Porcupine Newsletter

Volume 6 Number 2

AUGUST 1995 **ISSN 0309-3085**

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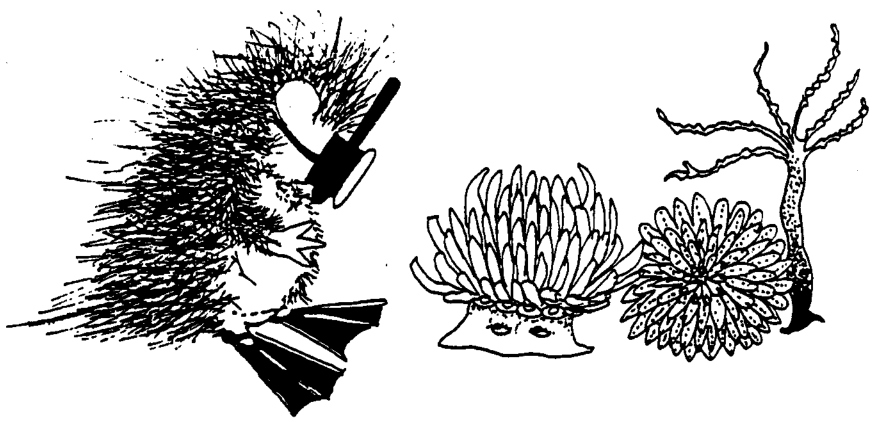

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EDITORIAL

Due to matters beyond Hon. Ed.'s control, there is rather short notice of the next meeting in Cardiff, but please take note of the details and make every effort to attend what promises to be a very interesting meeting.

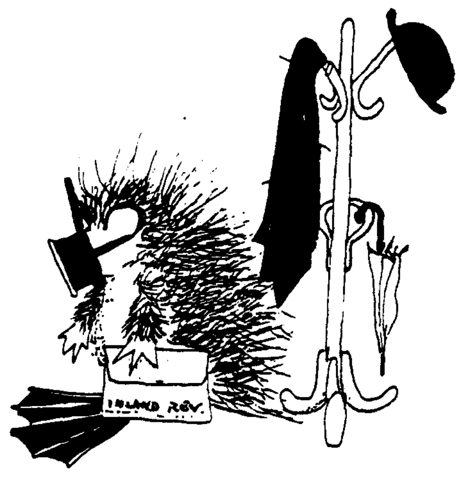
Jon Moore has provided the updated Membership List. Please refer corrections/emendations to him and not to me!

As promised, this issue mainly contains papers from the Millport meeting for which there wasn't space in 6 (1). It is nice to be able, on occasion, to give room to longer contributions. but I am always pleased to receive short items which enable me to fill up corners and make use of our many drawings.

I have been struggling with little success to persuade my computer to accept your disks (perhaps my fault!), which has meant retyping and introducing errors. Life would be much more straightforward if you could possibly convert to ASCII TEXTFILE.

INCOME TAX RELIEF in respect of PORCUPINE annual membership subscriptions:

PORCUPINE has been approved by the Board of Inland Revenue under Section 201 Income & Corporation Taxes Act 1988 that with effect from 6 April 1995 if members wish they can now obtain tax relief on their subscriptions. Should there be any problems, explain the situation to the local tax inspector quoting Head Office reference number SAPP/T1644/32/ 1995/JEM.



THE SOFT BOTTOM BIOTOPE: UTOPIA FOR THE MONITORING BIOLOGIST

By MYLES O'REILLY
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The Clyde River Purification Board (CRPB) is one of ten Scottish river purification authorities with a statutory remit to undertake pollution monitoring of river, estuarine and marine coastal waters (SRPBA, 1992). The essence of the CRPB's mission statement is to "maintain and improve the quality of controlled waters within its area". The CRPB seeks to achieve its environmental quality objectives *via* the licensing and control of discharges in combination with both chemical and biological monitoring programmes. The sampling and analysis programmes carried out by the freshwater and marine sections of the scientific services are driven by consent compliance monitoring, water quality classification schemes and a panoply of parliamentary acts and EC directives (Haig, 1986).

The effects of pollutants on biological systems is of more fundamental concern than any actual measured levels themselves and is expressed in a number of environmental objectives: passage of migratory fish through estuaries; benthos capable of supporting fish stocks; protection of shellfish, etc. Almost all components of marine ecosystems have some monitoring potential - plankton, benthic invertebrates, fisheries, sea birds and sea mammals. However, some of these populations are highly mobile or display marked seasonal variation presenting considerable sampling and interpretational difficulties. Ideally, sampling efforts should be targeted towards an assemblage of organisms that is relatively sedentary, varies little throughout the year, is easy to sample quantively, and has identifiable links to likely contaminant pathways. The "soft bottom biotope" fulfills all these requirements and its infaunal community of macrobenthos has long been recognised as the mainstay of marine biological monitoring.

Sediments act as a natural sink for marine pollutants accumulating suspended solids (eg. from sewerage outfalls) as well as organic and inorganic contaminants bound to particulate matter. The sedentary macrobenthic community living within the sediment is continuously exposed to any contamination or organic deposition and integrates any effects with time. Macrobenthic infaunal communities are relatively easy to sample throughout the year using cores or quadrats in the intertidal or grabs and cores for sublittoral sediments. Sampling strategies and analysis methods have been thoroughly tested and standardised and the available taxonomic literature is comprehensive (Henderson & Elliott, 1989; Rumohr, 1990; Rees, H, *et al.*, 1990, 1991; MAFF, 1993; Rees, E I S, 1994). Although the analysis of benthic samples time-consuming, this is outweighed by the integrative effects such that annual sampling is often more that adequate to follow impact trends.

The CRPB has carried out a number of macrobenthic stuudies within its area, many of which remain ongoing after more than 20 years:

Clyde Estuary - recovery after chronic organic and industrial pollution.

Garnock Estuary - recovery after acute chemical pollution.

Irvine Bay - waste from chemical, pharmaceutical and pulp mill processes in addition to domestic sewerage outfalls.

Loch Creran and Girvan - organic waste from alginate (seaweed) processing.

Ironotter Point, Greenock - a new long sea domsetic sewerage outfall commissioned in 1991.

In addition, the rapid expansion of the fish farm industry over the last 15 years on the west coast of Scotland, with nearly 50 marine finfish cage sites now in the CRPB area, has created additional monitoring requirements. The farm licensees are required to carry out annual self monitoring in accordance with procedures set by CRPB. Certain sites are then selected each year by the CRPB for more detailed audit monitoring.

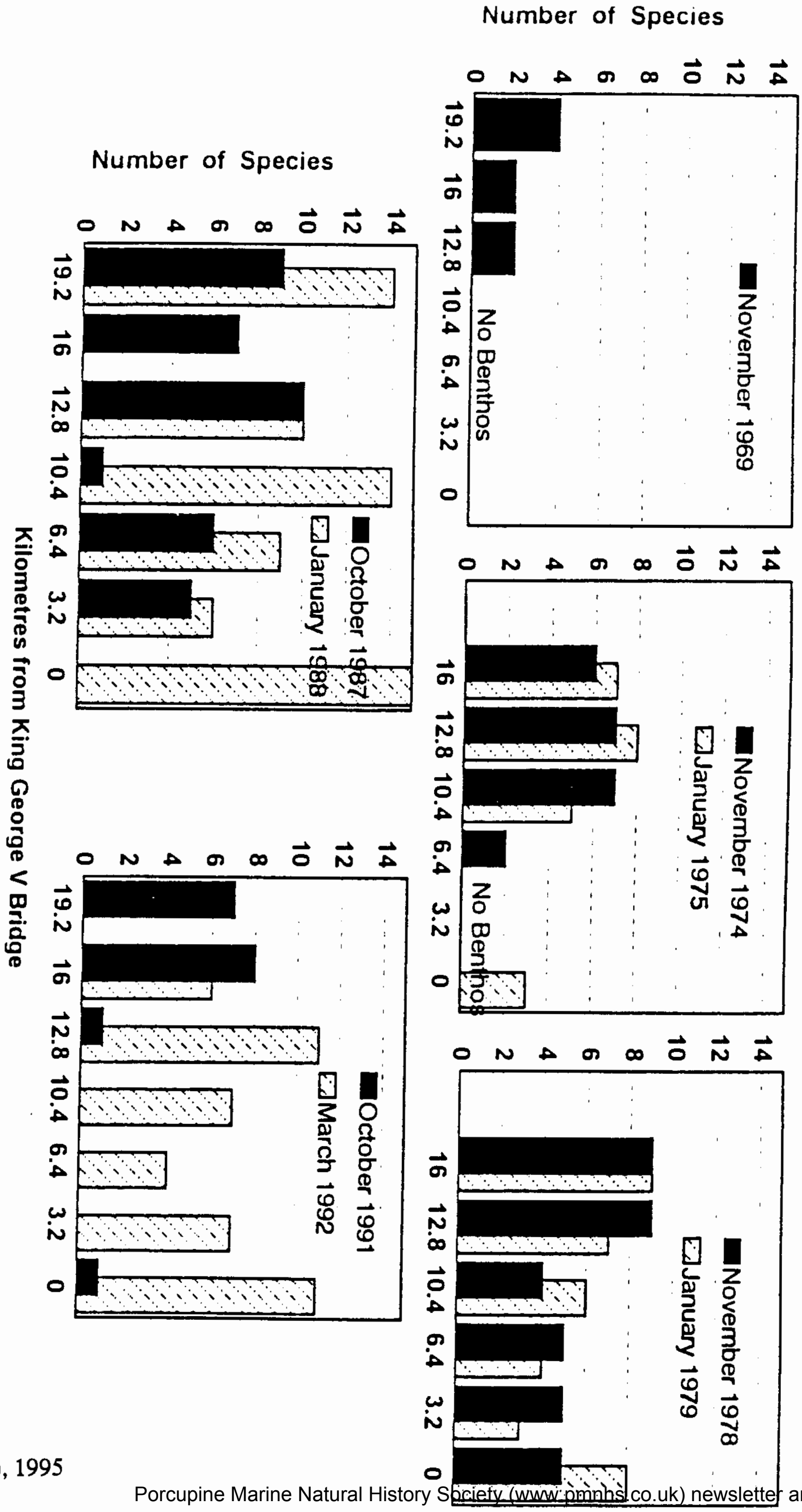


FIGURE 1 - RECOVERY OF THE CLYDE ESTUARY:

Species Richness of Bottom Fauna

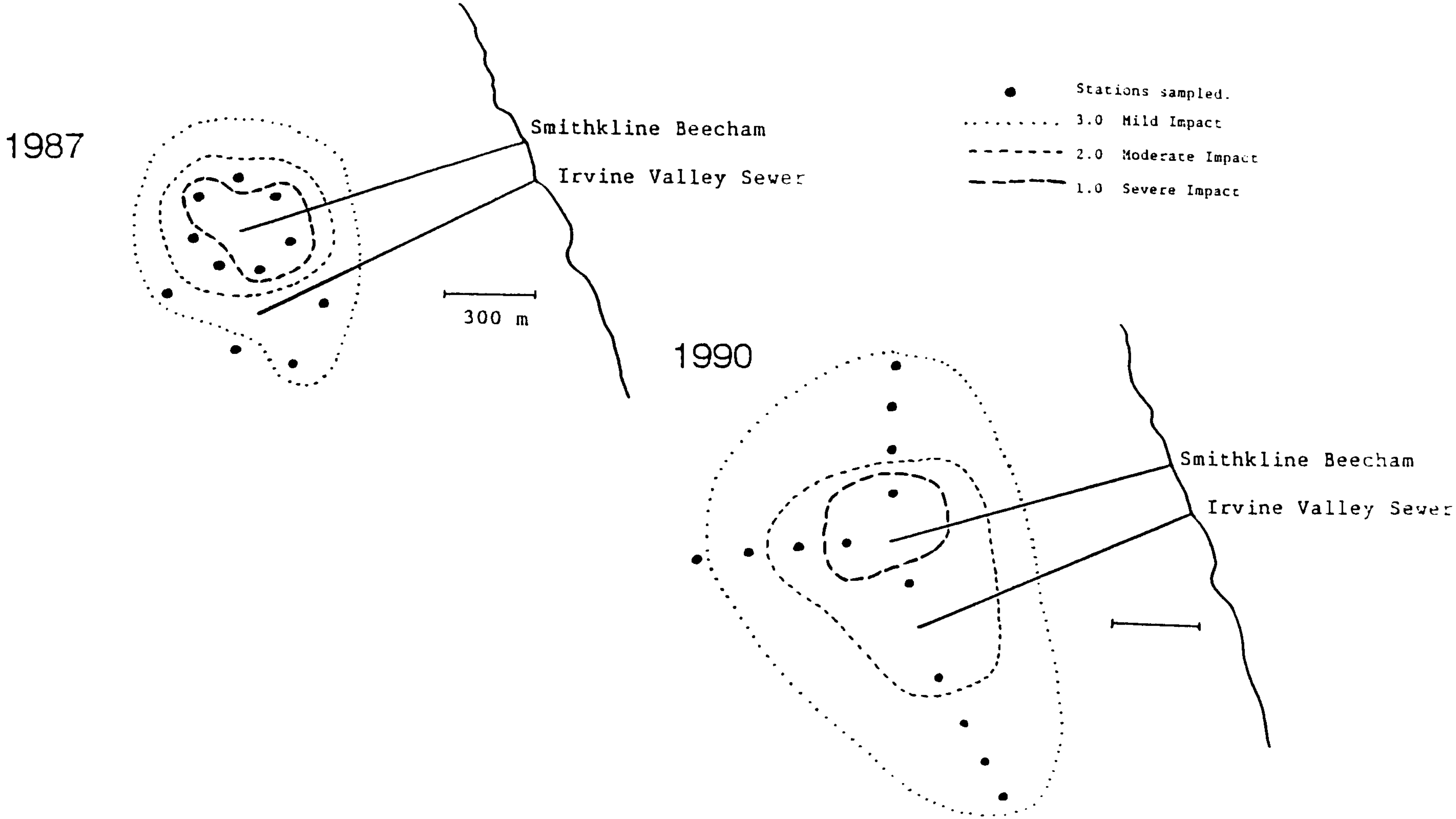


FIGURE 2 - IMPACT IN IRVINE BAY:

Shannon Diversity Values of Bottom Fauna

YEAR	1981	1984	1985*	1987	1989	1990+
a) Mean Diversity (Shannon Weiner)						
	2.18	1.86	1.00*	1.45	1.54	1.08+
b) Total Abundance of faunal specimens.						
	1823	2758	6726*	28107	4101	11198+
c) Numerical Abundance of Indicator Species.						
Nematoda	309	12	356*	12865	2458	8591+
Ophryotrocha	100	1595	5693*	12861	105	0+
Mediomastus	644	92	55*	127	163	22+
Capitella	0	96	108*	204	41	107+
Oligochaeta	56	4	0*	1253	1124	2367+
d) % Abundance of Indicator Species.						
Nematoda	17	<1	5	46	60	77
Ophryotrocha	5	58	85	46	3	0
Mediomastus	35	3	<1	<1	4	<1
Capitella	0	3	2	<1	1	1
Oligochaeta	3	<1	0	4	27	21

Data based on 7 stations at 150m with 5x 5cm(diam.) cores per station.
* Data based on 7 stations at 150m with 2x 5cm(diam.) cores per station.
+ Data based on 3 stations at 150m with 5x 5cm(diam.) cores per station.

TABLE 1 - IMPACT IN IRVINE BAY:

Shannon Diversity Values and Abundances of Bottom Fauna and "Indicator" Taxa around a pharmacuetical outfall

The Clyde Estuary has undergone a remarkable recovery over a period of more than 20 years (McKay *et al.*, 1978). The benthic fauna shows a gradual increase in species richness and a recolonisation of the upper reaches of the estuary occurred throughout the 1970's and 1980's (Figure 1). The return of salmon runs in 1983 after an absence of over 100 years brought home the tremendous improvements of water quality (Hammerton, 1986). Periods of faunal instability remained, however - a dry summer in 1991 precipitated a faunal crash by the Autumn of that year, athouth benthic populations rapidly regained lost ground by the Spring of 1992.

A similar recovery of intertidal macrobenthos was recorded on the west bank of the Garnock Estuary over a three year period following the cessation of chemical discharges in 1982. Sparse populations of *Nereis diversicolor* and *Mya arenaria* expanded and were augmented by a widespread recolonisation by *Macoma balthica*, *Cerastoderma edule* and *Corophium volutator* along with littorinid gastropods and barnacles.

The response of macrobenthic community structure to a gradient of organic enrichment was reviewed in detail by Pearson & Rosenberg (1978). They described a grossly polluted zone devoid of macrofauna, an adjacent polluted zone occupied by highly elevated populations of a few enrichment "indicator" species, and a transition zone where a number of other characteristic "indicator" species display slightly elevated populations. These faunal changes produce characteristic perturbations of the community parameter - species richness, abundance, biomass and diversity - all of which can be measured by the monitoring biologist. Such enrichment gradients are typically associated with marine cage fish farms, domestic sewerage outfalls or other industrial organic discharges such as pharmaceutical or alginate processing wastes.

In Irvine Bay the combined effect of Smithkline Beecham's pharmaceutical outfall and Strathclyde Region's Irvine Valley Sewerage outfall is clearly reflected in reduced diversity (Shannon-Weiner Index) values for the macrofaunal community (Figure 2) along with enhanced abundances of recognised enrichment "indicator" taxa. Time-series monitoring of a circlet of "inner" stations around the pharmaceutical outfall highlights the high abundances of five such "indicator" taxa and interesting fluctuations of their populations over a nine year period (Table 1).

Populations of large nematodes (*Pontonema* sp.) and the polychaetes *Ophryotrocha hartmanni* and *Mediomastus fragilis* were already elevated in 1981. By 1987, nematodes and *O. hartmanni* had reached superabundant levels totally dominating the community. These two taxa of minute worms accounted for 92% of the total organisms sampled. Other larger "indicator" taxa (*Mediomastus fragilis, Capitella capitata* and the oligochaetes *Tubificoides benedeni* and *T. insularis*), although present in elevated numbers, were masked by the superabundance of the former taxa and together constituted less than 6% of the fauna.

By 1990, the populations of *O. hartmanni* had disappeared from the inner stations. Despite this change the fauna remained highly impacted, with nematodes attaining a dominance of 77% of sampled organisms in 1990, and with oligochaetes doubling their populations since 1987 and accounting for 21% of sampled organisms. The mechanisms regulating these faunal fluctuations are not fully understood.

In contrast to the long term studies in Irvine Bay, the construction, in 1991, of a completely new long sea sewerage outfall at Ironotter Point, Greenock (Hunter & Scott, 1991), provided the CRPB with an opportunity to study the initial effects of organic enrichment on a macrobenthic community. A baseline survey had been caried out in 1989 prior to construction and in 1992, approximately one year after commissioning of the new outfall, a

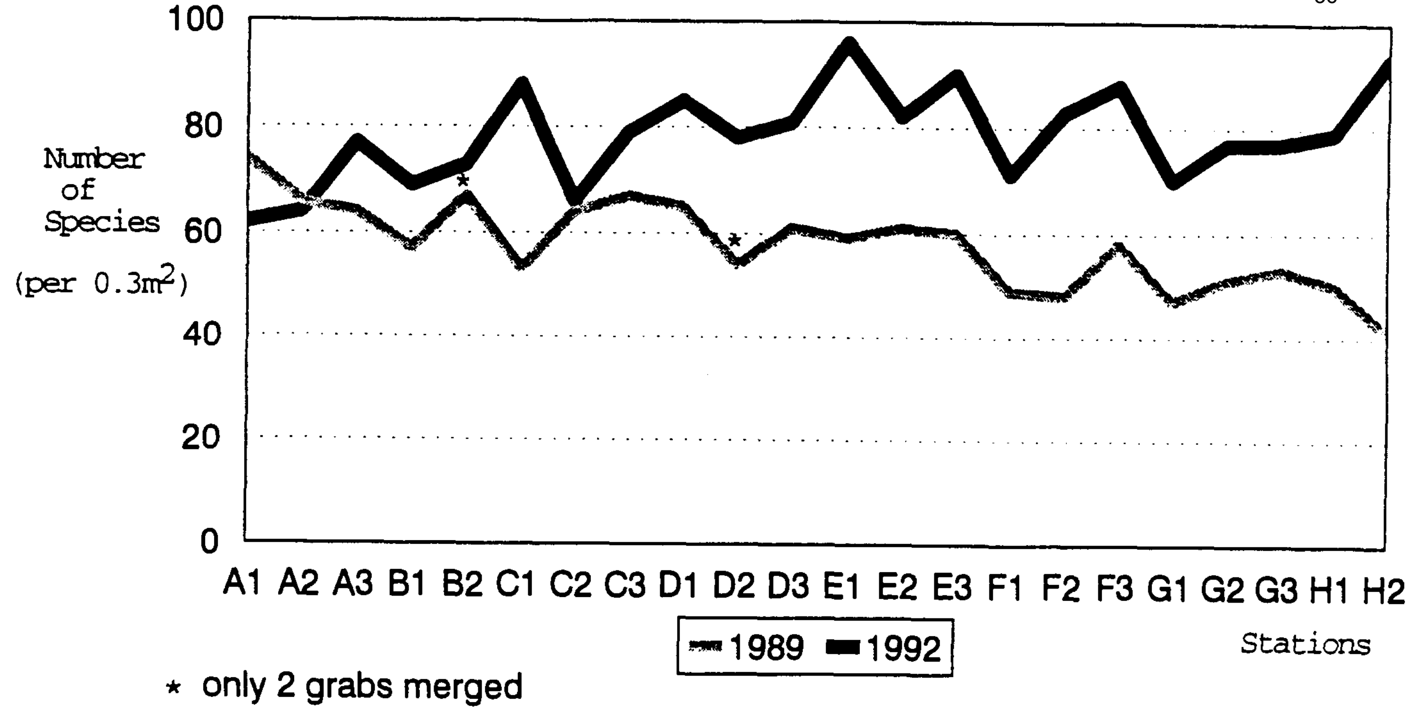


FIGURE 3 - IRONOTTER POINT - 1989 & 1992:

Species Richness of Bottom Fauna

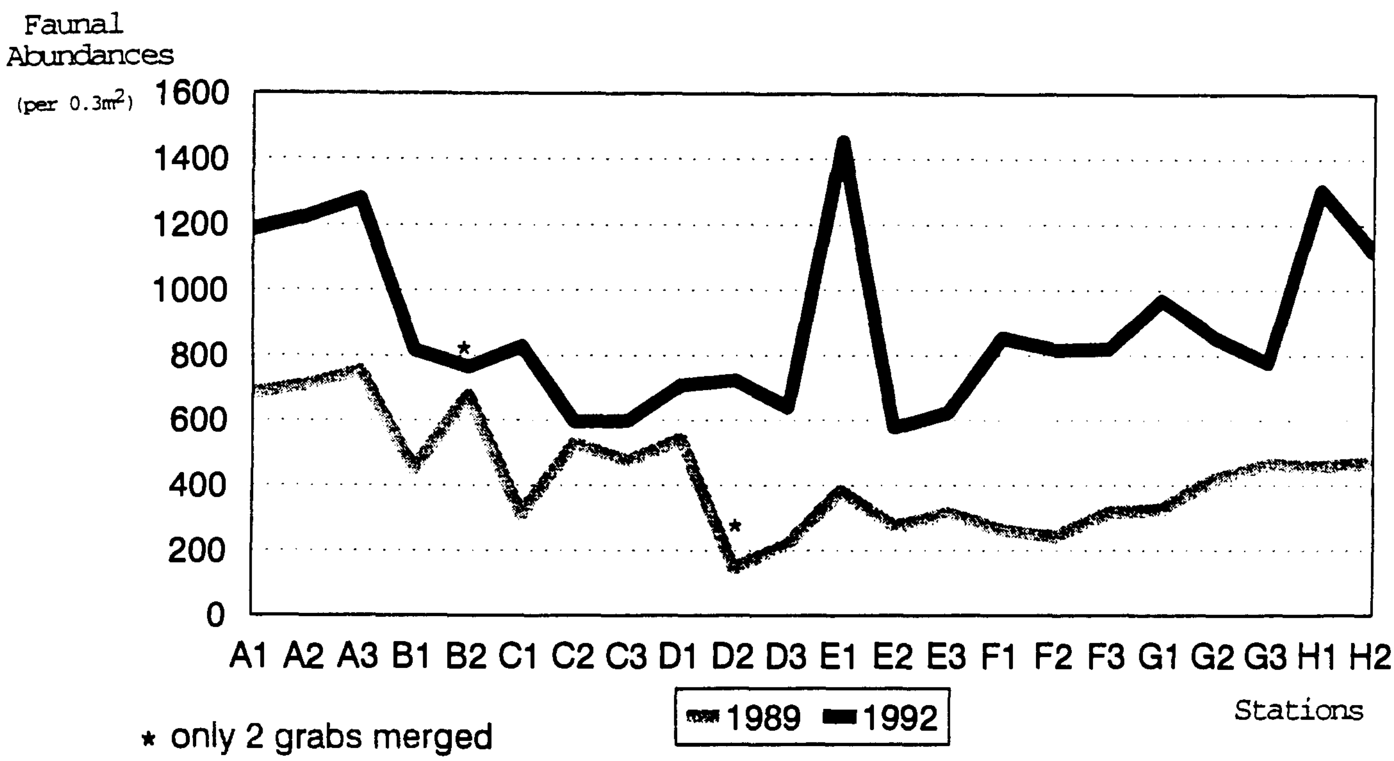


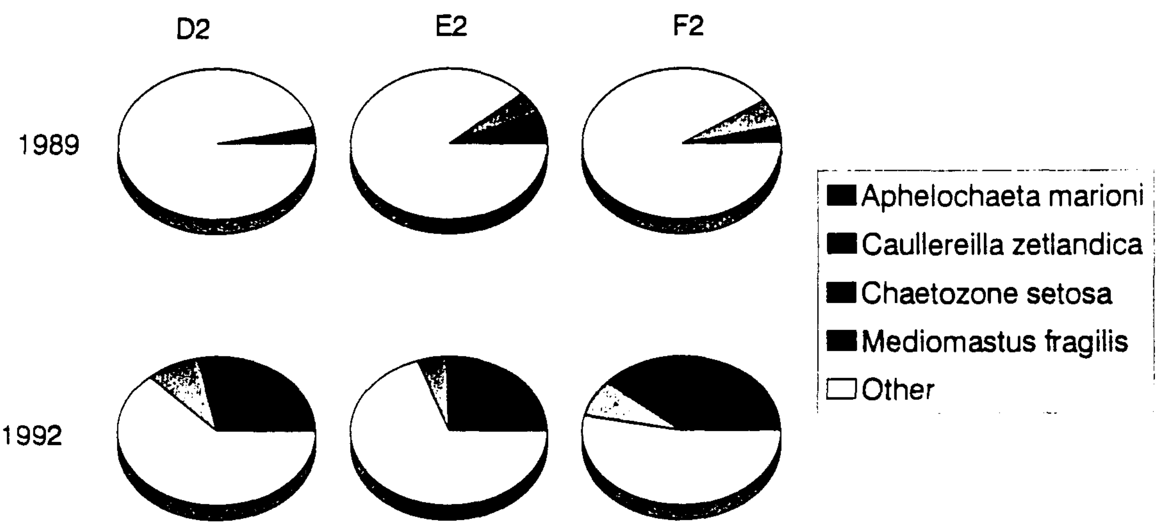
FIGURE 4 - IRONOTTER POINT - 1989 & 1992:

Abundances of Bottom Fauna

preliminary monitoring survey was undertaken with Day Grab benthos samples collected at 22 stations.

The 1992 survey indicated that species richness and faunal abundancies were already increasing throughout the area (Figures 3 and 4) although the diversity values remained more or less unchanged. The enhanced faunal abundancies were mostly attributable to an influx of four polychaete enrichment "indicator" species - *Mediomastus fragilis*, *Apheliochaeta marioni*, *Caulleriella zetlandica* and *Chaetozone setosa*. The change of proportional abundancies of these "indicator" species and all other macrofaunal species is illustrated for three selected stations (Figure 5). The "indicator" species accounted for less than 10% of faunal abundancies in 1989 but by 1992 they had attained approximately 30-50% of the total. Despite these population changes, the diversity of the macrofaunal community remained high, suggesting minimal impact only. Continued monitoring should allow the development of enrichment effects and any associated impact to be followed.

A beneficial spin-off of the detailed soft bottom studies carried out by the CRPB has been the discovery of a number of invertebrate species rarely recorded or previously unknown in British waters. Some of these are associates of larger common macrofaunal organisms.



<u>FIGURE 5 - IRONOTTER POINT - 1989 & 1992:</u>

<u>Proportion of "Indicator" species to all other Bottom Fauna</u>

During the surveys at Ironotter Point, for instance, three interesting associates of the polychaete *Terebellides stroemi* were recovered (Figure 6): *Commensodorum commensalis*, a small commensal polychaete, which shares the hosts's tube, and which is rarely recorded in British waters; *Melinnacheres steenstrupi*, a parasitic copepod which attaches to the host's gulls, with only one British record off the west of Ireland (Gotto & O'Connor, 1980); and *Haematocleptes terebellidis*, an endoparasitic polychaete known only from rhe type description, 100 years ago, in Gullmarfjord, Sweden (George & Hartmann-Schroder, 1985).

Another unexpected discovery from the Ironotter Point survey was a single egg-bearing female of the ectoparasitic copepod *Spiophanicola spinosus* attached to the dorsum of the spionid polychaete *Spiophanes kroyeri* (Figure 7). This copepod, the only member of a new family, was described by Ho (1984) from material also collected on a sewerage outfall monitoring survey but off the California coast! Until now it has not been recorded from any other locality.

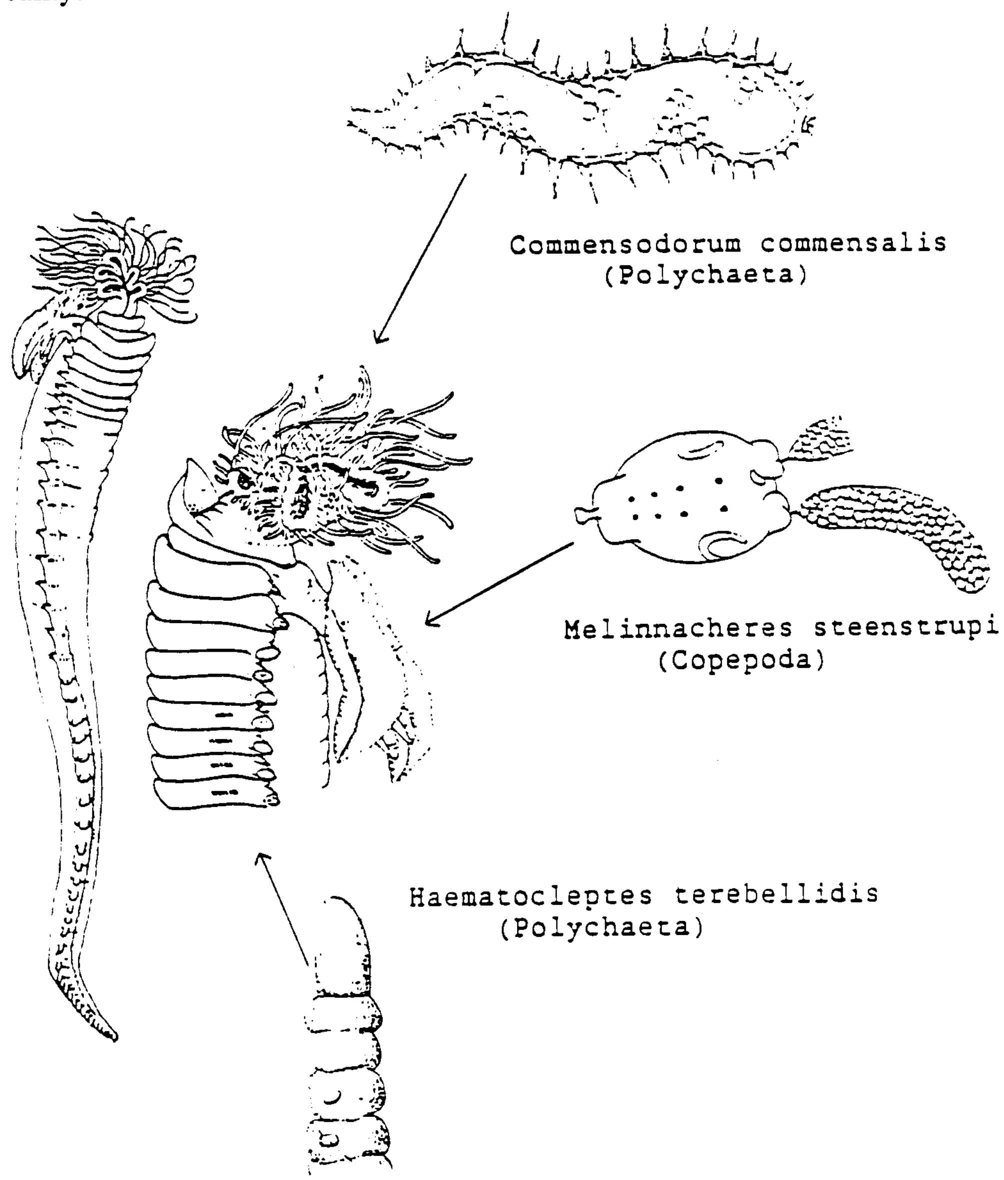


FIGURE 6 - Associates of the polychaete Terebellides Stroemi from Ironotter Point

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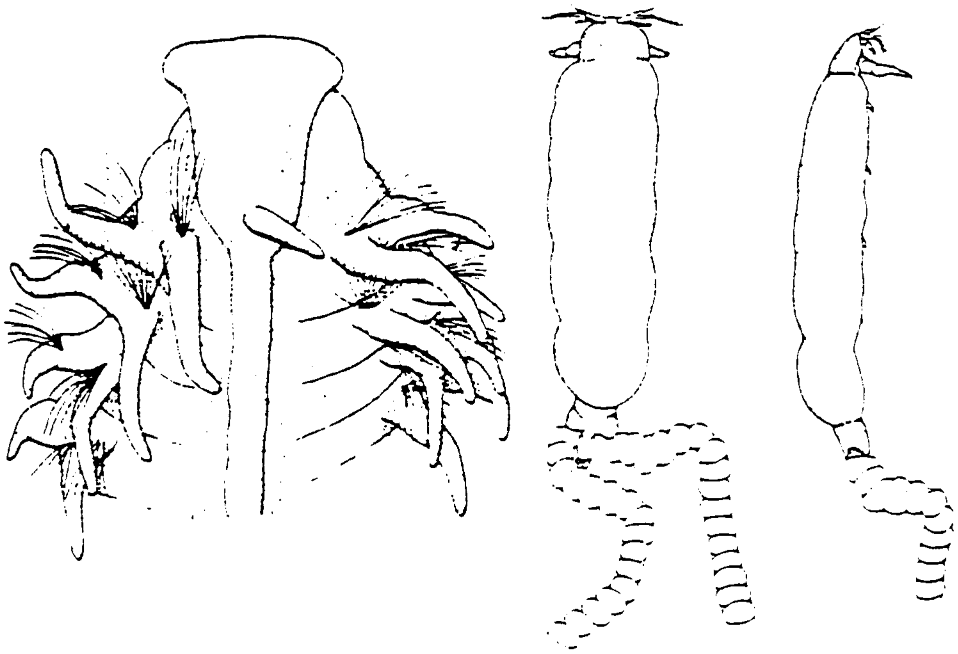

FIGURE 7 - *Spiophanicola spinosus* - a rare ectoparasitic copepod from the polychaete *Spiophanes kroyeri* at Ironotter Point

PECTENOGAMMARUS PLANICRURUS - THERE IS LIFE IN GRAVEL BEACHES

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INTRODUCTION

Clean gravel beaches are shifting, unstable places, bleakly exposed to the shaping forces of wind-driven tides. Beneath the surface of the gravel conditions are but little sheltered from the fluctuations of the environment at large. It is an unpromising habitat in which to search for invertebrate life, and yet it is here that the gammarid amphipod *Pectenogammarus planicrurus* Reid is to be found, in the interstitial spaces of an environment traditionally regarded as sterile.

This amphipod was described by Reid (1940) as a new species of *Gammarus*. *Pectenogammarus* was erected as a new sub-genus, subsequently to be raised to the rank of genus (Reid, 1944). Reid found the species to be plentiful "under stones near high-water mark on the chalky shores of the south coast of England". The type locality at Saltdean is a gently sloping shore of solid chalk: *P. planicrurus* was found amongst flint shingle, which was restricted to a level near high-water mark.

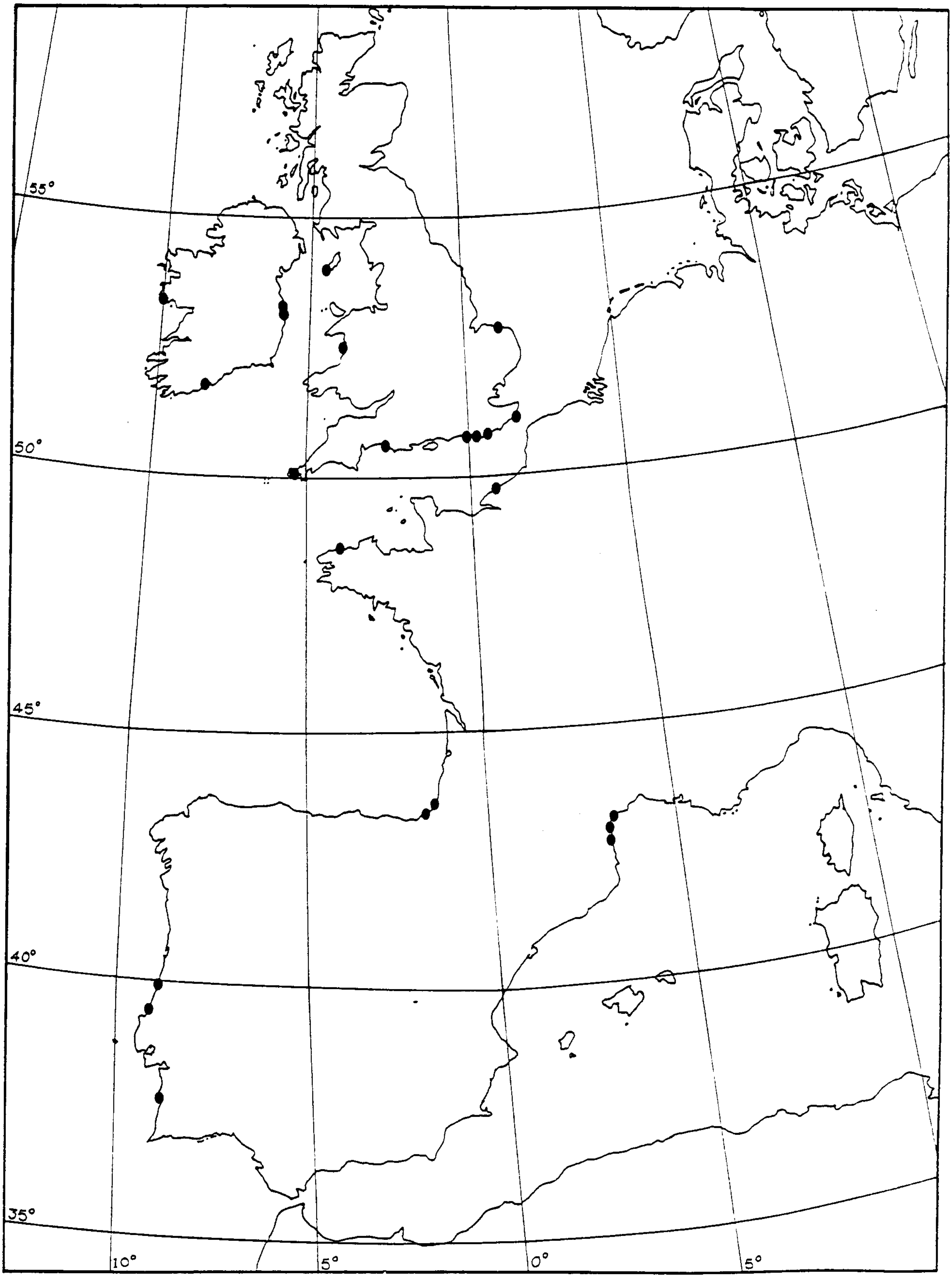
There are few records and little published information on the biology of *P. planicrurus*. The two major studies of this amphipod, by Morgan (1968) and Bell (1992), have concentrated on the abundant population at Aberystwyth on the west coast of Wales. This article is a summary of the current state of knowledge of its distribution and biology.

DISTRIBUTION

The known distribution of P. planicrurus is summarised in Figure 1. Stock (1982) described the distribution as of a west-Mediterranean Lusitanian type, and suggested that *P. planicrurus* is a southern element in the fauna of the Atlantic and Channel coasts. Lincoln (1979) includes *P. planicrurus* among the warm-temperate species of Gammaridea, i.e. the 'Mediterranean' species which penetrate the Atlantic coast of Europe as far northwards as the south and west coasts of Britain and Ireland. he most striking common factor from the known sites of *P. planicrurus* is the substratum, which is always coarse, and often very cleangravel. Lowered or variable salinity and/or proximity to freshwater run-off are also frequent, but by no means universal features.

The species has been recorded from widely scattered localities in the British Isles, the western Mediterranean and on the Atlantic coasts of France and the Iberian peninsula. There appears to be no geological factor common to the sites. The earliest records are for Cardigan Bay at Aberystwyth, where E. E. Watkin discovered the species in 1939. Watkin's description of the species as *Gammarus cambriensis* Watkin was submitted for publication shortly after Reid's 1940 paper had been accepted by the Annals and Magazine of Natural History (J.D. Fish, personal communication). The Aberystwyth beaches, described by Morgan (1970), are of unstable gravel derived from Silurian grits and shales of the Aberystwyth series, and glacial boulder clay.

Figure 1. The known distribution of *Pectenogammarus planicrurus*.



Morgan (1970) briefly surveyed the Channel coast from Brighton, Sussex, to Deal in Kent, and found large numbers of *P. planicrurus* on some chalk and flint beaches. Where the pebbles and gravel extend down to low-water, as at Seaford, Sussex, the species was present over most of the intertidal range. The vertical range at the type locality is probably restricted by the absence of suitable substrata at lower levels on the shore.

In a survey of the Amphipoda of the Isle of Man, Jones (1948) recorded *P. planicrurus* "under stones between HWN and LWN at Spaldrick", where there were too few to formulate a general idea of its habitat. The species was later recorded in surf plankton over sand in Port Erin Bay, Isle of Man, by Fincham (1970), who described it as a tidal immigrant.

Elsewhere in Britain, *P. planicrurus* has been recorded from Sheringham in Norfolk (Hamond, 1967), where G.I. Crawford found the species in 1948 and 1949. This is the only east coast record to the present author's knowledge. In 1991, *P. planicurus* was recorded at low densities in coarse gravel on the lower shore at Eype, West Dorset (personal observation). The British Museum (Natural History) collection of the species includes material from one other locality in south-west England: Penzance in Cornwall, where it was collected in large numbers by F.W. Rowe, under stones in shingle in the high tide zone (R.J. Lincoln, personal communication).

In Ireland, *P. planicrurus* was first recorded by Duhig & Humphries (1955) from two sites just to the south of Dublin Bay - Shanganagh Strand and White Rock, Killiney (see also Duhig, 1960). Specimens were collected at the water's edge, and under boulders in sand at the edge of a limestone boulder clay area. J.M.C. Holmes also has taken the species at Killiney, and at a number of other Irish sites: Youghal in Co. Cork, Malahide in Co. Dublin and Greystones in Co. Wicklow (J.M.C. Holmes, personal communication). At the last two of these sites *P. planicrurus* was taken in a light-trap in night-time surf plankton samples. The species has also been recorded at Rinvyle in the Connemara region of the Galway coast (Stock, 1973).

Outside the British Isles, the presence of *P. planicrurus* was first discovered in the western Mediterranean. Kant et al. (1968) found specimens near the mouth of l'Etang de Canet, among *Mercierella* on bridge pilings, and in coarse sand "trés tourmenté par l'action des vagues". The organism has since been recorded from several shingle beaches on the Languedoc coast to the north of Banyuls (Stock, 1973), including the mouth of the Tech (Stock, 1982). Coarse substrata and lowered salinity appear to be common factors at these Mediterranean sites.

The chalky shores of the Channel coast of France are strikingly similar to their English counterparts, and it is surprising that *P. planicrurus* has only once been recorded in this region: Stock (1982) collected specimens at Sainte-Marguerite (Seine-Maritime), from a clean gravel bank, in a supra-littoral brackish water spring. Despite intensive sampling, Stock was unable to find the species elsewhere on the French Channel coast. On some of the chalky beaches of the Boulonnais and Picardie coasts, *P. planicrurus* appears to be replaced by Gammarus duebeni Lilljeborg or Gammarus salinus Spooner.

The French Atlantic coast has yielded two other records of *P. planicrurus*. Van Maren (1975a) mentioned its presence at Plovan-sur-Mer in Brittany, and Stock (1982) recorded it at Guéthary (Basse-Pyrenées) close to the Spanish border. Stock also listed a record from the Spanish side of the border at Guetaria near San Sebastian. The remaining Atlantic records are from three sites in Portugal, namely Porto Novo and Sao Martinho do Porto (Estremadura) and the port of Sines (Alentejo Baixo) (Van Maren, 1975b). All three sites have coarse substrata, but there were too few samples for Van Maren to make any conclusions on the biology of the species.

TAXONOMY

Pectenogammarus planicrurus is the only representative of its genus. The species has remained in an independent taxon since the elevation of *Pectenogammarus* to full generic status by Reid (1944). It is Gammarus-like in form, but is readily distinguished from other species by characters discussed below.

The essential morphological features are: (a) the dense comb-like fringes of setae on the distal margins of the coxal plates and margins of the pereopods and uropods in mature males (Latin *pecten* = comb); (b) the shortness and breadth of the pereopods in both sexes (Latin *planus* = flat, crus = leg) (see Lincoln, 1979). In the extreme development of setation in the male, *P. planicrurus* resembles most closely certain species of *Echinogammarus*, such as *E. foxi* (Schellenberg) and *E. pungens* (Milne-Edwards) (Stock, 1982). Karaman (1977a,b) went so far as to regard *Pectenogammarus* and *Echinogammarus* as synonymous, on the basis of the similarity of the limbs and mouthparts. However, Stock (1982) noted two features of maxilla 1 which separate *Pectenogammarus* from the two most closely related genera, *Echinogammarus* and *Chaetogammarus*. Firstly, the left and right palps are almost symmetrical, except that the right palp is armed with spines slightly more robust than those on the left; *Chaetogammarus* and *Echinogammarus* have dentiform spines on the right palp and quasi-setiform spines on the left. Secondly, the inner plate has the aspect of a triangle with rounded sides and is wider than it is long; in *Chaetogammarus* and *Echinogammarus* the inner plate has the form of a pointed oval, longer than it is wide. *Pectenogammarus* remains an independent taxon, although without doubt closely allied to *Chaetogammarus* and *Echinogammarus* (Stock, 1982).

Reid's (1940) description has been supplemented by several workers. Morgan (1968) amplified Reid's description, using specimens from Cardigan Bay; these he found to be in every way identical to specimens from the type locality in Sussex. Kant et al. (1968), noting the first Mediterranean records of the species, stated that their specimens did not entirely correspond with Reid's figures. However, having examined material from the Sussex coast and compared it with Mediterranean specimens, they were confident that the samples were of the same species.

ECOLOGY

The ecology of gammaridean amphipods, and in particular the Gammaridae, has been extensively studied in recent years. Their ease of collection and amenability to experimentation have made them popular subjects for research. *Pectenogammarus planicrurus* is among the least studied of gammarids, perhaps because of its restricted distribution and relatively recent discovery as a new species. The brief appearances of the species in the literature have mainly concerned its distribution and taxonomy, with some notes on its habitat.

The most strikingly unusual feature of the species' biology is the environment in which it lives. In western Europe, *P. planicrurus* is almost unique among amphipods in being a permanent intertidal resident of unstable gravel beaches. These are extraordinarily rigorous and often sterile environments. At Aberystwyth, the only other macro-invertebrate species noted in gravel samples are archianellids of the genus *Protodrilus* and, in calm conditions, especially after large quantities of macroalgal detritus have been deposited on the beach, idoteid isopods and a variety of gammaridean amphipods, notably *Atylus swammerdami*

(Milne-Edwards) (personal observation).

The first major contribution to our knowledge of the ecology of *P. planicrurus* was made by Morgan (1968, 1970), who studied aspects of its biology in Cardigan Bay. Morgan (1970) indicated an intimate connection between the local distribution of the animal and the nature of the substratum, a feature more typical of meiofauna. According to Morgan, salinity is unimportant, and such factors as water turbidity and exposure are of significance primarily in the way in which they interact with the nature of the substratum. Morgan showed that it is the size of spaces within the gravel in relation to the size of the animal which is critical. He defined a 'critical ratio of entry' relating gravel particle size to the maximum diameter of animal attempting to pass through 'throats' connecting the interstitial spaces, and a 'critical ratio of occupation' below which high mortality was observed in animals attempting to enter the substratum.

Bell (1992) went even further in demonstrating the importance of substratum particle size: in field samples at Aberystwyth, both the density and size distribution of infaunal *P. planicrurus* was determined by the size of smaller particles within the substratum, which, in a mixture of particle sizes, are those which define the size of interstitial spaces. Substratum particle size was more important in determining the nature of the population than any other aspect of shore location, such as shore level (within intertidal limits) and depth within the substratum. Indeed, it was apparent that substratum preferences are an important factor driving the population dynamics of the species, causing size-dependent migration between areas of different grades of gravel. Short distance migration may be one reason why *P. planicrurus* enters the surf plankton (Morgan, 1968; Fincham, 1970; Bell, 1992).

Particle size preferences place one major constraint on the species - an upper limit of body size. Among the Gammaridae, *P. planicrurus* is a small species, with a body length of up to 9 mm in males and 6 mm in females. Given the nature of the gammaridean body plan, this places further constraints on some aspects of the species' biology, notably reproductive output. Bell (1992) observed broods of up to 18 eggs in laboratory maintained *P. planicrurus*, but more typical brood sizes in field samples were 5-6 eggs (see Bell & Fish, in press). Brood sizes in other (larger) species of gammarid range up to 250 eggs (e.g. Steele & Steele, 1991). For populations to persist in the harsh gravel beach environment, *P. planicrurus* needs a high reproductive output at the population level, and so small brood sizes are compensated for by early maturation and optimization of reproductive trade-offs, such as those between fecundity and egg size and between fecundity and parental female survival (Bell & Fish, in press). At Aberystwyth, *P. planicrurus* has a semiannual life-history pattern (i.e. young produced early in the year mature and reproduce within the same year) with multiple, overlapping generations (Bell, 1992). It is probable that the northerly limit to the distribution of *P. planicrurus* is defined by the lowest temperature at which such a life-history is possible.

The apparent harshness of the gravel beach environment belies the rich rewards for an organism capable of withstanding the rigours: an almost complete lack of competing species, a relative absence of predators and an abundant supply of food in the form of macroalgal and other detritus. It is probable that *P. planicrurus* is capable of also feeding on suspended particles and phytoplankton in the intertidal waters (J.D. Fish & L. Rickard, personal communication). Gravel beaches are not popular study sites for invertebrate biologists and it is probable that the relatively small number of records of *P. planicrurus* is due at least partly to lack of survey effort. I would be extremely interested to hear of new records of the species.

ACKNOWLEDGEMENTS

I am indebted to my PhD supervisor Dr John Fish for kindly guidance during my study of *P. planicrurus* at Aberystwyth. Thanks are due also to Professor John Barrett for provision of laboratory facilities and to many other staff and students in the, then, Zoology Department for abundant help and advice. The study was funded by a University of Wales Studentship.

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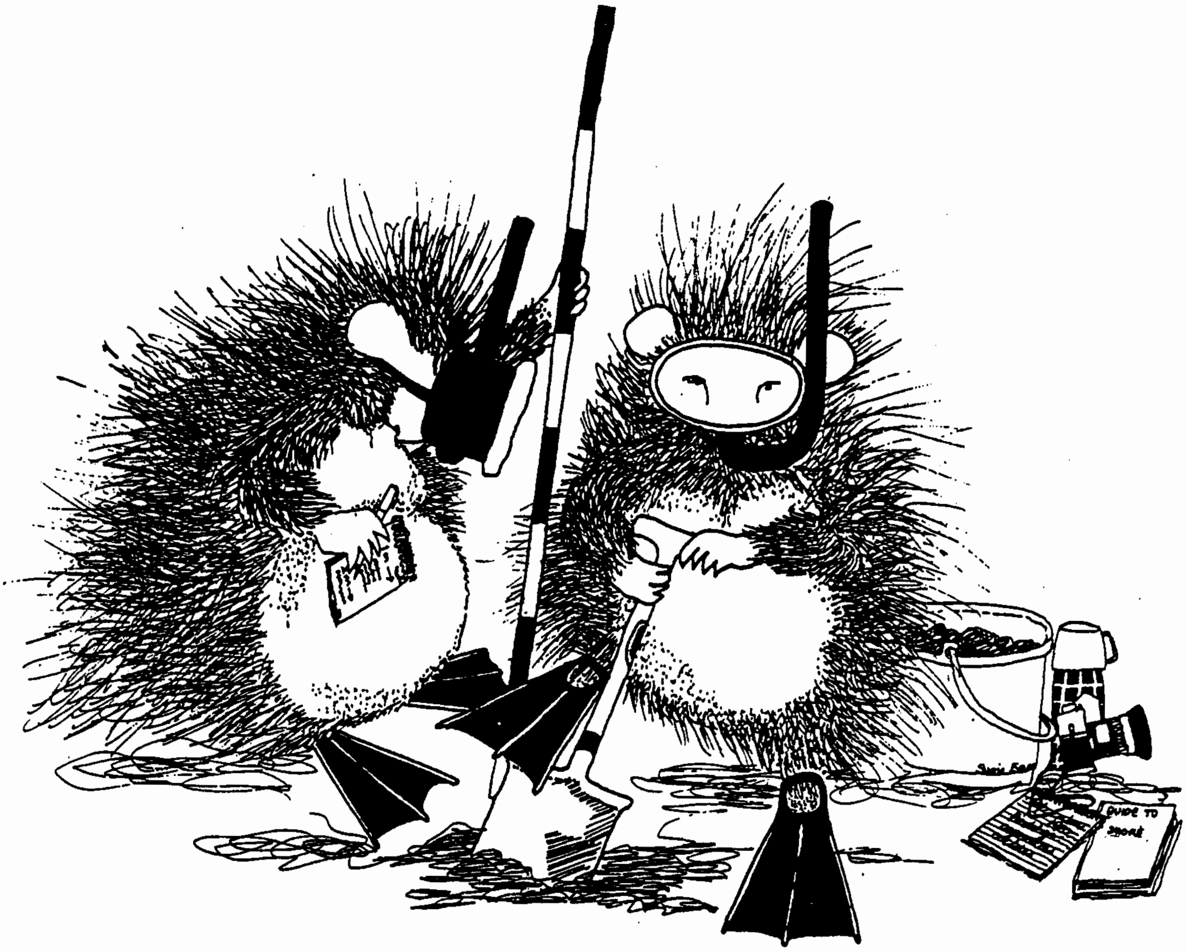

FEEDING BEHAVIOUR OF FOUR SMALL PROSOBRANCHS OF THE LOWER SHORE ALGAL TURF WITH SPECIAL REFERENCE TO *RISSOA PARVA*.

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INTRODUCTION

On rocky shores a belt of seaweeds extends from high water mark to about 20m below low water mark, depending on light values. The lower shore is frequently colonised by algae which form a turf of red algae which are variously frondose and filamentous. Anyone who has examined the associated fauna will be familiar with the small prosobranch molluscs *Rissoa parva* (da Costa, 1778), and also *Tricolia pullus* (L., 1758), *Lacuna pallidula* (da Costa, 1778) and *L. parva* (da Costa, 1778). These four species are conspicuous and common components of the turf. As part of an undergraduate independent project, certain algal species were sampled to determine the diversity and density of molluscan populations inhabiting the different algal species. In addition, some choice chamber work was carried out using the above four mollusc species to determine whether choices made by the molluscs in laboratory conditions would reflect the observed distributions in the field. Gut and faecal pellet contents were obtained and examined to look for evidence of diet. This paper summarises the results of sampling and laboratory work including a discussion on behaviour observed during filming of the snails in the laboratory by means of a microscope and video camera.

EXPERIMENTAL OBJECTIVES AND METHODOLOGY

A collection site on the Isle of Wight was selected to obtain animals for the experiments. Horse Ledge is a subhorizontal platform of Lower Greensand on the southeast coast of the island about 1km due south of Shanklin Chine. The area of the ledge is about 2,560m^2 and algae were collected from sheltered and exposed sides of the ledge with a third control site on the top of the platform at MLWM.

During visits made in August, September, November 1993 and January 1994, collections of 500ml compressed volume of the following algae were made: *Palmaria palmata* (P), *Corallina officinalis* (Co), *Mastocarpus stellatus* (M), *Chondrus crispus* (Ch), *Catenella caespitosa* (Ca), *Ceramium* sp. (Ce), *Griffithsia* sp. (G), *Cryptopleura ramosa* (Cr), *Laurencia pinnatifida*, *Sargassum muticum* (S), *Enteromorpha* sp. (E), and *Cladophora* sp.(Cl). Not all the above species were sampled on each visit: availability varied and some species, e.g. *C. ramosa* was not considered to be growing extensively enough to justify collection of a sample each time. A more accurate measurement of volumes of samples was later obtained in the laboratory using water displacement method. Numbers obtained for individuals of the mollusc species living in the weeds were then standardised to 500ml. At the same time as the collection of algae, weeds *in situ* were shaken over a 1mm mesh sieve in order to dislodge animals. This enabled collection of additional live animals for the choice experiments. *R. parva* was abundant, the two *Lacuna* species reasonably common and occasional specimens of *T. pullus* were collected. Preliminary experiments with these four species and selections of algae enabled an assessment of the willingness of the animals to perform in the laboratory conditions. *T. pullus* proved to be particularly passive in its behaviour. In addition to the choice chamber work, individuals of the four species were placed in petri dishes with a small sample of certain algae. Movements and grazing behaviour were observed through a microscope and filmed with a colour video camera. Based on results obtained, it was decided to focus more rigorous choice chamber work on *R. parva.*

RESULTS AND OBSERVATIONS

A total of 26 mollusc species was obtained from the weeds during sampling. Table 1 gives data obtained in August 1993 and shows the population densities standardised to 500ml. This is comparatively low diversity compared to much of the British coast, especially the southwest and western seaboards. Also the population densities of rissoids other than *R. parva* were extremely low: it is evident that *R. parva* dominated the microhabitat. A similar distributional picture for the species was obtained later in that year. The data in Table 1 should be noted in conjunction with Table 2 which gives information on the degree of exposure of the individual numbered algal samples 1-30. The counts obtained for the different algal species show that in the field there is apparent preference on the part of *R. parva* for certain algae, e.g. *Corallina, Ceramium, Griffithsia* and *Cyrptopleura.* This trend persisted during the sampling period.

Working exclusively with *R. parva,* a series of choice experiments was devised using, from a range of 8 algal species, a choice of two at a time with five replicates each with 25 snails. It was not practical to monitor the experiments and take regular counts of snails on algae and distributed around the container. The experiments were left for a period of about five hours in a room of constant temperature at 11°C. The results obtained are presented as a series of histograms (Figure 1). The black bars indicate the algal species which is constant across the graph and the cross-hatched bars represent the alternative alga offered. Stippled bars indicate snails distributed about the chamber, having made no apparent choice at the time of counting and dismantling the experiment. The data show that *Ceramium* and *Griffithsia* were preferentially chosen when offered against most other algae. In particular, *Ceramium* was consistently chosen in preference to an alternative alga, except when offered against *Griffithsia.* This latter species shows a strong selection except against *Corallina.* In most experiments a large number of snails were not located on algae at the end of the experiment. In some cases the numbers of snails having made no choice exceeded the sum of the snails on both algae in the chamber. During counting of snails at the end of the experiment with *Palmaria,* it was noted that fragments of the alga from the mature region of the plant with obvious epiphytes and detritus trapped on the surface were more attractive to the snails than the young, uncolonised, growth. This observation was tested with an experiment where young and mature growths were offered as alternatives and results suggested that this was indeed the case.

Wigham (1975) showed that the distribution of *R. parva* in algal turfs was associated with sediment content because the size of the settling veligers was within the size range of silt particles trapped by the most favoured algae, indicating that settlement is a passive process. Fretter & Manly (1977) suggested that juveniles are found on the same algal substrata as adults because habitat selection by the settling veligers persisted into maturity. Field observations over several years have shown that *R. parva* is able to exploit surface fronds, interstices of holdfasts and detritus trapped at the bases of plants in the algal turf, but they are also common on undersides of rocks and in sediment in pools across a broad area of the intertidal and sublittoral.

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TABLE 1(a): List of mollusc species and numbers of individuals per algal sample - August 1993. (Numbers of individuals standardised to 500 ml).

Sample no. Species mollusc/alga	1 Cl	2 M	3 M	4 Cl	5 G	6 S	7 G	8 P	9 M	10 Co	11 Co	12 Cl	13 Cr	14 Ca	15 Co
Tectura virginea															
Patella vulgata															
Helcion pellucidum		4	17				3	2	8	2			13		
Gibbula cineraria															
Tricolia pullus	**1**	**4**			**6**	**6**	**2**			**6**	**6**		**6**	**6**	
Lacuna pallidula			**21**						**54**	**8**			**31**		
L.parva		**4**	**21**						**12**				**26**		
L. vincta			8				2			2	8		26		
Littorina obtusata	4						7		25			1	10		31
Eatonina fulgida	1														
Rissoa interrupta															3
Rissoa parva	**211**	**252**	**58**		**792**	**214**	**737**	**9**	**208**	**933**	**158**	**145**	**2130**	**192**	**11**
Alvania semistriata					6						4				
Onoba aculeus										6				2	15
O. semicostata							2			17					1
Nucella lapillus															1
Omalogyra atomus					1										
Ammonicerina rota	1						2					1		2	
Runcina coronata									4						
Limapontia senestra	32											131			
Facelina auriculata													4		
Mytilus edulis	6	4			1	8			21	8	28	2	6	50	1
Musculus discors	4						2			4		1	12	174	
Lasaea adansoni	3						2				2			84	
Venerupis senegalensis							3			2	2		2		
TOTAL NO. OF INDIVIDUALS	**263**	**268**	**125**		**806**	**228**	**762**	**11**	**332**	**988**	**208**	**281**	**2255**	**510**	**83**

Nomenclature is after Smith & Heppell, 1991. Species used in choice experiments are emboldened. Samples 1 and 4 amalgamated in error and processed as one sample standardised to 500 ml. Key to alga abbreviations appears in the text.

TABLE 1(b): List of mollusc species and numbers of individuals per algal sample - August 1993. (Numbers of individuals standardised to 500 ml).

Sample no. Species mollusc/alga	16 S	17 M	18 Ce	19 E	20 Ch	21 M	22 Ch	23 M	24 Ce	25 Cl	26 G	27 S	28 Cr	29 S	30 Ch
Tectura virginea													2		
Patella vulgata					1										
Helcion pellucidum					3		11	8					2		23
Gibbula cineraria								1							
Tricolia pullus	**2**	**7**			**1**		**1**	**1**	**6**		**1**	**10**	**11**	**1**	
Lacuna pallidula	**2**	**3**		**1**	**7**	**38**	**13**	**37**	**1**	**1**	**2**	**8**	**25**	**14**	**2**
L.parva		**1**			**29**	**2**	**22**	**18**	**1**				**32**		**2**
L. vincta					4	2	5	8				3	9		1
Littorina obtusata	27	48	3	6	4	41	1	21			1	3	12	2	
Eatonina fulgida															
Rissoa interrupta													5		
Rissoa parva	**27**	**12**	**179**	**10**	**228**	**94**	**131**	**251**	**343**	**142**	**711**	**100**	**3048**	**134**	**215**
Alvania semistriata															
Onoba aculeus					1										
O. semicostata													3		
Nucella lapillus															
Omalogyra atomus															
Ammonicerina rota								1							
Runcina coronata															
Limapontia senestra			1							41					
Facelina auriculata															
Mytilus edulis		1		1	3		5		11	2		2	5	2	
Musculus discors											1		12		
Lasaea adansoni															
Venerupis senegalensis													5		
TOTAL NO. OF INDIVIDUALS	**58**	**72**	**183**	**18**	**281**	**177**	**189**	**346**	**362**	**186**	**716**	**126**	**3171**	**153**	**243**

Nomenclature is after Smith & Heppell, 1991. Species used in choice experiments are emboldened. Samples 1 and 4 amalgamated in error and processed as one sample standardised to 500 ml. Key to alga abbreviations appears in the text.

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FIGURE 1. Histograms A - H showing results of choice chamber experiments where each of 8 algal species is offered against the other 7 in experiments of 5 replicates of 25 snails.
Solid bars = snails selecting the species constant in the choice experiment; hatched bars = snails selecting alternative algal species; stippled bars = snails not located on algae at the end of the experiment.

FIG. 1A. *Palmaria* choice expt
(*Rissoa parva*)

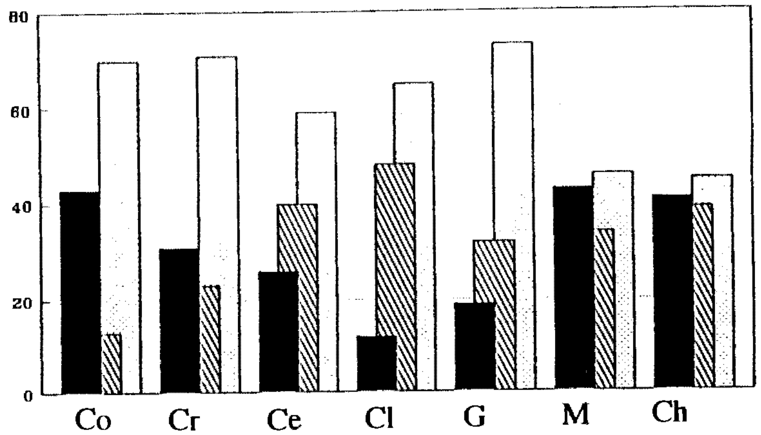


FIG. 1B. *Corallina* choice expt
(*Rissoa parva*)

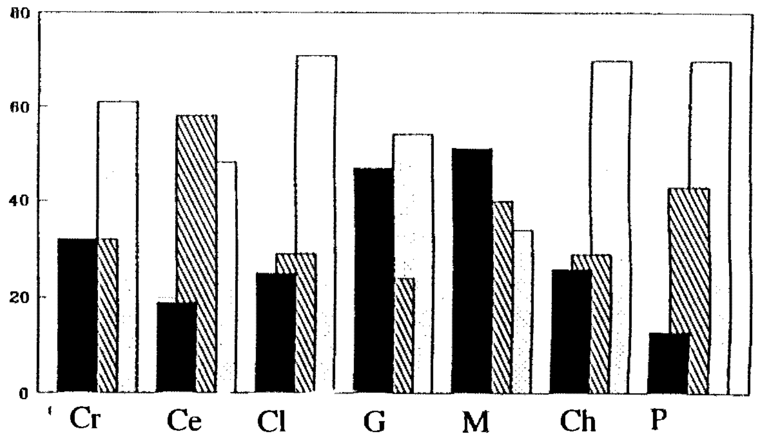


FIG. 1C. *Cryptopleura* choice expt
(*Rissoa parva*)

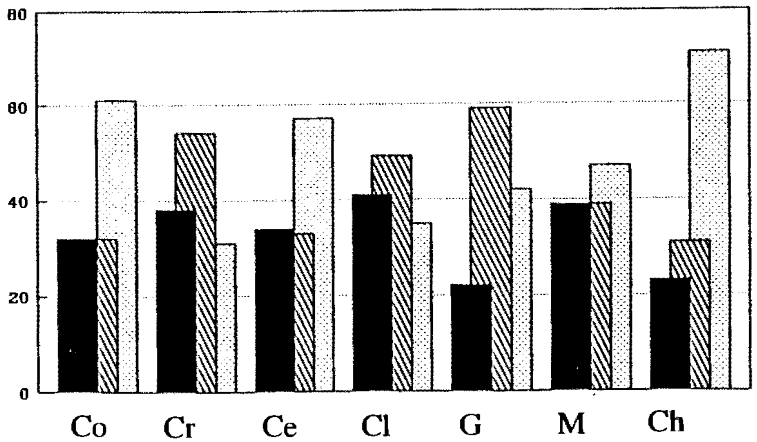


FIG. 1D. *Ceramium* choice expt
(*Rissoa parva*)

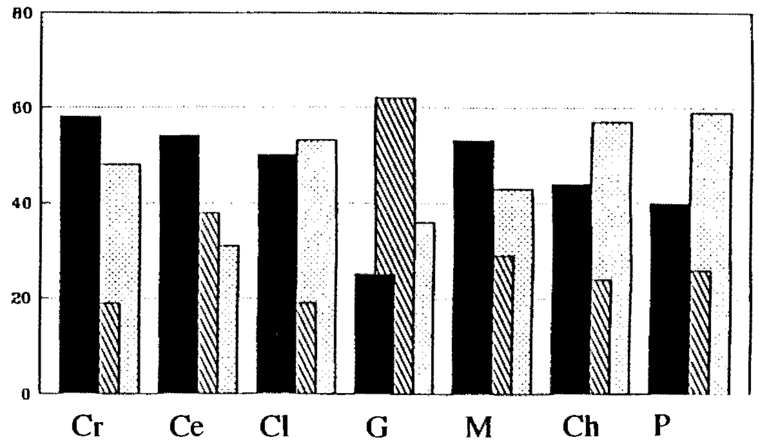


FIG. 1E. *Cladophora* choice expt
(*Rissoa parva*)

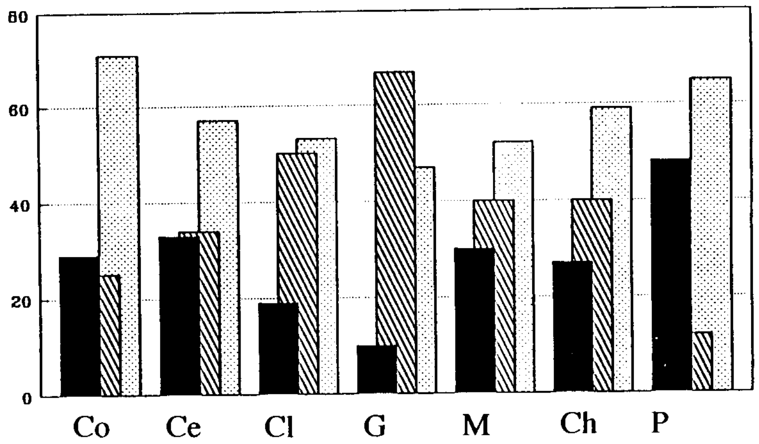


FIG. 1F. *Griffithsia* choice expt
(*Rissoa parva*)

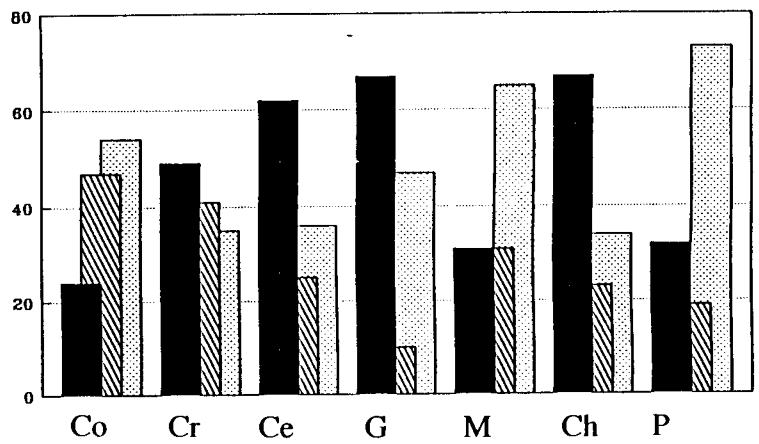


FIG. 1G. *Chondrus* choice expt
(*Rissoa parva*)

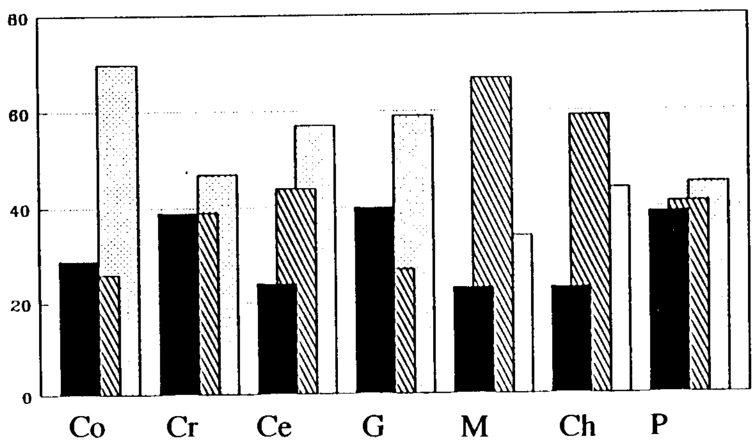
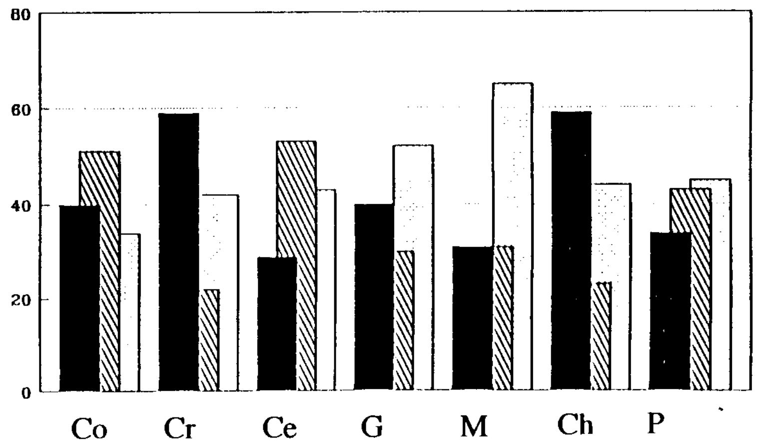


FIG. 1H. *Mastocarpus* choice expt
(*Rissoa parva*)



Named alga   Alternative alga   No selection

Table 2: Number of individuals of *Rissoa parva* and no. of species per sample for each alga species standardised to 500 ml. Data (Aug.`93) grouped in order of exposure. Platform top considered to be more exposed than northern edge of ledge.

Sample no.	Alga species	Zone	No. of individuals	No. of mollusc spp.
25	*Cladophora* sp.	Shel	142	4
12		Con	145	6
4		Exp)		
1		Plat)	211	9
23	*Mastocarpus stellatus*	Shel ELWM	251	9
21		Shel	94	5
9		Con	208	7
3		Exp Im	58	5
2		Exp Em	252	5
17		Plat	12	6
26	*Griffithisia* sp.	Shel	711	5
7		Con	737	10
5		Exp	792	5
29	*Sargassum muticum*	Shel	134	5
27		Con	100	6
6		Exp	214	3
16		Plat	27	4
8	*Palmeria palmata*	Con	9	2
24	*Ceramium nodosum*	Shel	343	5
18		Plat	179	3
19	*Enteromorpha* sp.	Plat	10	4
22	*Chondrus crispus*	Shel ELWM	131	8
20		Shel	228	10
30		Exp	215	5
28	*Cryptopleura ramosa*	Shel	3048	13
13		Con	2130	11
10	*Corallina officinalis*	Con	933	10
11		Exp	158	7
15		Plat	11	7

Key to abbreviations: Con Control; Exp Exposed; Plat Platform; Shel Shelter; Em Emersed; Im Immersed; ELWM Extreme Low Water Mark

GUT CONTENT AND FAECAL PELLET INVESTIGATION - A SEARCH FOR EVIDENCE OF DIET

Although the distribution of *R. parva* on the various algal turf species appeared to show some preference on the part of the snails, it cannot be assumed that this is exclusively dietary preference.

In order to identify dietary elements of this and the other three species of mollusc, gut content and faecal pellet material were examined. Snails were isolated for a period of days and then kept in a small container with one algal species for a week. Faecal pellets were collected, squashed between a slide a cover slip and examined. The shells of some *R. parva* were cracked and the soft parts removed. The gut was examined using the same method as for the faecal pellets. In the case of *R. parva*, no conclusive evidence of epithelial tissue was found in the pellets or gut, but diatoms, bacteria and spores as well as sediment grains were.

VIDEO RECORDING OF GRAZING BEHAVIOUR

During filming, differences in the behaviour of the four mollusc species were noted. *Tricolia pullus* tended to move over the surface of the algae slowly and remained immobile for extended periods compared with the other three. Both *Lacuna* species were more active, moving more readily through the algae with active tentacles, but the snails became quiescent after 10 minutes or so. Because of the shell morphology and short blunt snout, it was not easy to observe grazing activity in *Lacuna*. In contrast, *R. parva* was extremely active, moving readily through the algal fronds and continuing to do so for up to an hour, even though some heating of the water had taken place.

Observations have shown that the feeding mechanisms of the four species vary and that this variability is not just a function of the radula and diet but also snout and mouth morphology. For *T. pullus* in particular, but less so for both *Lacuna* species movement over the algae was hesitant, slow and ceased shortly after set-up, possibly demonstrating a negative reaction to lighting, temperature increase and the artifical conditions. *Rissoa parva* seemed less affected by the experimental conditions and continued to move freely over the algae, casting its mobile slender and bifurcated snout about in an apparently random fashion whilst picking at the surface of the algae as if it were selecting specific items. These snails were also observed to pluck at fine epiphytic algal filaments.

Rissoa parva is a annual species with up to 6 generations per year and an average life cycle of 3-5 months (or 8-9 months for overwintering animals). Shells of mature animals become colonised with encrusting organisms and during filming individuals were seen to graze on the shells of other snails. *Rissoa parva* possesses an adhesive gland on the foot enabling it to attach itself firmly to a substratum. It also can release its foot from the point of attachment whilst remaining anchored by a mucus string., Thus anchored it is able to exploit the surface flim, hanging below the surface and achieving directional movement by flexing the anterior and posterior regions of the foot alternately. This behaviour was observed by Wigham (1975) in newly settled snails. Whilst working with veligers in experimental conditions he noted that agitation of sea water in their container caused them to produce a secretion from the base of the foot by which they anchored to the nearest available surface.

Little is known about the predators of small snails in red algal turfs (Hayward, 1988). They may be eaten by non-selective predators (fish, crabs, larger snails) and possibly by juveniles of larger carnivorous species such as *Nucella lapillus* (L., 1758). They may be taken inadvertently by larger herbivores such as fish. They have also been found in the gut contents inadvertently by larger herbivores such as fish. They have also been found in the gut contents of wading birds such as the Knot (Summers & Smith, 1983).

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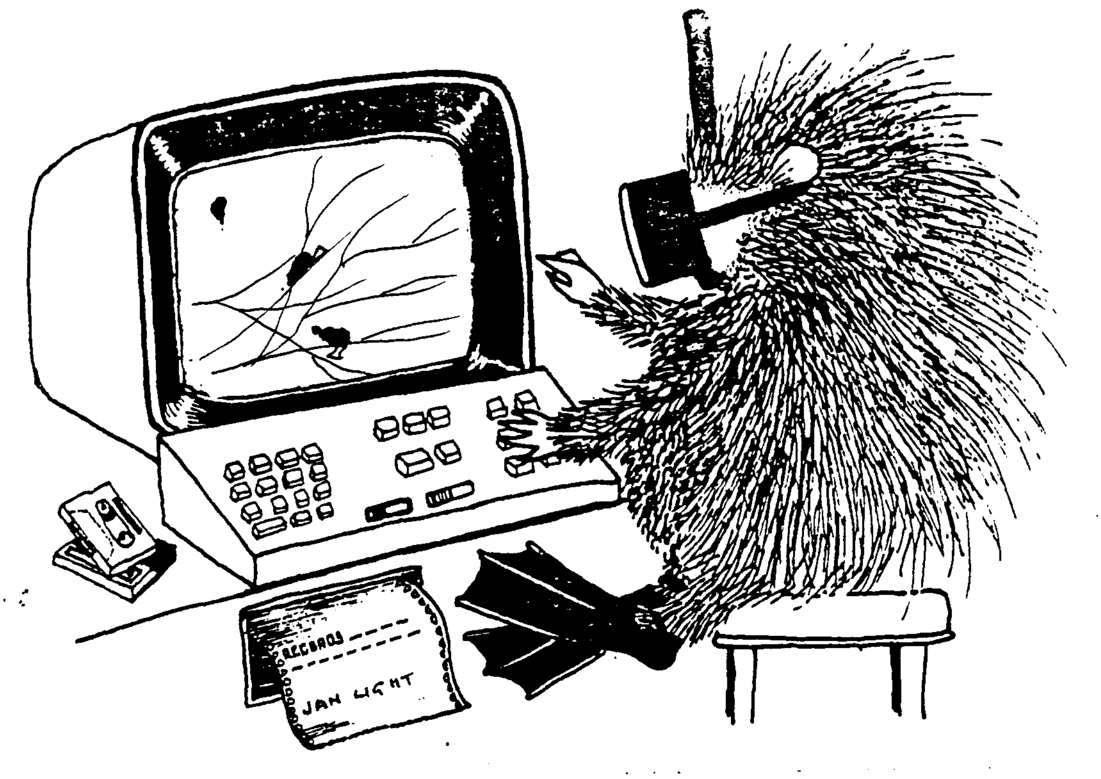

BOOK REVIEW

MARINE ENVIRONMENTAL MANAGEMENT. REVIEW OF EVENTS IN 1994 AND FUTURE TRENDS. 1995. Bob Earll. pp 115. £30.00

These are the Conference Proceedings from the Second Marine Environmntal Management meeting organised by Bob Earll. The meeting took place in London on 17-18th January 1995 and included papers from 19 speakers. The conference has become an annual event and is an excellent way to keep up with marine environmental issues spanning many disciplines.

All the major events of the year are covered, both the spectacular ones like newsworthy fisheries disputes and important behind the scenes developments. Two useful appencices list the events of 1994 and 1995 and beyond.

The Proceedings provide a ready reference source on a wide range of topics. The papres include a useful review of coastal zone management and catchment management plans. CZM seems to be the 'in' thing at the moment. Water quality and pollution control are tackled in a range of papers covering the effects of industrial chemicals in estuaries, the continuing problem of sewage pollution, NRA monitoring around our coasts and the offshore oil and gas industry.

The status of fisheries and new approaches to their management are covered, along with effects on them of sand and gravel extraction. Birds and archeology are not forgotten. An excellent review on marine environmental assessment in Scandinavia gives an idea of the complexity of this task and the importance of getting it right. Developments on the EC Habitats and Species Directive and the EC Environmental Assessment Directive are also covered. Dry stuff for wet marine biologists but essential.

I was also delighted to find that one of my hobby horses was aired: this is waste minimisation. Cleaner technology and recycling projects in industry can benefit companies financially as well as lessening pollution of our rivers and coastal areas.

In addition to papers from the speakers, the Proceedings include four supplements: (1) Water quality and polluton control; (2) Fisheries; (3) Marine Nature Conservation; (4) Law. These are in the form of summaries of important issues and the Proceedings are worth buying for these alone. I have found them very useful for finding various bits of information and as a guide to where to get more. For example the water quality and pollution supplement ranges from Mersey anglers eating unfit fish to the North Sea ministerial meeting. The Fisheries supplement includes drift net fisheries, Canadian cod fisheries and overcapacity.

The state of the marine environment has at last become an issue and if you want to be part of that issue and keep up to date, then these Proceedings are for you. This A4 soft-back book won't take up much space on your bookshelf, but should spend much of its time open on your desk. If you missed this year's meeting, try for next year's. I found it well worthwhile.

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BOOK REVIEW

MARINE ALGAE OF NORTHERN IRELAND. 1995. O. Morton. Ulster Museum. Belfast. pp vii + 123. £6.95 pbk

Osborne Morton is algal curator at the Ulster Museum and belongs to the old school of biology by being a naturalist with a keen eye in the field, which has been put to good use in producing this book. This publication is a compendium of records of seaweeds belonging to the Chlorophyta, Phaetophtya and Rhodophyta (excluding planktonic species and most unicells) from the province of Northern Ireland, which comprises the coasts of Counties Londonderry, Antrim and Down. Biogeographically, this restriction is not useful, since the adjacent county of Donegal extends as far north and there are at least a few algae, such as *Grateloupia filicina* and *Fucus distichus*, which have been recorded from Donegal but not as yet Northern Ireland.

In addition to his own material, the author has examined other collections, going back to John Templeton who started collecting at the end of the 18th Century, through to the present time, incorporating recent surveys. These have been valuable in extending into the sublittoral and have discovered seaweeds, for example *Porphyropsis coccinea*, not previously recorded from the Province. On the other hand, the only record of *Derbestia marina* (*Halicystis*-phase) dates from 1896 and I am sure it is still present, being well within its geographical range. Records from the literature have also been used to produce an inventory of species. This has resulted in a total of 356 algae for Northen Ireland, representing just over 70% of all the species listsed by Guiry (1978) for the whole of Ireland.

Although in its introduction MANI (to emulate Osborne's system, q.v. later) is stated to be based on the style of Stewart & Corry's "*A Flora of the North-east Ireland*" (Hackney, 1992), it is not a true flora. There are no keys provided, with detailed descriptions or full synonymy. For each species, a comment as to its abundance and habitat is presented, together with distributional data (site, date and source). A topographical index is given, listing all the sites mentioned in the text, assigned to county, with grid reference and location. The main virtue of this book is that where possible records have been checked and the nomenclature revised, mainly in accordance with South & Tittley (1986). This must have been a very laborious process for the author.

An obvious comparison is between this work and that by Guiry (1978). The latter deals with all the Irish coastline and includes only published records of benthic algae, which have not been verified. Thus, these two works, although overlapping somewhat, are complementary and necessary to any future workers on the seaweeds of Northen Ireland. I would have liked it clearly indicated, perhaps by a symbol or otherwise listed in a table, when an alga was included in MANI but not in Guiry's Concensus, as in the cases of the newly described species *Schmitzia hiscockiana* and *Gelidiella calcicola*, and the recently discoverd *Schmitzia neapolitana*. There are, of course, recent nomenclatural changes to make direct comparison between these two works more difficult in some instances, which the reader would have to realise from such works as South & Tittley (1986). For example, the alga now called *Erythroglossum laciniatum* used to be known as *Polyneura gmelinii*.

It is a welcome change to see the coralline reds well represented, which is not usually the case for this perplexing group. usually referred to collectively as "Lithothamnia". As with other difficult taxa, specialist help has been provided, as indicated in the Acknowledgements. If Dutch workers (e.g Keoman & van den Heok, 1980) has been followed rather than the rather simplistic treatment given by Burrows (1991) to such green algae as *Ulva* and *Enteromorpha*, then more species would have been recognised within these genera. The sea lettuce, *Ulva lactuca*, may not be so common as most people think! Similarly, the red alga, *Gracilaria verrucosa*, requires further investigation in view of the recent treatment by Steentoft *et al.* (1995).

I found the author's method of citing references confusing and time-wasting. I would have preferred them to be all together at the end of the book and referred to in the text in the convential way. Instead, Osborne has listed them at the end of the Introduction and then at the end of the main text, whoch results in some repetition. Furthermore, he has employed within the text a system of abbreviating commonly used publications and authors, which are then listed separately from the more conventionally cited references.

The book contains 16 coloured plates of high quality, depicting different habitats of seaweeds, herbarium specimens and *in situ* photographs, as well as some illustrations of historical interest. However, there is much wasted space, with many half plates occupying the entire page. So as to keep down printing costs, this space could have been taken up with perhaps line drawings of the photographed specimens, showing their characteristic features.

Overall, this is an interesting book with plenty of distributional data useful to the phycologist involved in the Irish and British floras. It indicates that the careful collector continues to have an important part to play in descriptive marine ecology. Also, the sublittoral still has many species, either new to science or to the region, to be encountered, For its price, a bargain - and there are not many reviewers who can say that these days for new books.

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BOOK REVIEW

BENTHIC BIODIVERSITY IN THE SOUTHERN IRISH SEA. 1995. Mackie, A.S.Y, Oliver, P.G. & Rees, E.I.S., 1995. ***Studies in Marine Biodiversity and Systematics from the National Museum of Wales. BIOMôR REPORTS. 1: pp271.*** **£25.**

This work represents the most comprehensive study to date of a little-known region in British seas. It results from two surveys in 1989 and 1991 covering an area from Anglesey to southwest of Pembrokeshire to depths in excess of 100m, using a combination of quantative and qualitative techniques. Data on sediment characteristics, both chemical and physical, are presented. As with many earlier surveys, benthic communities are identified and correlated with sediment granulometry. This investigation goes considerably further than most, however, as the authors have called upon additonal specialists to provide truly comprehensive coverage of macrofaunal taxa. Some 1045 species were recorded from 73 stations, with many potentially 'new' species requring further taxonomic study. Major faunal groups are dealt with in turn by the individual specialists. Much effort has been directed towards data analysis using a range of statistical techniques. Chapters are devoted to classification and ordination, fauanl assemblages and biodiversity. Three major benthic assemblages with 8 subdivisions, and a further assemblage restricted to an inshore region of Cardigan Bay are identified. The data is presented in a series of attractive colour maps, with text boxes highlighting the key species. Extensive appendices of raw data and a comprehensive bibliography make this report an excellent source for future studies in the area.

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