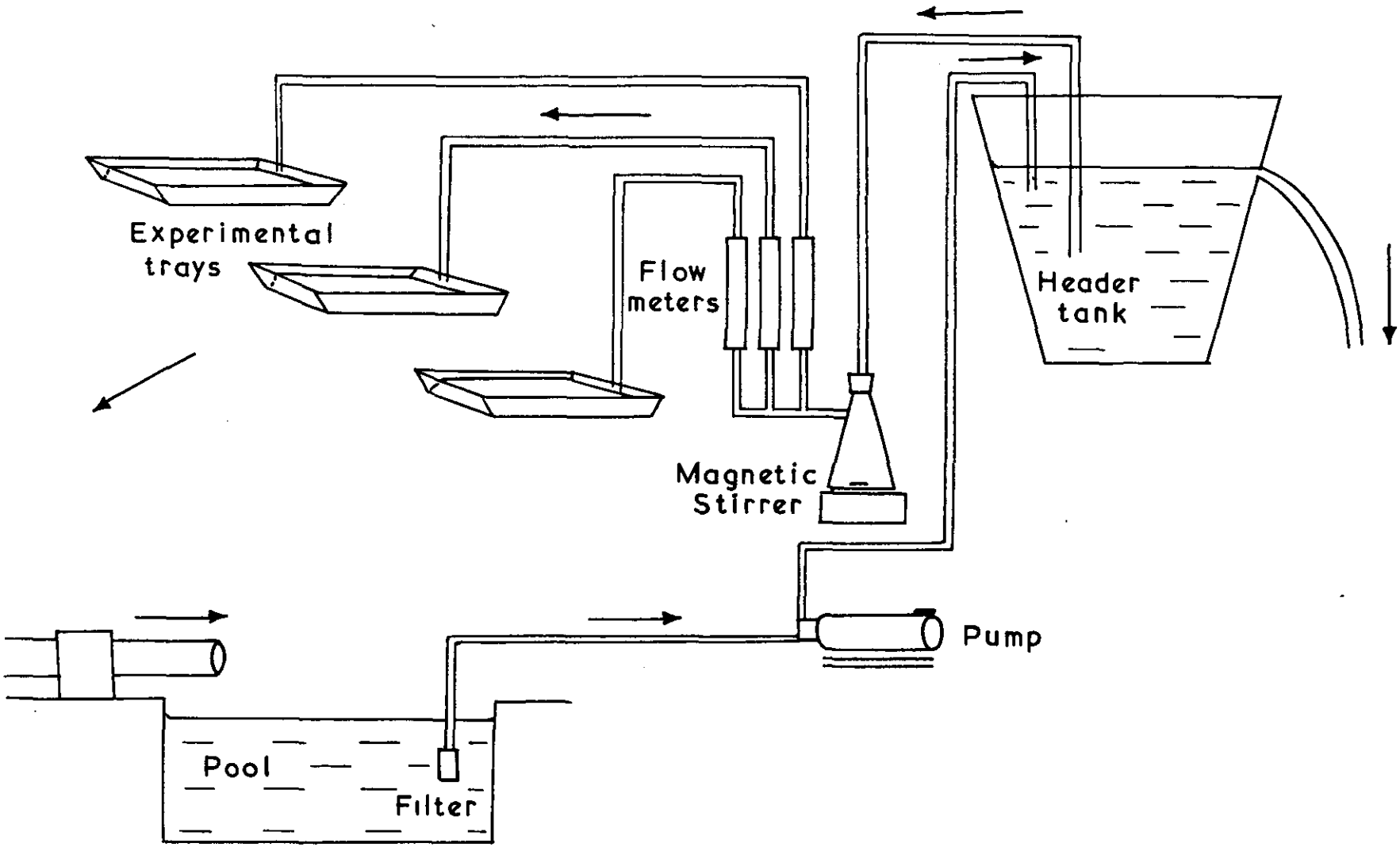

Fig. 2. Flow diagram of experimental system arrowheads indicate direction of water flow.

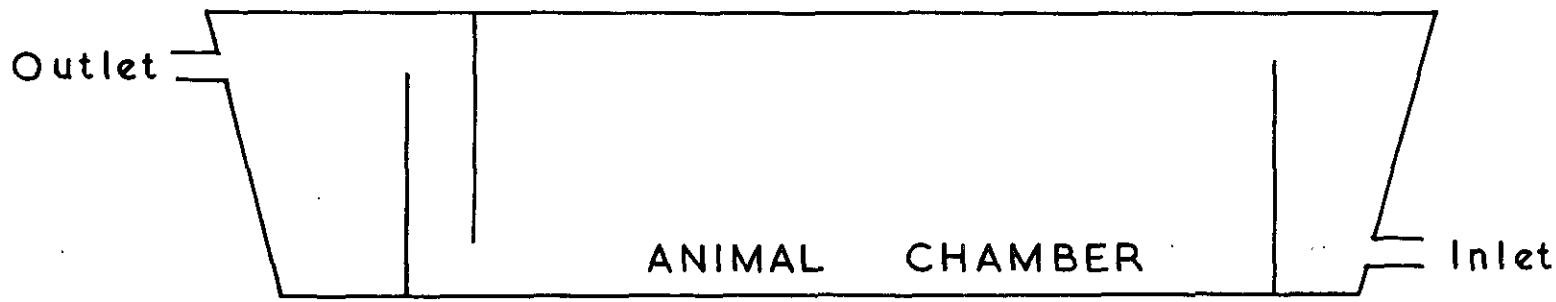

Fig. 3. Gross-section of experimental trays showing baffle arrangement and direction of water flow.