Annual and spatial variation in the *Abra* community in Liverpool bay

Benthos
Muddy-sand
Variation
Monitoring
Liverpool Bay

Benthos
Vase
Variation
Baie de Liverpool

E. Ivor S. Rees, Anthony J. M. Walker
Marine Science Laboratories, University College of North Wales, Menai Bridge, Gwynedd LL59 5EH

ABSTRACT

Based on 12 years of sampling in Liverpool Bay a number of spatial and temporal variants of the *Abra* community can be recognised : *a*) species poor localities that are consistently dominated by *Pectinaria koreni* or *Abra alba*; *b*) unstable fluid muds with ephemeral recruitments of *Pectinaria*; *c*) species rich localities with a range of alternative dominants; *d*) heterogeneous offshore localities that are temporarily colonised by *Abra* community species. General colonisation events occurred in 1972 and 1978 which may be synchronised with events elsewhere in the North Sea.

Oceanol. Acta, **1983.** Proceedings 17th European Marine Biology Symposium, Brest, France, 27 September-1 October, 1982, 165-169.

RÉSUMÉ

Variations spatio-temporelles chez l'espèce *Abra* dans la baie de Liverpool

En se basant sur 12 années de prélèvements dans la baie de Liverpool, il est possible de reconnaître chez l'espèce *Abra* un certain nombre de variantes spatio-temporelles : *a*) des zones pauvres à espèces toujours dominées par *Pectinaria koreni* ou *Abra alba*; *b*) des vases fluides et instables à recrutements éphémères de *Pectinaria*; *c*) des zones riches en espèces avec un éventail d'espèces dominantes; *d*) des zones hétérogènes au large, qui sont temporairement colonisées par les espèces du peuplement à *Abra*. Des vagues cycliques de colonisation généralisée ont été observées en 1972 et 1978, apparemment synchronisées avec des événements survenus ailleurs en Mer du Nord.

Oceanol. Acta, **1983.** Actes 17^e Symposium Européen de Biologie Marine, Brest, 27 septembre-1^er octobre 1982, 165-169.

INTRODUCTION

Benthic communities of the shallow water muddy sand or *Abra* type, occurring in the turbid waters of shallow bays and outer estuaries, are inherently variable. Patch size, shape and location can vary along with gross changes in the abundance of the dominant species (Eagle, 1975). In Liverpool Bay the muddy sand patches are relatively small and occur around the margin of the bay wherever the form of the sand banks or headlands reduces tidal current or wave effects, but many *Abra* community species also occur at lower densities on the heterogeneous sediments offshore.

Arising from proposals to increase the rate of sewage sludge dumping, a broad scale survey in 1970 (Rees *et al.*, 1972) has been followed by repeated annual sampling of selected stations over a period when the dumping rate has risen from 40×10^3 dry tonnes to 70×10^3 dry tonnes. The dumping ground is of the dispersing type and is located on heterogeneous ground, so concentric zones of enrichment have not been detected. The annual sampling has had to be widespread, so providing data on general fluctuations in abundance. Over the same time span the muddy sand patch in Red Wharf Bay, 60 km to the west, has also been sampled on sufficient occasions for comparisons to be made between the fluctuations there and those at sites nearer the Mersey and the dumping ground.

MATERIAL AND METHODS

With the exception of 1971 and 1976, a monitoring cruise was made to Liverpool Bay each year from 1970 to 1982 on dates between early September and early

October. At 18-25 stations grabs of the Smith, McIntyre and Day types taking 0.1 m^2 were used sufficient times to get three adequate samples, of which the two with most sediment were screened on a 1 mm mesh nylon sieve. In Red Wharf Bay attention has mainly been focused on one site at the eastern end of the bay where annually up to thirty replicates have been taken from an anchored ship. Positions have been fixed by Decca Navigator.

POPULATION VARIATION IN THE WHOLE BAY

Since the sediment type at any one station is apt to vary from time to time and since the number of samples in any one patch was relatively small, a better impression of population variations is obtained by examining the data from the bay as a whole. The proportion of the grabs, treated singly, in which a species occurs at various levels of abundance, gives a measure of its success in that year. Frequency distribution plots of × 2 geometric abundance classes (Fig.) show that when a species such as *Pectinaria koreni* was abundant it was picked up at moderate abundance levels across the sub-optimal habitats as well as being in great abundance in the muddy sand patches.

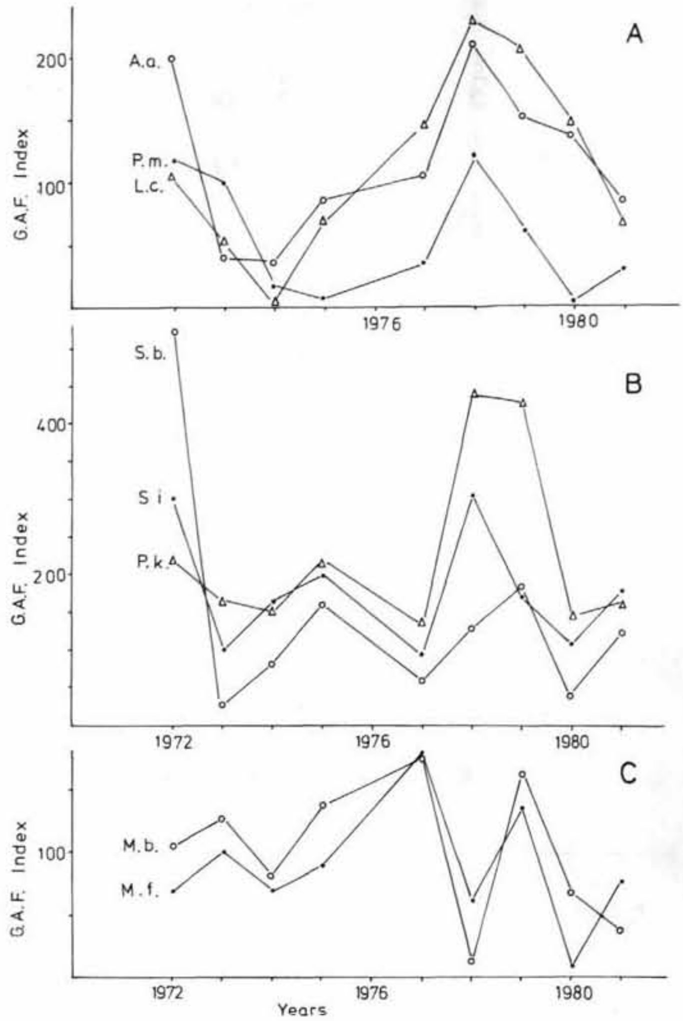
The geometric frequency approach can be extended to give a single weighted index figure for each year by taking the sum of the percentage frequencies in each class multiplied by their geometric class notations as in the following example :

Geometric abundance frequency index (G.A.F.)

× 2 geometric class	% frequency of grabs	Weighted values
0 (0)	50	0
I (1)	35	35
II (2-3)	10	20
III (4-7)	3	9
IV (8-15)	2	8
		G.A.F. index 72

The G.A.F. index for some species such as *Lumbrineris gracilis* and *Nephthys hombergi* varies little and they could be classed as conservative, using the terminology of Buchanan *et al.* (1974). Many others are more volatile but seem to exhibit considerable synchrony in the timing of their fluctuations. This is particularly so for *Abra alba* and *Lanice conchilega* [Fig. (*A*)]. Although the peak concentrations were not at the same stations the timing was similar. There were also similarities in the timing of the variations in *Pectinaria koreni*, *Scalibregma inflatum* and *Spiophanes bombyx* [Fig. (*B*)]. These species, together with *Abra alba*, *Lanice conchilega* and *Phoronis mulleri*, all tended to peak in 1972 and in 1978-1979. *Mysella bidentata* and *Mediomastus fragilis* [Fig. (*C*)] have closely similar patterns of variation but are out of synchrony with the others.

Variation at the Red Wharf Bay site was similarly large in spite of the much greater species richness. *Spiophanes bombyx* was particularly abundant in January 1973 thus fitting in with the extremely high numbers encountered in Liverpool Bay in autumn 1972 (which fell to a minimum in autumn 1973). The highest count of *Pectinaria koreni* (3 177 m^2) was in 1978. *Abra alba* was high in January 1973, 1978 and 1979. *Mysella bidentata* was particularly abundant in Red Wharf Bay in 1979. This supports other indications that the year to year variations may be similar along a lot of the coast of the eastern Irish Sea.



Figure

Geometric abundance frequency (G.A.F.) index variation 1972-1981. A) Abra alba. Phoronis mulleri *and* Lanice conchilega; B) Spiophanes bombyx. Scalibregma inflatum *and* Pectinaria koreni; C) Mysella bidentata *and* Mediomastus fragilis.

There are also indications that variations in the Irish Sea may parallel those seen in the North Sea. *Spiophanes bombyx* was the numerical dominant at a muddy sand station off Northumberland in 1972 and did not appear in the top five ranking in any other year in the 1972-1976 period (Buchanan *et al.*, 1978). They also had *Chaetozone setosa* in rank two in the same years as it was most abundant in Liverpool Bay. The fluctuations in the abundance of *Phoronis mulleri* in Liverpool Bay seem to have been in phase with the fluctuations in the German Bight (Rachor, Gerlach, 1978), but off Northumberland the peak was in 1974 when it was low in the German Bight and Liverpool Bay. In general there are many similarities with the patterns of fluctuation shown in the German Bight by Ziegelmeier (1978) and Rachor and Gerlach (1978).

Long term records of the fluctuations in abundance of *Pontopereia affinis* in the Baltic (Lassig, Lahdes, 1980) clearly indicate oscillations on a 6-7 year period. Ziegelmeier (1978) also showed that there were signs of a 6 year period in the oscillations of *Spiophanes bombyx* in the German Bight. The two main peaks seen so far in Liverpool Bay have been 6 years apart.

The widespread nature of the major recruitment events suggests that global instability is more important than neighbourhood instability in this context. The 1972 recruitment of spionids in Liverpool Bay seems to have been a reflection of much wider events that took place in European seas at that time. It coincided with a general climatic reversal in the North Atlantic (Dickson *et al.*, 1975). In Liverpool Bay a marked bloom of *Gyrodinium aureolum* in autumn 1971, which caused mortalities of benthic invertebrates (Helm *et al.*, 1974), may have opened the communities. However, as far as is known, such blooms were not recorded in the North Sea that year. No changes in species abundances could definitely be ascribed to drastic variation in sediments or hydrodynamic conditions in the bay.

VARIATION IN PARTICULAR PATCHES

Tables 1 and 2 show the top ranked species for each year at a station near the Mersey Bar and at a station in the Burbo Bight. In some years only 3 or 4 species were common enough to be included. In spite of being dominated by short lived species and being in situations where winter storm disturbance is likely to be frequent (Rees *et al.*, 1977), the dominant fauna was remarkably consistent from year to year. With the exception of one year at each station they have consistently been dominated by either *Pectinaria koreni* or *Abra alba*. During 10 years, only 5 species have appeared in the first two ranks at the Mersey Bar station and in the Burbo Bight only 4 species occupied these positions over 8 years. By contrast, at the Red Wharf Bay site (Table 2) the rank 1 and 2 positions have been occupied by 9 different species in 6 sampling years. Only the amphipods *Ampelisca brevicornis*, *A. tenuicornis* and *Photis longicaudata* were dominant for more than one year.

Dominance of soft bottoms by *Ampelisca* is unusual in European waters. Estimated densities rose from about $40/m^2$ in May 1980, to $800/m^2$ in July to over $2\,000/m^2$ by December, apparently remaining high through 1981, over $3\,000/m^2$ being present in November 1981. By the spring of 1982 the *Ampelisca* population had declined to less than $150/m^2$. At such high densities the amphipod tubes may have had an influence on sediment stability.

Although Red Wharf Bay is, by the standards of inshore waters, quite species-rich, the high numbers of the erratic dominants result in Shannon-Wiener diversity values that are quite low (typically about 2.5). The other sites have even lower diversity values (0.8-2.0).

In the years when particular species that are characteristic of the inshore muddy sands are highly abundant

Table 1

The five top ranked species for each year at a Mersey Bar station (upper figures) and at a Burbo Bight station (lower figures). In some years only 3 or 4 species were moderately abundant.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Pectinaria koreni	— 4	— 1	— 2	1 1	1 —	2 —	1 —	3 —	1 —	2 1	— 1	1 1
Abra alba	— 2	— 4	1 1	— 4	3 —	— —	3 —	1 —	2 2	1 2	1 2	2 2
Nephthys hombergi	— 3	— 2	— 4	5 —	5 —	3 —	4 —	5 —	3 3	4 3	2 3	3 3
Mysella bidentata	— —	— —	4 —	4 3	2 —	1 —	2 —	2 —	— 5	— —	4 —	— —
Owenia fusiformis	— —	— 3	— 5	— —	— —	— —	— —	— —	— 4	— —	— —	— —
Spisula subtruncata	— —	— —	5 —	3 —	4 —	— —	— —	— —	— —	5 —	3 —	— —
Pholoe minuta	— —	— —	— —	— —	— —	— —	— —	4 —	— —	— —	— —	5 —
Scalibregma inflatum	— —	— —	2 —	— —	— —	— —	— —	— —	— —	— —	— —	— —
Phyllodoce maculata	— —	— —	— —	2 —	— —	— —	— —	— —	— —	— —	— —	— —
Eumida sanguinea	— —	— —	3 —	— —	— —	— —	— —	— —	— —	— —	— —	— —
Eteone longa	— —	— —	— —	— —	— —	— —	— —	— —	— —	3 —	— —	— —
Ophiura spp. (juvs.)	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	4 —
Capitella capitata	— 1	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —
Mediomastus fragilis	— —	— —	— —	— 2	— —	— —	— —	— —	— —	— —	— —	— —
Oligochaete		— —	— 3	— —	— —	— —	— —	— —	— —	— —	— —	—

Table 2

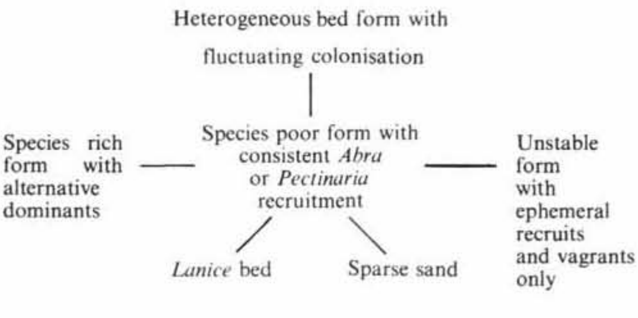
The five top ranked species for each year at the Red Wharf Bay station.

	1973	1977	1978	1979	1980	1981
Pectinaria koreni	4	—	1	4	—	—
Abra alba	3	—	—	3	—	—
Nephthys hombergi	5	3	3	—	—	—
Mysella bidentata	—	—	—	1	4	—
Ampelisca spp.	—	5	—	—	1	1
Photis longicaudata	—	—	—	—	2	2
Lanice conchilega	1	—	—	2	—	—
Nucula turgida	—	4	2	—	—	4
Notomastus latericeus	—	1	—	—	—	5
Scoloplos armiger	—	—	—	5	3	3
Spiophanes bombyx	2	—	—	—	—	—
Spisula subtruncata	—	2	—	—	—	—
Phyllodoce mucosa	—	—	4	—	—	—
Owenia fusiformis	—	—	5	—	—	—
Acrocnida brachiata	—	—	—	—	5	—

they tend to spread out over the heterogeneous sediments offshore. These changes influence the position of stations in reciprocal average ordinations (Hill, 1973). In Liverpool Bay the axis I trend is from the densely populated but low diversity muddy sand patches to the more sparsely populated but diverse heterogeneous areas in deeper water. In the years when *Pectinaria* was particularly abundant the ordination positions of the stations moved towards the inshore end of the axis. It was noticeable that the stations that moved most on axis I were those close to the apex of the dumping ground. At the same time the abnormal abundance of *Pectinaria* also reduced the Shannon-Wiener diversities at the dumping ground from values of about 4.5 that are typical of the offshore grounds to about 3.0. When the *Pectinaria* declined, diversities went back up to about the former levels.

CONCLUSIONS

The variants of the *Abra* community differ in their occurrence in both space and time according mainly to the balance that is struck between the rate of accumulation of organically rich fine sediment and the frequency of disturbance. Diagrammatically this may be summed up :



The basic form of the community occurs where the input of fines is fairly high but the frequency of instability generated both by meteorological events and the activity of the dominants prevents diversification of the fauna. Where the rate of accumulation of fines is so high that unstable fluid muds form then samples may contain very high numbers of *Pectinaria* recruits or nothing but a few erratic vagrants depending on recent events. In the more stable situation exemplified by Red Wharf Bay, *Pectinaria* and *Abra* may be replaced as the dominants by a wide range of other species. Patchy recruitments of tube-building species and bivalves such as *Spisula subtruncata* adds to the range of complexity. Even though large fluctuations occur in the populations of the dominants, the community is structured and longer-lived species persist at moderate levels of abundance. Thistle (1981) suggested theoretically that examples should occur of species being maintained as dominants by frequent disturbance but being displaced in more stable conditions. The present data conforms to that model.

There can be a variable interface with the sparsely inhabited mobile sands or dense sublittoral *Lanice* beds. Variation in the amounts of organic fines retained in heterogeneous sediments intermittently allows components of the *Abra* community to spread offshore. Even in situations where dumped material disperses fairly rapidly the dumping may enhance the opportunities for offshore colonisation by *Abra* community species. However, this may be balanced by increased bioturbation of the sediment, exposing the fines to winnowing. In such situations the influence of dumping may manifest itself as amplification of population variations that are fundamentally engendered by remote events in the marine climate.

Acknowledgements

We are grateful to the Water Directorate of the Department of the Environment for their continued support of the Liverpool Bay sampling. Thanks are also due to the many colleagues who in various years have assisted us at sea and in the processing of samples, notably, A. R. Ward, R. A. Eagle and P. L. Allen.

REFERENCES

Buchanan J. B., Kingston P. F., Sheader M., 1974. Long-term population trends of the benthic macrofauna in the offshore mud of the Northumberland coast, *J. Mar. Biol. Assoc. UK*, **54**, 785-795.

Buchanan J. B., Sheader M., Kingston P. G., 1978. Sources of variability in the benthic macrofauna of the south Northumberland coast, 1971-1976. *J. Mar. Biol. Assoc. UK*, **58**, 191-209.

Dickson R. R., Lamb H. H., Malmberg S. A., Colebrook J. M., 1975. Climatic reversal in the northern North Atlantic, *Nature, London*, **256**, 479-482.

Eagle R. A., 1975. Natural fluctuations in a soft bottom community. *J. Mar. Biol. Assoc. UK*, **55**, 865-878.

Helm M. M., Hepper B. T., Spencer B. T., Walne P. R., 1974. Lugworm mortalities and a bloom of *Gyrodinium aureolum* Hulbert in the Eastern Irish Sea, Autumn 1971, *J. Mar. Biol. Assoc. UK*, **54**, 857-869.

Hill M. O., 1973. Reciprocal averaging. An eigenvector method of ordination, *J. Ecol.*, **61**, 237-249.

Lassig J., Lahdes E., 1980. Biological monitoring effects studies in the Baltic Sea : a review of activities carried out in Finland, in : *Biological effects of marine pollution and the problems of monitoring*, edited by A. D. McIntyre and J. B. Pearce, *Rapp. PV Réun. Cons. Int. Explor. Mer*, **179**, 212-227.

Rachor E., Gerlach S. A., 1978. Changes in the macrobenthos in a sublittoral sand area of the German Bight, 1967-1975, *Rapp. PV Réun. Cons. Int. Explor. Mer,* **172,** 418-431.

Rees E. I. S., Walker A. J. M., Ward A. R., 1972. Benthic fauna in relation to sludge disposal, in : *Out of sight out of mind,* Report of a working party on sludge disposal in Liverpool Bay, 2, Appendix 14, 297-343. H.M.S.O.

Rees E. I. S., Nicolaidou A., Laskaridou P., 1977. The effects of storms on the dynamics of shallow water benthic associations, *Proc. 11th European Symposium on Marine Biology,* edited by B. F. Keegan, P. O'Ceidigh and P. J. S. Boaden, Pergamon, London, 465-474.

Thistle D., 1981. Natural physical disturbance and communities of marine soft bottoms, *Mar. Ecol. Prog. Ser.,* **6,** 223-228.

Ziegelmeier E., 1978. Macrobenthos investigations in the eastern part of the German Bight from 1950 to 1974, *Rapp. PV Réun. Cons. Int. Explor. Mer,* **172,** 432-444.