

Porcupine Newsletter

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PORCUPINE ANNUAL GENERAL MEETING

This will take place on SUNDAY 6 APRIL at Portaferry. If you have any item you would like to be discussed please inform Ian Killeen now.

There will be a committee meeting prior to the AGM. Please could council members who will be present contact Ian as soon as possible, telling him of any business they might have. He would like to know who will be present and wishes to draw up an agenda.

EDITORIAL

This issue of PORCUPINE NEWSLETTER is composed of one paper and many Abstracts of contributions to the Egham meeting and thus is a little different in layout. I now have no copy at all for the next issue and would be grateful for articles and news items. May I draw your attention to the Letter to the Editor: ideas please.

Again may I draw your attention to the next meeting of PORCUPINE which will be at Portaferry 5-6 April 1997. See the enclosed leaflet. This will be an excellent meeting so if you can possibly get there, and haven't already done so, please contact Julia Nunn ASP.

Most back numbers of PORCUPINE NEWSLETTER are still available and are now all with me. We would be delighted to sell them at £1 per copy including postage & packing. Discounts for larger orders negotiable. Please contact me. I will bring advance orders to Portaferry.

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RECENT MUD SHRIMP BURROWS AND BIOTURBATION

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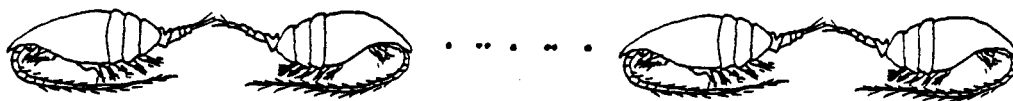
INTRODUCTION

Eight species of mud shrimp (Crustacea: Decapoda: Thalassinidea) are found in British waters, occurring from the intertidal to depths of 1400m, in admixtures of sediment from mud to pure sand (Hayward & Ryland, 1995). There are primarily suspension-feeding species such as *Upogebia pusilla*, *Upogebia deltuara* and *Upogebia stellata*, and primarily deposit-feeding species such as *Jaxea nocturna*, *Axius stirhynchus*, *Calocaris macandreae*, *Callianassa tyrrhena* and *Callianassa subterranea*. All these species construct marvelous burrows which vary in their inter-specific design and complexity (eg. Nash *et al.*, 1984; Nickell & Atkinson, 1995; Rowden & Jones, 1995).

The present investigation of one of these mud shrimps, *Callianassa subterranea*, was stimulated during an interdisciplinary study of sediment resuspension in the North Sea. As part of this large study (NERC's North Sea Project), we were charged with elucidating the potential influence of the benthic fauna on the physical properties of the seabed. In addition, we were asked to highlight the implications of such possible modifications for sediment resuspension in the North Sea.

METHODS

The primary site of investigation was in 50m of water in the southern North Sea; the bottom consisted of muddy-sand and was sampled remotely using box-coring and still photography on three occasions in 1989 (Rowden & Jones, 1994). Because of the site's position and depth, direct field investigations were limited, therefore, we used laboratory experimental studies to quantify the species' influence (via its bioturbatory activities) on sediment resuspension. Shrimps, collected from the site by repeated box-coring, were maintained on the ship in small individual containers for the duration of the cruise, then transported to the laboratory in Plymouth (together with a quantity of their native sediment for stocking the experimental setup). The experimental tank contained circulating seawater (the temperature of which could be controlled), into which so-called microcosms (plastic containers which represented the surface area available to a single shrimp under natural population density) holding sediment (which had been allowed to re-consolidate for 2 weeks), and one shrimp of known size and sex were placed. Shrimps began to burrow almost immediately after their introduction into the microcosms. Burrow inhalent openings, and the mounds of sediment expelled during burrow construction and maintenance, were apparent on the sediment surface shortly after introduction of the mud shrimps. This expelled material was collected (by syringing it from a dessert pot placed over the exhalent hole) daily for a week and, thereafter, twice a week for 90 days. Following each sampling, the expelled sediment was washed, dried and weighed. The experiment was run at three temperatures (7, 9 and 15°C) selected based on the temperatures at the North Sea study site in January, May and September (the times of the main interdisciplinary investigation cruises). After the expulsion rate experiment at 15°C was terminated, resin casts of burrows were made to examine details of burrow structure (Rowden & Jones, 1995).



RESULTS

Bioturbatory activity

After an initial period of high expulsion activity (which was correlated with establishing the burrow), the shrimps settled into a regular pattern of expulsion activity and inactivity. Larger shrimps actively expelled sediment for extensive periods which were separated by a few long breaks of inactivity (week or more). Smaller shrimps exhibited shorter periods of expulsion activity and, although these were also punctuated by bouts of inactivity, they only lasted a couple of days. The results show that the amount of material expelled to the surface mounds (daily rate) was related significantly to size and temperature. That is, smaller animals expelled less sediment from their burrows than larger ones, and animals experiencing the summer temperature (15°C) expelled significantly greater quantities than those experiencing spring (9°C) and winter temperatures (7°C) (Fig. 1).

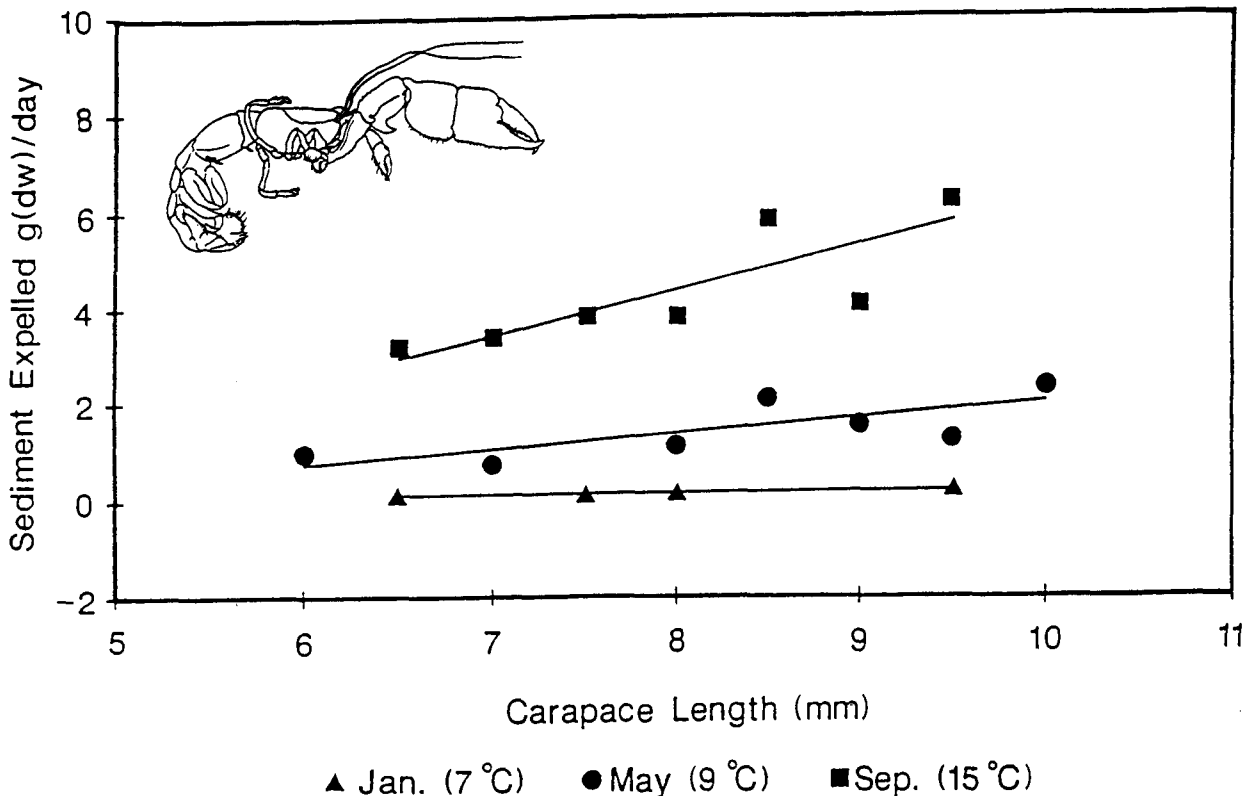


Figure 1. Relationships between mud shrimp size, temperature and sediment expulsion rate for *Callianassa subterranea* from the North Sea study site

The population size structure of *Callianassa subterranea* at the study site (Rowden & Jones, 1994), together with the results of the expulsion activity experiment (Fig. 1) (see also Rowden & Jones, 1997a), allowed an estimation of the amount of particulate material expelled to the sediment surface by the burrowing and feeding activities of these animals for each of the three study months (0.06 kg/m²/month in January, 0.4 kg/m²/month in May and 2.8 kg/m²/month in September). From a non-linear quadratic regression of the sediment expulsion rates against temperature it was possible to obtain estimates corresponding to temperatures between 6 - 15°C. Combining these predicted values with the monthly seawater temperatures measured at the site in 1989, an annual pattern of *Callianassa* sediment expulsion was obtained (Fig. 2). The model illustrates that the shrimps expelled relatively negligible quantities of sediment during the months of January to April, before they began to increase output steadily through the spring and early summer. The maximum expulsion rate was achieved at the end of the summer, then activity decreased through the autumn before sediment expulsion returned to more modest rates, corresponding to the lower temperatures experienced at the year's end. The summed monthly estimates predict a total annual sediment expulsion of 11 kg/m²/yr (Fig. 2). Seabed photographs went some way to confirming this picture of seasonal bioturbatory activity. In January, there was no visible evidence of *Callianassa* activity, the bed appearing essentially flat and smooth; whilst in September, the bed was littered with numerous *Callianassa* expulsion mounds and the depressions which indicate the inhalent entrances to their burrows (Rowden et al., 1997a).

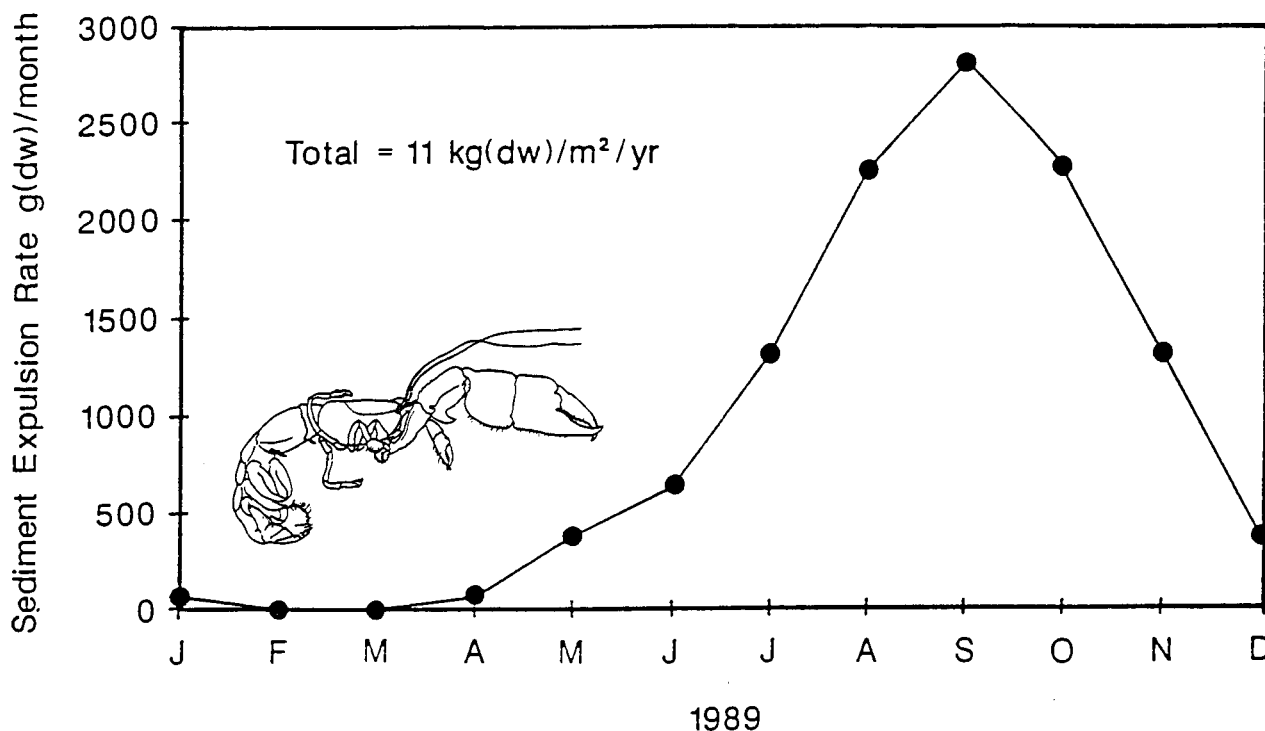


Figure 2. Estimated annual pattern of sediment turnover by *Callianassa subterranea* at the North Sea study site

Burrow structure

The resin casts revealed a wonderful, highly complex burrow form consisting of a multi-branched network of tunnels connected to several inhalent shafts, each terminating in a funnel-shaped opening at the surface (Fig. 3).

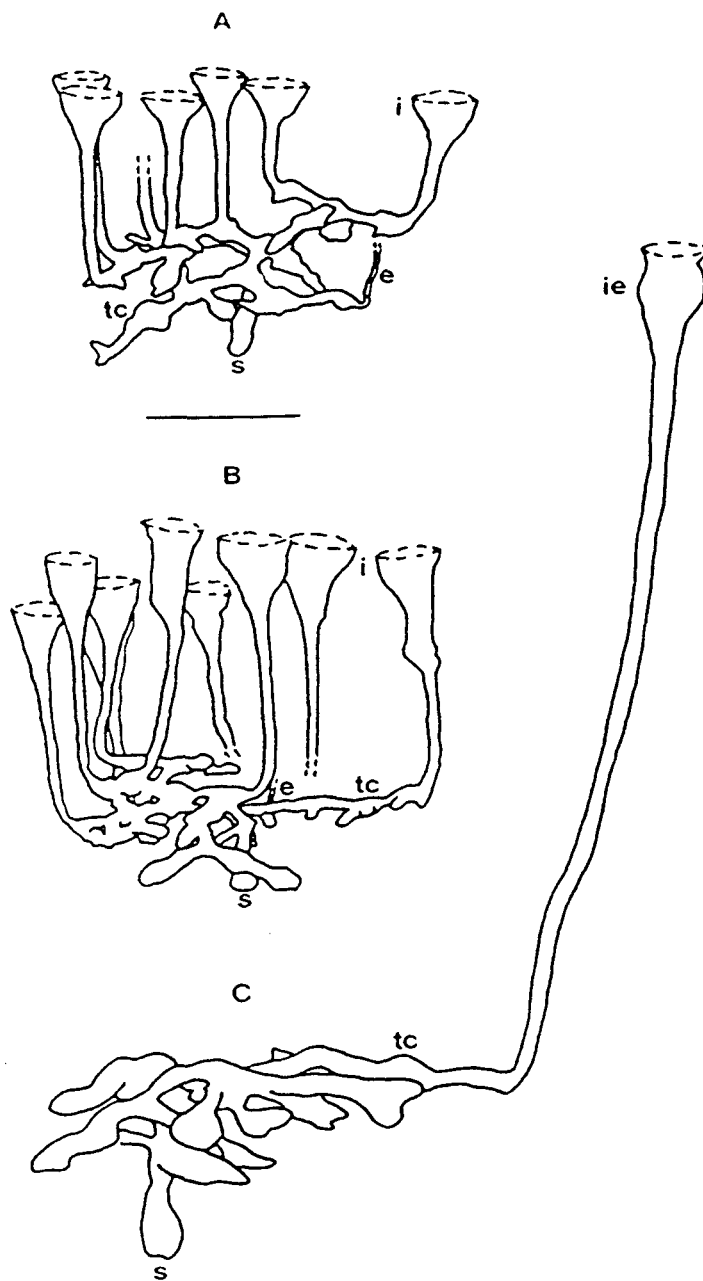


Figure 3. Resin casts of *Callianassa subterranea* burrows made in (A) sandy sediment from the North Sea study site, (B) redrawn from Witbaard & Duineveld (1989); and (C) in muddy sediment from a Scottish sea loch (redrawn from Atkinson & Nash, 1990) (i = inhalent opening; e = exhalent shaft; ie = inhalent and exhalent opening; s = sump; tc = turning chamber) (scale bar = 10cm). Exhalent shaft not cast in C. (Figure reproduced from Rowden & Jones, 1995)

In addition, a single (sometimes 2 or 3), much narrower exhalant shaft ended at the surface in the mound of expelled sediment. The mean diameters of tunnels, shafts and burrow volume were related directly to the size of the constructing shrimp. The only significant difference in burrow form between males and females was the number of shafts (and corresponding inhalant openings); females constructed between 4 and 5, whereas burrows of males possessed between 6 and 8 openings. The burrow tunnels were punctuated with a number of turning chambers which the shrimp uses for changes of direction (by somersaulting). The resin casts also revealed how the *Callianassa* burrow effectively utilises the space (for deposit feeding) which it occupies. Sediment cores taken at the study site revealed some interesting profiles for the geotechnical measures made. In particular, elevations in water, organic and fine fraction content were found to coincide with the mean depth achieved by the horizontal network of tunnels of the laboratory-cast burrows. Such values give indirect evidence of the physical influence that burrows impose on the sediment in which they are constructed (Rowden et al., 1997a).

DISCUSSION

The influence of mud shrimps on the total sediment dynamics of the North Sea is difficult to estimate because of variabilities related to current strength, temperature, mud shrimp population density and differences in bottom sediment characteristics. *Callianassa subterranea*, however, has the potential to contribute significantly to the process of sediment resuspension considering its wide geographical range in the North Sea. Thus, it was the recommendation of this study (to the North Sea Project) that the activities of *C. subterranea* must be included in any discussion of the fate of contaminants and the modelling of water quality in the North Sea (Rowden et al., 1997b).

Comparison of our burrows with those cast by other workers studying *Callianassa subterranea* indicate similarities and differences. The burrows cast in the laboratory by Witbaard & Duineveld (1989) of shrimps from sandy sediments of the North Sea were remarkably similar to those of our study; however, those of Atkinson & Nash (1990) cast in situ in the muddy sediment of a Scottish sea loch were, on the whole, of a simpler (the latter usually comprising of only one inhalant opening) and deeper (up to 81cm deep) construction (Fig. 3) (Rowden & Jones, 1995). Clearly, *C. subterranea* exhibits plastic burrow construction behaviour. The differences between burrows constructed in mud (Atkinson & Nash, 1990) and in sand (Witbaard & Duineveld, 1989; Rowden & Jones, 1995) may be related to differences in the associated organic content of the sediment. The sediment organic concentration at our site in the North Sea was much lower than at the Scottish sea loch. As *C. subterranea* is a deposit feeder, it is likely that in low food conditions animals are forced to construct more complex burrows to support their energetic costs compared with animals living in the organically-rich sediments of Scottish sea lochs.

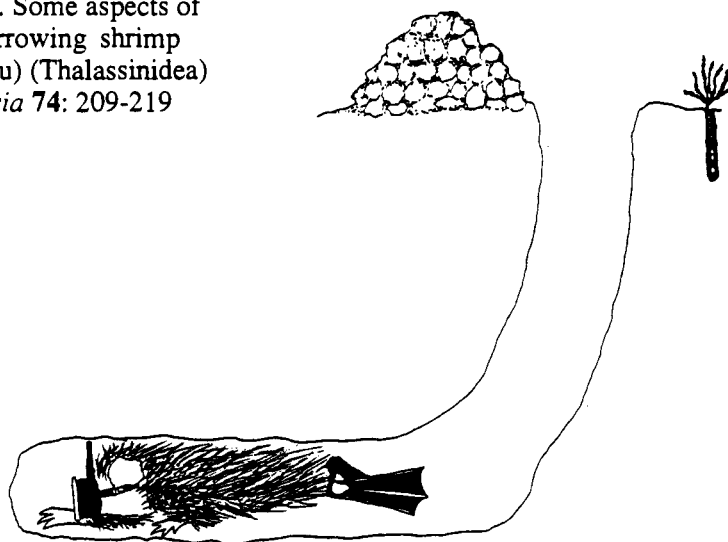
In conclusion, our study of one recent thalassinid species, *Callianassa subterranea*, confirms that mud shrimps are major bioturbators of marine sediments. There are both negative and positive implications of this behaviour for fossil studies. One negative aspect is that bioturbatory activity can obscure or alter traces of any associated fauna. A positive aspect is that such mud shrimp activity will leave a particular signature in the stratigraphy which will at least indicate their presence even if neither burrow nor organism is preserved. Our finding that individual mud shrimp species are capable of exhibiting burrow plasticity means that it is possible to misinterpret a fossil species' identity solely from the remains of its burrow (unless the range of its burrow plasticity is known). Thalassinid burrow form, however, might be usefully utilised to infer the fossil sedimentary environment. We believe this second finding merits further attention and discussion by those who study both recent and fossil burrowing fauna.

ACKNOWLEDGEMENTS

We thank Jan Light and John Wilson for the invitation to present our work at the very successful Porcupine Meeting held at Royal Holloway ('Animal and Sediment Interactions in the Marine Environment'), and Taylor & Francis (Publishers) for permission to reproduce Figure 2 from our paper in the Journal of Natural History (Vol. 29). The study was part funded by a DoE contract (PECD 7/8/141) for which we are most grateful.

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**SHORT CONTRIBUTIONS: ABSTRACTS AND POSTERS OF
THE EGHAM MEETING
"ANIMAL AND SEDIMENT INTERACTIONS IN THE MARINE
ENVIRONMENT"**

**HOLOCENE PALAEOENVIRONMENTAL EVIDENCE FROM SUB-
FOSSIL MOLLUSC SHELLS IN THE SOUTHERN NORTH SEA**

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The floor of the Southern North Sea between Flamborough Head and the North Norfolk coast consists of a relatively flat plateau with water depths generally between 30 and 35 metres. This plateau is mostly underlain by till deposits left behind by the retreat of glacial ice which covered the area around 18,000y BP. As the Pleistocene ice sheets melted sea levels rose, but it was not until around 8,700y BP that the southern margin of the rapidly expanding North Sea entered the northern part of the area. By around 6,400y BP the North Sea had spread southwards to reach limits similar to those of the present day.

Holocene marine deposits on the shelf in this area include thin sand sheets and sand ribbons. Thicker sands have accumulated to form linear sandbanks up to 40 metres thick. Holocene marine sands are also found within a series of elongate palaeovalleys. The unfilled portions of these palaeovalleys form the bathymetric enclosed deeps which include Inner Silver Pit, Sole Pit and Well Hole. Cores from the infills have recovered marine sands which contain a fauna of marine molluscs including the Queen Scallop (*Aequipecten opercularis*). One shell from a depth of 1.72 metres within the infilling sediments has yielded an age of 1835 + 50y BP indicating a relatively rapid rate of deposition. The dated subfossil *Aequipecten* shells can be used to study past environmental conditions including variations in water temperature. Analysis of oxygen isotope ratios in transects of samples taken from successive growth increments of an individual shell enable the seasonal variations in water temperature to be determined. Results so far from shells dated 1835 to 2250 + 50y BP show summer and winter temperatures to be similar to those at the present time.

During the transition from terrestrial to marine conditions intertidal sediments were deposited in the area now covered by the Southern North Sea. The rapidity of the transgression has meant that only thin patches of these deposits have been preserved, representing a relatively narrow time span. Seismic profiles and shallow core data allow the distribution of the preserved remnants to be mapped. The distribution of certain intertidal mollusc shells, such as *Cerastoderma edule*, in the surface sediments appears to reflect the mapped distribution and may additionally indicate former limits of intertidal deposition where the Holocene sequence has been removed by erosion.

BIOGENIC CARBONATES AND MACROFAUNA ON THE NORTH SCOTTISH CONTINENTAL SHELF

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Biogenic carbonates are forming extensively on the continental shelf west and north of Scotland. These carbonates have been accumulating since the Flandrian transgression and their faunal compositions reflect the variations in the present-day sedimentary environments on the shelf. The sediments are predominantly carbonate rich sands which often form sand waves and sand patches as a result of the influence of tidal currents. The sediments range in thickness from a few cms to 2m. but on the inner shelf bedforms of up to 20m thickness may occur.

As part of a study into the Recent sediments and associated fauna of the middle and outer continental shelf and upper slope, a series of benthic and sedimentary samples collected by Smith McIntyre grab from stations on two transects running sequentially for 130 km have been analysed. The transects run north west and south east of the island of Foula on a bearing of 310°. Sediments grade from coarse shell gravels and shell lag deposits south and west of Shetland to calcareous sands across the shelf. On the outer shelf and shelf edge the sediments are dominantly siliciclastic grading from muddy sand through pebbles and cobbles to boulders on the upper slope. Analysis of the faunal composition of the sediments shows that on the inner and middle continental shelf between the south of Shetland and Foula the sediments are rich in bivalves, encrusting serpulids and barnacles in varying proportions. Gastropods and echinoderms occur relatively consistently throughout. Between northwest of Foula and the shelf break there are extensive sand patches which support a characteristic fauna which includes the free-living serpulid *Ditrupa arietina* and 'stick' bryozoans of the family Crisiidae.

Analysis of the benthos shows that the assemblages of the inner/middle shelf environment and the shelf edge/upper slope environment each contain species exclusive to their respective habitats. Conspicuous species in the former environment include, for example, a suite of bivalves including *Glycymeris glycymeris*, *Spisula elliptica* and *Gari tellinella* while the echinoid *Cidaris cidaris* and the bivalve *Astarte crenata* are common in the latter areas. Live-collected specimens of some species such as *Antalis entalis*, *Timoclea ovata* and *Circomphalus casina* are present in both environments. The distributional patterns of the living fauna are reflected in the faunal composition of the skeletal components of the associated sediments.



BURROWS AND BURROWING ACTIVITY IN PRESENT DAY ENVIRONMENTS AND THEIR IMPLICATIONS FOR THE FOSSIL RECORD

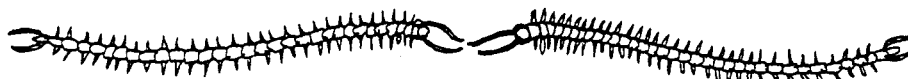
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Almost all superficial sediments in marine, deltaic and estuarine environments contain infaunal animals that construct burrows, transport sediment or leave traces. Some of the abundances of these organisms are extraordinary. Small infaunal Crustacea that construct simple burrows in estuarine environments have densities of up to 4000 organisms per metre². The effects of this activity range from transient phenomena that are apparently ephemeral, to features that are so long-lasting that they are likely to be incorporated into the fossil record. At one extreme, for example, burrowing worms can produce microscale changes in the oxygen profiles and nitrate concentrations just above and within their burrows, and their burrow linings provide microhabitats for meiofauna and micro-organisms. The burrowing of some organisms such as the lug worm *Arenicola marina* can produce shell beds below the zone of their activity. On a larger scale, fish produce mega-burrows that are sometimes complex and extend more than a metre into the sedimentary fabric. When infilled these burrows may be readily recognised below the normal zone of biological activity. We have recorded what appear to be infilled mega-burrows of this sort in sediments in the Pacific Ocean at water depths in excess of 4000 metres. There is consideration of the potential time scale of these burrowing activities in relation to the development of a permanent record in the sedimentary column, and one can discuss ways in which some of this surficial biological activity is coupled with and eventually incorporated into the fossil record, while other parts are entirely lost.



DISTRIBUTION PATTERNS, FEEDING TYPES AND SEDIMENT PREFERENCES IN POLYCHAETES

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Examination of the distribution patterns of species of benthic polychaetes off the coast of Northumberland indicates that most have restricted distributions. Division of the sea bed by sediment types is not particularly easy except in very broad terms. In general, there is a good fit between species distribution patterns and the distribution of these rather broadly defined sediment types. However, there are some species which seem to be rather widespread, and consequently catholic in their tastes regarding sediment. This makes these species, their feeding biology and life histories particularly interesting.

ANIMAL-SEDIMENT INTERACTIONS IN THE INTERTIDAL ZONE

By JOHN MURRAY

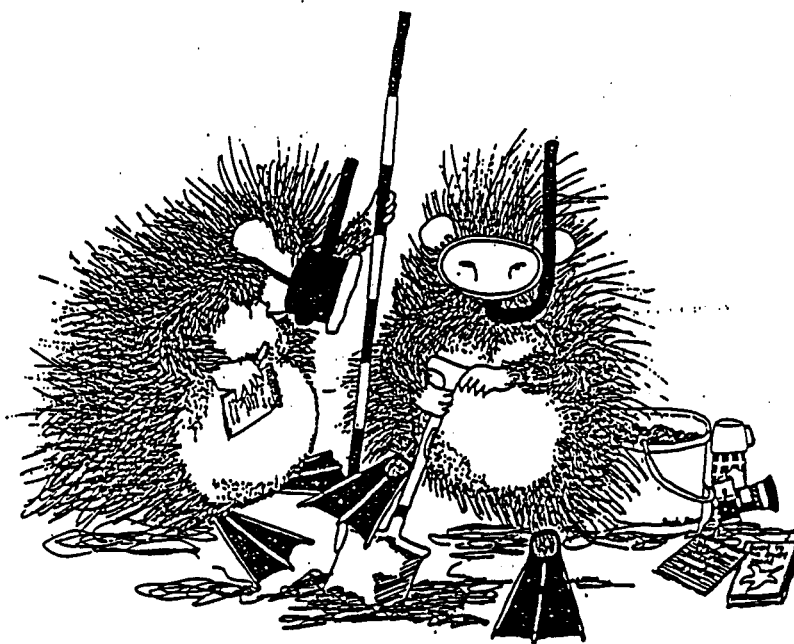
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We all know that organisms are influenced by the sediment in which they live and the sediments are in turn influenced by the organisms, most noticeably by bioturbation. In practice, biologists studying the organisms commonly take a sample and preserve it before sieving out the organisms which are now dead. Likewise, the sedimentologists take a sediment sample and carry out a size analysis, perhaps gathering information on TOC and CaCO₃. Correlations between sediment types and faunal abundance or distribution may be made from such data.

Very few people look at the sediment in its natural state to observe processes in action. The aim here was to reveal some faunal-sediment interactions by means of video recording observations of freshly collected sediment.

In the intertidal zone of Southampton Water, the sediment is populated with large numbers of meiofauna (Foraminifera, Nematoda, Turbellaria, Ostracoda). In muddy areas, the small gastropod *Hydrobia* is commonly abundant and *Corophium* is also present. All these forms are infaunal, although some spend part of their time at the sediment surface. Within the sediment, they are confined to the oxidised surface layer or the oxidised haloes around burrows of larger organisms. All these small organisms influence the sediment by making microscopic burrows. Some secrete mucilage to lubricate their movement and this binds clay minerals into aggregates. *Hydrobia* actively ingests the clay-grade sediment for food and produces large numbers of faecal pellets made of clay. *Corophium* makes open burrows which it flushes with circulating water. Ostracoda appear to graze on material (?bacteria) coating sand-sized grains. Sandy sediments are constantly disturbed by Ostracoda which have a similar size to the detrital particles.

The message here is that much can be gained by looking at fresh material in a natural state.

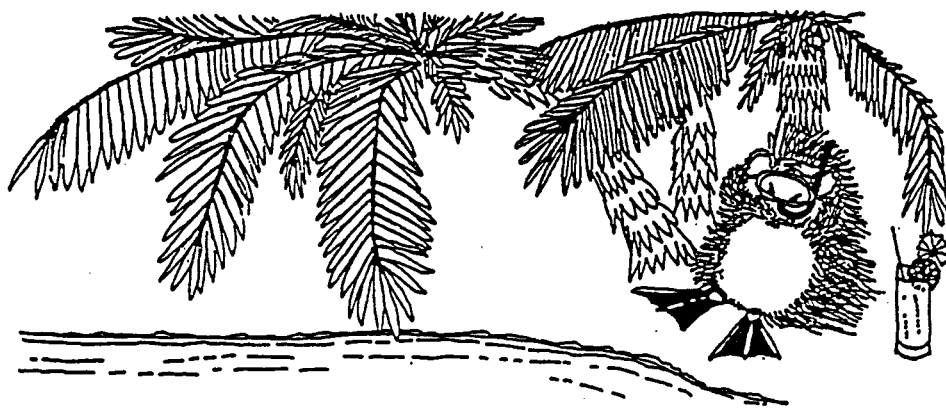


MACROBENTHIC COMMUNITIES IN CARBONATE SEDIMENTS OF ROCAS ATOLL (NE BRAZIL)

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Rocas is the only atoll in the South Atlantic and is situated 266 km offshore from the NE Brazilian coast (3°51'S 33°49'W). The atoll has a slightly elliptical shape, with the long axis measuring around 3 km, and its reef rim composed exclusively of coralline algae, vermetids and foraminiferans. During March/April and July/August 1994, macrofaunal and superficial sediment samples were taken from 45 sites in the surrounding sublittoral area, central sand flat and reef flat pools. Satellite imagery was used to guide field work and to aid the understanding of the spatial configuration of the sediments and faunas. Distributional techniques, univariate and multivariate methods were used in order to analyse and compare the spatial distributions of the sediments and faunas and the interactions of each in the three sampled habitats. In the sublittoral area, the influence of strong SE currents is shown by the presence of coarse sand and low species diversity and abundance. As a consequence of changes in the hydrodynamic regime, sediment grain size decreases in the central sand flat, and particularly in the reef flat tidal pools. Benthic invertebrates of these habitats show higher diversity and population density. This first survey on Rocas Atoll suggests that local macrobenthic communities are conditioned by the degree of exposure of the habitats. The composition of these communities and the spatial distributions reflect the prevailing sedimentation patterns of each particular area.



DEEP WATER CORAL REEFS WEST OF NORWAY

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The deep-water coral *Lophelia pertusa* (L.) is widely distributed in the north-east Atlantic. Detailed investigations of the occurrence of this coral on Rockall Bank showed that it occurs as patches which are more or less circular and may be up to some 50m in diameter. These patches contain many individual colonies which are generally about 1.5 - 2m in height. There is no evidence of significant vertical build-up of coral debris in these patches.

The occurrences of deep-water corals west of Norway are very different. Investigations to date have shown the presence of a deep-water coral reef mound complex in excess of 5km in length and up to 35m in height located on a former glaciated shelf in 270m of water at ca 64° N off mid Norway. The reef mound is located on a narrow rocky ridge that is bordered by glacio-marine deposits. The ridge lies in a narrow deep water channel between two adjacent shallow water shelf banks. Despite the considerable thickness of the coral framework, the whole reef mound must be relatively young. The glacial retreat from that location commenced approximately 13 - 12ka ago and lasted until 7 - 6ka when the modern oceanographic and nutritional regime was established along the Norwegian shelf.

During the period 12 - 7ka the area was affected by a rapid sea-level rise, by sedimentation patterns related to iceberg activity (formation of iceberg plough marks and deposition of ice-rafted debris) and by pulses of water of reduced salinity due to the discharge of meltwater from the decaying ice shield. Such conditions are clearly unsuitable for the settlement and growth of corals but they provide the crucial prerequisites for the subsequent development of the coral reef within a siliciclastic sedimentary environment. Initial reef growth started on exhumed rocky outcrops along the ridge which largely controls the elongate geometry. Apart from this reef mound chain, several smaller circular patches or slightly elongate mounds always occur on the gravel and boulder accumulations which fringe the iceberg plough marks.

Investigations using underwater television suggest that there were at least two phases of intense reef mound development during the latter part of the Holocene.

Lophelia pertusa

Illustration from Wyville Thomson, 1874. "The depths of the Sea"



PALAEOICHOLOGY AT SEA: ARE THERE REAL EXPLANATIONS TO EMPIRICALLY USEFUL OBSERVATIONS?

By ROLAND GOLDRING

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Study of animal and plant activity in fossil sediments has increased over the past decade and now plays a significant role in applied geology: in the interpretation of ancient sedimentary environments and in the field of petroleum production. But study of modern activity patterns has not altogether kept pace, except with deep sea traces. Some of the problems facing palaeoichnology and the possibilities of resolving these, such as the reality of the colonization window (the time slot available for larval settlement or relocation, relative to sedimentation); passive and active burrow fill, especially in the formation of concentric lamination; ichnotaxobase validity (is the fossil morphology sufficient?); extinction of behaviour patterns at the Precambrian - Cambrian boundary.

BIOLOGICAL EFFECTS ON SEDIMENT GEOTECHNICS AND GEOCHEMISTRY IN COASTAL ZONE AND OFFSHORE ENVIRONMENTS

**By AZRA MEADOWS*, MASROOR A SHAIKH, FRASER J C WEST
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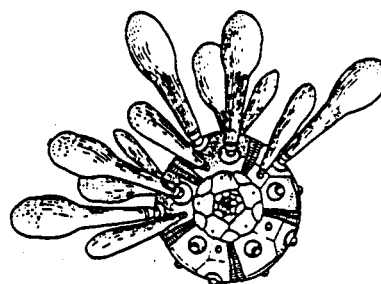
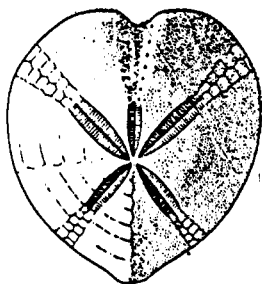
Biological activity can have major implications on sediment stability, erosion and deposition in sedimentary environments. Furthermore, biological effects on the geotechnical and geochemical properties of sediments are diverse, and may have major significance for civil and environmental engineering, coastal zone development, and the offshore oil industry. We have considered examples of how benthos affect the geotechnics and geochemistry in contrasting sedimentary environments of the coastal zone and offshore region. Under laboratory enrichment conditions, estuarine heterotrophic and photosynthetic micro-organisms can have dramatic effects in reducing sediment permeability. This is a result of microbial blocking of the inter-particle pore spaces and hindering fluid exchange between surface sediments and the overlying liquid. Field studies in the intertidal environment have shown a surprising degree of spatial variability in the relationships between infaunal communities and sedimentary parameters such as shear strength and redox. This may have implications for the development of biodiversity and its variability. Surface-dwelling organisms can also have a major impact on sedimentary ecosystems. For example, mussel beds are well-documented from both the intertidal and sub-littoral zones and may act to protect coastal zone environments. Investigation of the relationship between redox and pH in sedimentary environments have demonstrated that biological activity may be very important both in the intertidal zone and in unusual anoxic conditions in the deep sea. The possible reasons for this include *in situ* activity and biological inputs from the water column. Benthos-sediment interactions, therefore, have important environmental implications for coastal zone protection and management and for our future understanding of processes in deep water sedimentary ecosystems.

CONSTRAINING SURFICIAL MOVEMENT DUE TO BIOTURBATION BY MODELLING SEDIMENT TOPOGRAPHY OVER MID-OCEAN RIDGE FAULT SCARPS

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Bioturbation in pelagic sediments on slopes may cause some downslope movement of the sediment surface by mechanisms such as burrow collapse and burrow excavation. If this hypothesis is correct, these may cause a slow movement analogous to hillslope creep on land. Constraining the rates of movements due to these processes in deep water, however, is difficult due to the inaccessibility of these areas and because effects of creep-like movements are likely to be obscured by the results of more energetic sedimentary processes. Some work has been done on modelling sediment topography across fault scarps on the Galapagos Spreading Centre in the eastern Pacific using bear-bottom sediment profiler records. Assuming the movement can be described using the diffusion transport model, which has been used for hillslope creep on land, the sediment topography can be modelled with a down-slope flux of - 16 g/cm/yr for a 30° slope, which corresponds to a 2 cm/yr creep rate if the mobile layer is 25 cm thick. Due to complications such as effects of bottom currents and surficial slumping along scarp edges, these values are upper bound on creep rates and are generally much lower than rates due to other sedimentary processes.



SEDIMENTS AND ECHINOID EVOLUTION

By EDWARD P F ROSE

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Echinoids first occur in the fossil record in the Late Ordovician, and persist throughout the subsequent Palaeozoic as relatively rare individuals, of low diversity, "regular" (radially symmetrical) in their test morphology, probably all epibenthic, living mainly in hard substrates, and feeding by scraping. The most dramatic change in ecological strategy occurred within the Mesozoic, with adaptation to feeding on and within unconsolidated sediment, "Irregular" (bilaterally symmetrical) echinoids first occur in the Early Jurassic (Sinemurian-Pliensbachian), quickly radiating into three distinct clades with parallel evolution on an exocyclic from an endocyclic periproct and other morphological features indicative of infaunal and sediment-ingesting adaptive strategies. Within the irregulars, further evolution was influenced by factors which enhanced an organism's ability to eat or avoid being eaten. Spatangoids first occur in the Early Cretaceous and diversify subsequently, with many lineages (e.g. *Micraster* in the Late Cretaceous, *Schizaster* in the Cenozoic) showing trends of burrowing adaptation associates with decreasing sediment grain size, arguably related to an ability to occupy deeper water habitats. Clypeasteroids, which first occur in the early Cenozoic, also show adaptive evolution related to substrate granulometry. Echinoids never burrow deeply, so their trace fossils are seldom preserved as direct evidence of their interaction with marine sediments, but that interaction profoundly influenced echinoid evolution at both small and large scales.

MARINE MOLLUSCA ASSOCIATED WITH THE REEF-BUILDING POLYCHAETE *SABELLARIA*

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Many species of molluscs, particularly those amongst the Mesogastropoda and Pyramidellidacea, are known to be ectoparasitic on other marine organisms, Whilst for some the hosts are well-known, for others, especially the smaller species, they are not. Until about 20 years ago the pyramidellids were thought to be host-specific. However, recent work has shown them to be more catholic, living on a range of mainly sedentary polychaete species. One species, *Noemiamea dolioliformis*, was regarded as rare with few live records and an unknown biology. Similarly the tiny acclid *Graphis albida*, was also poorly known with respect to distribution and ecology.

Fieldwork by the author in the last 7 years gave an indication that both these species were associated with the tube building polychaetes *Sabellaria* spp. Two species occur in British waters: *S. alveolata* and *S. spinulosa*. Both are colonial and live in tubes made of sand grains. *S. alveolata* in particular form reefs firm enough to walk on.

Systematic field work targeted at locating *N. dolioliformis* and *G. albida* has confirmed these inferences. *Sabellaria* colonies at several locations around British and Irish coasts and also along the Channel coast of France have been sampled and their molluscan faunas determined. This work has revealed that *Sabellaria* is the host for these two species. Of the 16 sites sampled, *G. albida* was found at 8 and *N. dolioliformis* at 11. Other pyramidellids, notably *Odostomia turrita*, *O. plicata* and *Partulida spiralis* were also found at many sites.

Further studies are required to determine more precisely the ecology of these molluscs within the *Sabellaria* colonies.

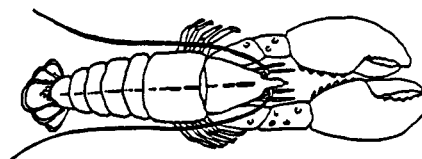
SESSILE AND MOBILE FAUNA AROUND AN ARTIFICIAL REEF

By ANTHONY C JENSEN, K J COLLINS, I P SMITH, J J MALLINSON
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Since deployment in 1989 the Pole Bay artificial reef has been the focus of work relating to colonization and fishery enhancement. Studies range from epibiota colonization of reef blocks to lobster and crab behaviour and their utilization of spaces within reef units. Comparisons can be made with other European artificial reef experiments.



THE USE OF MICRO-BEAM TECHNIQUES FOR THE ANALYSIS OF THE COLD-WATER CORAL *LOPHELIA PERTUSA*

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As we approach the turn of the century, public interest in the quality of our environment has never been higher. Scientists are increasingly being asked, has our environment changed? what is its condition now? and will we be able to monitor future degradation or improvement? The challenge for us is to find the best ways to achieve this. For a number of years corals have been investigated as potential direct or indirect recorders of the ocean environment. The particular advantages of coral colonies are that they are stationary, long lived (10s - 1,000s of years) and leave behind a solid growth structure. Previous work has demonstrated that the chemistry of the coral skeleton is influenced by temperature, environmental chemistry, vital effects and stress.

Earlier studies of coral chemistry have typically involved removing small slices of material in the direction of growth and determining on a millimetre scale, the oxygen and carbon isotopic ratios and/or the elemental concentrations of Sr (and U). These have been used primarily to calculate changes on sea water temperatures but have also been observed to relate to vital effects. More recently, several groups have tried to use micro-beam techniques to obtain such isotopic and elemental information. The advantage of these being great temporal resolution (less than a week's growth) and greater spatial resolution. The latter is important because coral growth mechanisms involve both lateral and longitudinal extension. Additionally, they are species dependent and require a clear understanding of the corals' biology.

In the current study the authors have primarily been concerned with warm-water corals collected from shallow depths in Australia. However, the opportunity arose to look at a deep cold-water coral *Lophelia pertusa* for comparison. The North Atlantic and in particular the Rockall area where this coral is found, has recently been highlighted for concern because of oil exploration. *Lophelia* is of particular interest because the few previous studies have demonstrated that variations in isotopic ratios and elemental concentrations are much larger than those expected from the narrow temperature ranges found in the deep ocean, and appear to be dominated by vital effects.

The *Lophelia* samples analysed had strong concentric features (assumed to be growth related) observable both in hand specimen and thin section. The trace elements Mg, Sr, Ba and U were determined across these growth features by two separate microbeam techniques: Laser ablation microprobe - inductively coupled plasma - mass spectrometry (LAMP-ICP-MS) and the Ion microprobe. The patterns observed by the two techniques are similar but cannot currently be correlated with the visual features. With a deeper understanding of the biology of *Lophelia* it is hoped that we will be able to use these techniques to quantify changes in growth rates, vital effects and stress with time.



THE ORIGIN OF TEMPERATE CARBONATE SEDIMENTS OFF ASTURIAS (NORTHERN SPAIN)

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The morphology and sedimentary processes of the sea floor off Asturias have been studied by Fernandez-ValdPs *et al.* (1994, 1995). They considered that the distribution of sediments on the platform results from changes in sea level associated with the last glaciation. The present study is centred on the biogenic content of these sediments, including the species compositions.

Five samples of coarse sand from the sea floor of the Asturias platform were studied. They range in depth from 17 to 42 metres. The dominant biological groups forming bioclasts are crustaceans (cirripeds) and molluscs (average 42% for crustaceans and 36.5% for molluscs).

The study of textural features on the surfaces of the mollusc shells reveals the existence of four categories:

1. Unaltered; the shells are not modified.
2. Corroded: the shells have been modified, with partial loss of ornament and shell colour. Sometimes the degree of corrosion is very high and they may show pitted surfaces.
3. Polished: the surface has been changed by fine abrasion, with loss of shell ornamentation and the development of lustrous appearance.
4. Stained brown; without natural pigmentation, and very shiny.

Most of the textures of the sediments are of the corroded type. There is a high content of microborings, particularly on the corroded type.

The study in detail of the molluscs present in the samples shows that species from rocky sea floors are dominant. Some species occur that do not belong to the area because they live in shallower water than that in which the samples were found (eg *Rissoa guerinii*). Also found in these samples was a smaller percentage of species from deeper water (eg *Cerithiopsis metaxa*). Also present are some species from sandy and muddy areas (eg *Hinia reticulata*). These specimens have a mostly corroded texture.

In general, the species found indicate an origin in shallower water than now. This is in agreement with a theory of a former low sea level. It is remarkable that there is a complete absence of supratidal forms and a low proportion of intertidal species.

The large amount of microborings, which contain limonite, show that the samples have remained in relatively undisturbed conditions for a long period, which created the right conditions for this high microboring activity.

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TROPICAL CRUSTACEAN BURROWERS

By CLARE BRADSHAW

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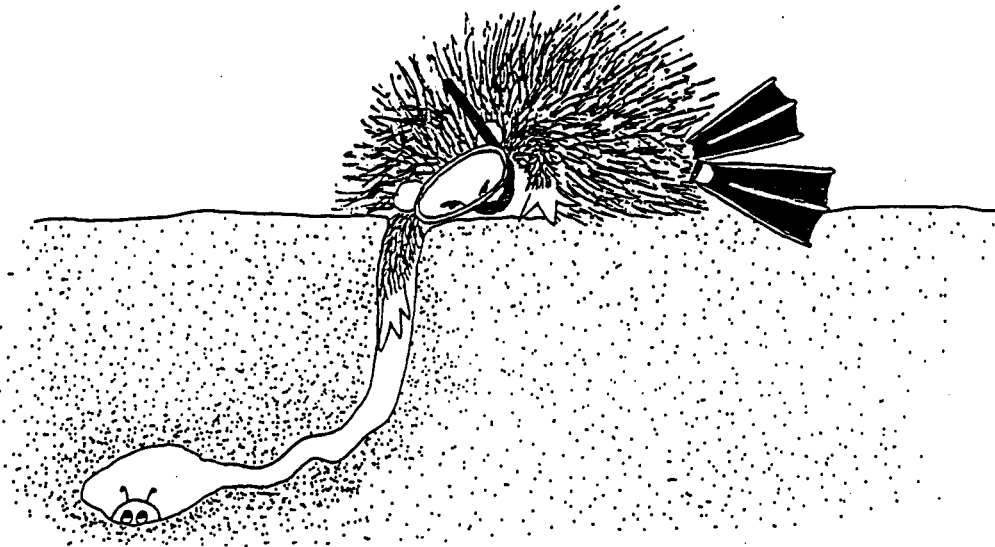
The three most common burrowing crustaceans in the muddy reef sediments of Ko Phuket (South Thailand) are intertidal soldier crabs (*Dotilla* sp) and alpheid and callianassid shrimps (intertidal and subtidal).

Soldier crabs are active during daylight low tides, when they feed on the sediment surface and excavate small cylindrical burrows. Due to their high densities, the resulting sediment turnover rate is high. Their distribution and extent of burrowing across the sand flat is strongly affected by the time of exposure.

Alpheid shrimps vary in their burrowing habitats, the intertidal species making irregularly-shaped sloping burrows and sorting coarse from fine debris as they shovel sediment to the surface. Offshore subtidal alpheids, in contrast, form deep spiral burrows and do not sort sediment. Turnover rates are much less than those of *Dotilla*.

Callianassid shrimps create the most complex burrows of the three crustaceans: a sediment mound and a crater at the surface are linked below by a complex system of chambers, which can contain accumulations of coarse material.

The subtidal environment has a higher preservation potential than the intertidal, with the deeper tier of burrows (in this case alpheids and callianassids) reworking the upper tiers in the most likely scenario of a slowly prograding reef and sediment slope. However, storm events have a major impact on the sediment record, and in the Phuket muds may have left their mark as a patchy coarse layer at depth.

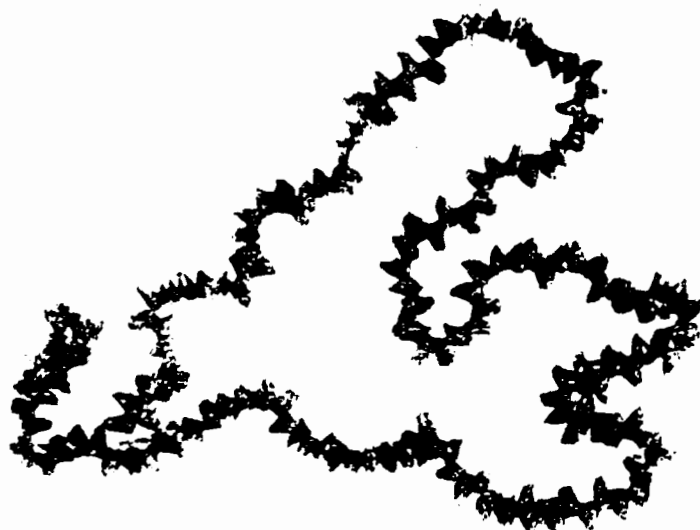
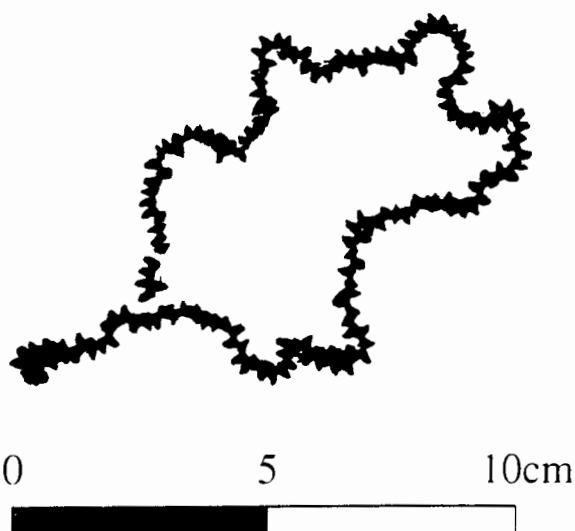


LETTER TO THE EDITOR

From Jenny Mallinson, Department of Oceanography, Southampton Oceanography Centre, European Way, Southampton SO1 3ZH, Tel: 01793 596299, e-mail: jxm@soc.soton.ac.uk

Does anyone know what creature(s) would have been responsible for this? It is a series of tiny box-like, hollow, angular capsules, some with a hole in the end, 'strung' together, in a continuous ring, as if on a thread. The whole was flexible when wet and still is now that it has dried, although the capsules look as if they are fused together. The 'necklace'-like structure is fragile but hangs on a finger without falling apart. The capsules are constructed meticulously from sand grains, more like the tube of the polychaete *Pectinaria* than the haphazard sticking together of *Lanice* tubes. The 'necklace' was found by divers on the seabed near the artificial reef to the north of the historic wreck site in Poole Bay, Dorset, in July 1996. It was in 12m of water on a flat sandy seabed scattered with weed-topped pebbles and shells.

Any ideas, even to Phylum, would be appreciated. Please contact Jenny direct and/or Hon. Editor so that the answer(s) can be published.



BOOK REVIEW

A Student's Guide to the Seashore (2nd Edition) by J.D. Fish & S. Fish. Cambridge University Press, Cambridge. ISBN 0 521 46819 1 (paperback). ISBN 0 521 46279 7 (hardback), 1996. i-xv + 564 pp, 341 text figs. Price: £19.95 paperback. £55 hardback.

The first edition of this book, published by Unwin Hyman in 1989 filled a void left by the classic, but long out of print *Littoral Fauna of the British Isles* by Eales. It provided concise, yet comprehensive information on seashore ecology with descriptive text and illustrations for the identification of all of the British intertidal phyla. It was the work that I found myself continually recommending for use particularly on marine field courses. However, it quickly went out of print and one found oneself saying "sorry, but its no longer available". I am, therefore, delighted that this new edition has been published.

As with the first edition, the authors state that the function of this work is as a field guide and biological text covering the common plants and animals of the shore which is intended for use by undergraduates, teachers and general naturalists. The opening sections cover the shore environment, collection, general principals of classification and nomenclature etc. The bulk of the work is given over to the systematic coverage of the fauna and flora with emphasis on biology and identification. The second edition has been increased by some 100 pages. The biological text has been expanded and updated to include nomenclatural changes and the results of recent studies, and additional species have been included. The most significant change has been the welcome addition of numerous dichotomous keys. For the more difficult groups such as crustaceans and polychaetes these are especially useful.

I have a few small criticisms of the new edition. The loss of the four pages of colour plates, obviously to reduce costs, is a pity. Those of the limpets, in particular, were the best around and clearly showed the differences in foot colouration. I would also like to have seen some of species redrawn. The illustrations of *Rissoa parva* (Fig. 141b & c), for example, are rather crude and could easily lead to misidentification. Another feature retained from the first edition and which I find infuriating is the splitting of the references. A list of References is given at the end of each phylum section (although few of these are actually referenced in the text. A different bibliography on a phylum basis is given at the end of the book.. Surely one set of references/bibliography for each phylum would be easier to use? The strangely generous page layout with wide margins and line spacing results in a book which is really too large to carry around on the shore. A more compact pocket sized guide may have been more user friendly.

In spite of these minor niggles, the second edition is an excellent piece of work. It continues to fill a niche between the more comprehensive and expensive *Marine Fauna of the British Isles* (Hayward & Ryland) and the more general *Collins Field Guide* (Hayward *et al*). I would recommend it to anyone involved in tutoring marine field courses and to general marine ecologists. At £19.95 for the paperback version it represents good value for money.

Ian Killeen