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ABSTRACTS OF POSTER DEMONSTRATIONS

A regional geological and geographical database for the northwest United Kingdom continental margin

M. S. Stoker and **D. Long**

British Geological Survey, Murchison House, West Mains Road, Edinburgh EH9 3LA, Scotland

The British Geological Survey (BGS) has been actively surveying the Continental Shelf and Slope around the United Kingdom since 1968, as part of its regional offshore mapping programme. In the past few years, most of the regional survey work has been concentrated along the Northwest Scottish Continental Margin (Fig. 1), and this work should be completed by 1986.

The geological database consists of shallow seabed samples which include surface grab samples, 1 m to 2·5 m gravity cores, 5 m rock cores, and 6 m vibrocores, and borehole information. Surface grab samples and gravity cores have been recovered down to water depths of 1200 m. In contrast, all of our borehole data are restricted to the shelf above 200 m water depth, although a number of sites proposed for this year are located below the shelf break. The length of the borehole is dependent primarily on the objective to be achieved; in Quaternary sediments up to 230 m of core have been recovered. Sedimentological, geotechnical, palaeontological, palaeomagnetic, X-ray, acoustic and various age dating studies undertaken on the recovered material provide a wealth of geological data.

The geophysical coverage includes shallow and deep tow sidescan sonars, echo sounder, pinger, shallow and deep tow boomers, sparker, small air and waterguns and gravity and magnetic measurements. These instruments are normally operated simultaneously using a purpose built firing control system.

These data are used to compile a variety of offshore geological maps at 1:100,000 and 1:250,000 scale. They give an insight into the regional geological framework and provide a basis for more detailed research and applied studies. These range from purely geological studies such as history of Quaternary sedimentation on the Shelf and Slope, and the evolution of the Continental Margin and related features, e.g. Wyville-Thomson Ridge, to slope stability and geohazard projects and regional geotechnical assessments which are aimed primarily at the offshore industry. It should be noted that all of our basic data are stored on open-file and are available for consultation to any interested parties, on application.

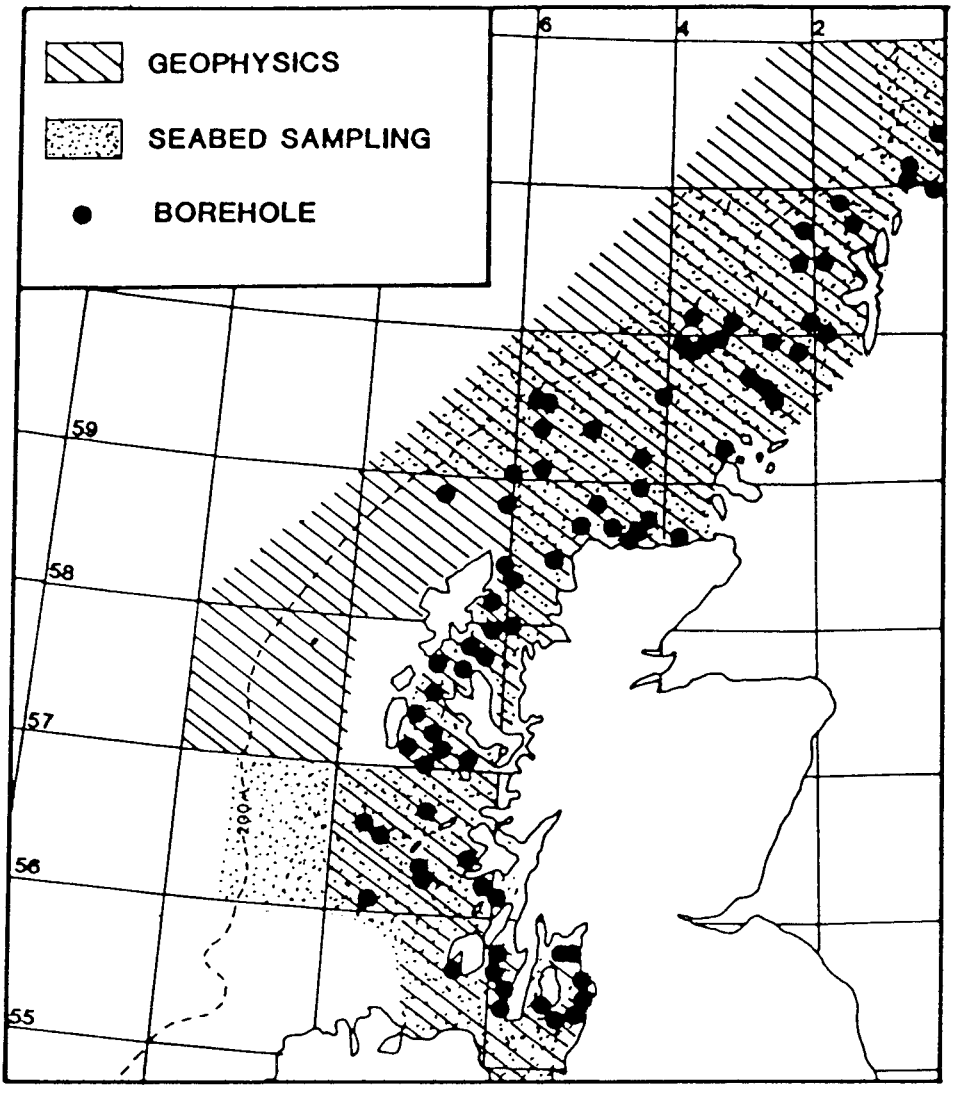

Figure 1. Regional geological and geophysical database on the northwest U.K. continental margin, March, 1985.

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A bathymetric, magnetic and gravity survey of the Rockall Bank

The Hydrographic Department

Ministry of Defence, Taunton, Somerset, U.K.

In two periods, March–May and September–November, 1969, H.M. Surveying Ship *Hecla* systematically surveyed the Rockall Bank. The main scientific and surveying aims of the project were:

(a) To delineate the topography of the bank
(b) To map in detail the complex magnetic fields over the bank
(c) To map the variations in the free-air gravity anomaly on the bank
(d) To obtain sea-surface temperature and salinity data at regular intervals during the survey.

The data obtained during the survey have been published by the Hydrographer in the form of four charts and one Admiralty Marine Science Publication; these form the basis of the Poster Presentation. The charts, all at a scale of 1:250,000 are: C6091—Bathymetry; C6091A—Free-air gravity anomalies (transparent overlay); C6091B—Total magnetic intensity (transparent overlay); C6091C—Magnetic Anomalies (transparent overlay).

The Admiralty Marine Science Publication is entitled *A Bathymetric, Magnetic and gravity survey of the Rockall Bank H.M.S.* Hecla *1969* and is by D. G. Roberts and M. T. Jones, published in Taunton in 1978. It is publication NP 650 (19). The report is concerned primarily with a narrative of the survey and detailed descriptions of the instrumentation and data-reduction methods used in the production of the charts of the Rockall Bank. The geophysical surveying equipment consisted of an Admiralty-type 773 echo-sounder and a Kelvin Hughes MS 38 recorder, a Varian Associates Direct Reading proton magnetometer and a Graf Askania GSS 2 seagravimeter.

The survey lines were originally spaced 2·5 miles apart in a 90° or 270° direction, although these were subsequently interlined to give a track spacing of 1·25 miles. In areas of rough bottom topography with depths of less than 100 fathoms, interlines were run at 0·6 mile line spacing and at 0·3 mile line spacing in the immediate vicinity of Rockall Island.

Continuous observations of depth, total magnetic field intensity, sea-surface temperature, wet and dry air temperatures, and solar radiation were taken throughout the survey and on passage to and from the survey area. Some of these data were recorded on the Automatic Data Logging System.

Examination of the magnetic anomaly chart and profiles shows two major different and distinctive discontinuities that separate areas of contrasting magnetic character. South of a 10 mile wide, approximately east–west trending discontinuity at 56°40′N the magnetic anomalies are highly irregular in both wavelength and amplitude in contrast to those in the north. This discontinuity, though less apparent in the gravity anomalies, may be a fault or the trace of an unconformity that separates the Lewisian rocks known to outcrop on Empress of Britain Bank from the extensive lava flows to the north.

North of this discontinuity, the anomalies are characteristically of short wavelength and large amplitude and can rarely be continuously correlated for more than five miles. Four areas of exceptionally complex character can be seen: around Rockall Island the anomalies have a distinctive pattern due to ring dykes associated with the eroded volcano and are associated with a positive 128 m gal gravity anomaly. Further south the other areas, which also form the shoals, may represent similar intrusive complexes although there are no major gravity anomalies associated with them. However, it is possible that these areas may be inliers of metamorphic rocks surrounded by lava flows.

Copies of the charts and the report can be obtained from Admiralty Chart Agents.

Drifting buoys in the Rockall Trough

D. Booth and **D. Meldrum**

Dunstaffnage Marine Research Laboratory, P.O. Box 3, Oban, Argyll PA34 4AD, Scotland

A series of drifting buoys, tracked by satellite and drogued at depths between 15 m and 165 m, have been released in Rockall Trough. The buoys were specifically designed for current measurement and have a low wind drag.

Results show a general northeastward drift from Rockall Trough into the Norwegian Sea via the Faeroe–Shetland Channel, as expected. The total transport of near surface Atlantic water through the Faeroe–Shetland Channel is estimated to be about $3 \times 10^6 \, m^3 \, s^{-1}$. Six buoys then travelled northeastwards along the Norwegian coast, but two buoys followed topography down into the Norwegian Trench, and became trapped in the mixing between warm Atlantic water and cool Norwegian coastal water.

Topographic guiding was also apparent in Rockall Trough, both at the Scottish continental slope and around the banks such as Rockall and Hatton, generally with shallow water to the right of the current direction. Away from steep topography, currents were weak except in eddies which were mainly found in two areas, northwest of Porcupine and around Anton Dohrn Seamount. Observed current speeds in the eddies were about $0{\cdot}5 \, m \, s^{-1}$ with periods between 1 and 6 days. Eddy radii ranged from 7 km to 50 km, comparable to the scale of temperature anomalies apparent on IR satellite images. This scale is about the internal deformation radius and the eddy formation mechanism is likely to include baroclinic instability. The small cyclonic eddies found near Anton Dohrn are probably shed from a Taylor column generated above the Seamount.

Tagging near surface water of Rockall Trough with drifting buoys has left us an impression of areas of strong circular eddy motion and regions of strong comparatively steady flow above topographic guiding, between which the flows have an irregular interweaving nature, and are perhaps the remnants of decayed instabilities and eddies producing large scale mixing.

Porcupine Bank: the superficial sediments and their fauna

G. Bowes

Department of Applied Geology, Strathclyde University, Glasgow

and

S. M. Smith

Royal Scottish Museum, Edinburgh

The superficial sediments of the Porcupine Bank have been classified according to their grain size and composition—the proportions of lithic materials, pelagic or benthic Foraminifera, other calcareous materials of benthic origin (Bryozoa, Mollusca, Cirrepedia). Four main *facies* have been identified. Living fauna was collected concomitantly and photographic evidence was obtained from a few stations. Communities have been recognised and the interaction of the substrate and the fauna has been considered.

1. In the deep water area to the west of Porcupine Bank there are considerable areas of outcrop. The superficial sediments are composed of abundant pebbles together with mud, which is dominated by pelagic Foraminifera, with lesser amounts of lithic sand and some benthic Foraminifera. The fauna obtained from this area is largely that of a shell gravel/pebble-based community dominated by *Limopsis aurita, Astarte sulcata* and *Brachiopoda.* The finer sediments have an *Ophiothrix lutkeni* community. Overall there is a high calcium demand with recycling of dead shells and input from pelagic Foraminifera.

2. The southwestern part of the bank has less than 50% lithic material but this, nevertheless, is the most abundant single component. The other components are mainly pelagic and benthic Foraminifera. Although pebbles have an immediate local effect on the total faunal composition, the muds and silts of this area have a clear pennatulid, *Hyalinoecia tubicola* and *Abra longicallus* community. Animals were generally rather sparse.

3. The sand-floored crescent around the northern and southern flanks of the bank have over 50% lithic component (in some areas up to 75%) with the rest composed of benthic and pelagic Foraminifera in more or less equal amounts. The area is characterised by a diverse fauna living on the firm sand, including *Actinauge richardii,* pagurids, *Gonoplax rhomboides, Astropecten irregularis,* echinoids, *Scaphander lignarius* etc. Photographs indicate that deep-burrowing Crustacea are abundant.

4. The finer sediment in the boulder field on the top of the bank has a matrix of carbonate sand whose constituents are Mollusca, benthic Foraminifera and only 15–45% lithic material. On the crest there are conspicuous amounts of fragments of Bryozoa, serpulids and Gastropoda. The fauna is the most diverse found, the hard sand communities being added to by those dominated by encrusting species living on the boulders, such as sponges, Bryozoa, serpulid

worms. There is a larger proportion of animals with high calcium demand. Grain size has proved to be of more importance in determination of the community than depth. Carbonate input is also important. Below a certain concentration of shelled animals, above which a shell gravel may be maintained without difficulty, the bottom sediments may have a very low carbonate content with shelly material coming mainly from Foraminifera. Field observations suggest that where shell is at a premium, upon the death of its maker it would be promptly colonised as a substrate from which carbonate could be extracted by a new arrival or as a home to pagurids, often one of the commoner species in such conditions. They live in gastropod shells until these fall to bits (very few empty gastropod shells were found). Shell fragments disintegrate to about 2 mm and then completely collapse. The absence of carbonate in the sediments indicates that it is very rapidly recycled into living organisms. Some differences in community structure between *facies* 3 and *facies* 4 may be attributable not only to grain size but also to the amount of calcium available.

A multiple corer for taking virtually undisturbed samples from shelf, bathyal and abyssal sediments

P. R. O. Barnett, J. Watson and **D. Connelly**

Dunstaffnage Marine Research Laboratory, P.O. Box 3, Oban, Argyll PA34 4AD, Scotland

Reliable samples are essential for accurate measurements of population densities, standing crops and energy flow. When sampling benthic meiofauna, it is necessary to sample the surface layer of the sea bed without disturbing or wafting it aside first before the sampler hits the bottom. It is well-known that most benthic samplers have serious deficiencies, yet the results obtained with them are frequently subjected to sophisticated techniques of statistical analysis. The problems of "bow-wave" effects when sampling the benthos have been emphasised by various authors for macrobenthos, meiobenthos and sedimentation rate and pollution studies.

Except for coring by divers, there is only one design of core sampler capable of taking a virtually undisturbed surface sediment sample; the Craib (1965) corer slowly lowers a plastic sampling tube into the sediment under the control of a hydraulic damper. Although this corer is very successful when used in sheltered inshore waters, there are considerable difficulties in obtaining samples from continental shelf and deep-sea sediments because valve-closing mechanisms are adversely affected by open sea conditions. Other alternatives for meiofaunal sampling include the use of benthic macrofaunal samplers (e.g. van Veen grabs, Reinek box corers) and subsequent subsampling by hand with small core tubes when the large sample has been recovered on deck. However, it has been shown that subsampling the van Veen grab will not give truly quantitative results; only subsampling in a box corer may be considered a quantitative method, although

several subsamples must be taken so as to represent the whole area within the box because the sediment surface is somewhat disturbed. Box corers seldom produce a sample with an undisturbed surface layer and it is unlikely that, when subsampled, the distribution of the meiofauna in the surface layer of the recovered box-core sample will be the same as its distribution in the sea bed prior to sampling.

A new corer was designed to overcome these various problems, and a description is given of a multiple corer (Barnett *et al.* 1984), based on the principle of the Craib (1965) corer, which takes short samples of shelf, bathyal and abyssal sediments with virtually no disturbance. An array of up to twelve plastic core tubes is lowered slowly into the sediment by a hydraulic damper mounted on a supporting framework. Experience has shown the corer to be reliable and capable of taking cores with clear, overlying water with no disturbance of the sediment/water interface.

Photographs have confirmed the undisturbed nature of the sampling process in sand, mud and ooze sediments. This has been used to advantage to sample the seasonally-deposited phytoplankton debris that forms a flocculent detrital layer on the surface of deep-sea sediments at certain times of the year. The corer has proved to be a successful method of sampling for studies of the microbiology and meiobenthos of shelf and deep-sea sediments. A recent development has been its use in the measurement of oxygen uptake in sediment cores incubated virtually *in situ* at depths down to 5000 m.

Barnett, P. R. O., Watson, J. & Connelly, D. 1984. A multiple corer for taking virtually undisturbed samples from shelf, bathyal and abyssal sediments. *Oceanologica Acta* **7**, 399–408.

Craib, J. S. 1965. A sampler for taking short undisturbed marine cores. *Journal du Conseil permanent international pour l'Exploration de la Mer* **30**, 34–39.

Sampling deep-sea benthos

R. Harvey

Dunstaffnage Marine Research Laboratory, P.O. Box 3, Oban, Argyll PA34 4AD, Scotland

The benthic sampling programme of the Scottish Marine Biological Association has investigated the distribution, abundance and biology of the animals living on the floor of the Rockall Trough at depths ranging from about 200 to 3000 m. Repeated sampling at two fixed stations over a ten-year period, together with more widespread sampling, has created a unique time series of samples from the deep-sea bottom.

The low density of most benthic animals dictates the use of towed samplers in order to obtain sufficient specimens for detailed studies. A Woods Hole-pattern epibenthic sledge with a 1 mm mesh, decreasing to 0·5 mm meshes in the cod end extension, has been successfully used for the recovery of the small sized faunal taxa. The "megafauna" (those animals generally large enough to be seen in sea-bed photographs) has been sampled using a 3 m-wide Agassiz Trawl. Both trawls are normally towed on the bottom for one hour. Quantitative samples have been

taken with a large USNEL spade box corer, which removes a relatively undisturbed mud core of 0·25 m^2 in area, and up to 40 cm deep. Such a large and cumbersome corer is necessary when sampling sparsely-distributed species at these depths in order to recover a large enough sample of the mainly burrowing fauna associated with the muddy sediment. The use of an acoustic pinger is essential for monitoring the operation of the corer on and near the sea bed.

The Cumacea (Crustacea) of the INCAL cruise

N. S. Jones

Department of Marine Biology, University of Liverpool, Port Erin, Isle of Man

Along with the other groups of the peracarid crustaceans, the Cumacea have been found in recent years to be numerically an important part of the deep sea benthos. The majority inhabit shallow burrows in muddy substrates and sort through the surface material for organic matter. Most are less than 8 mm long. As many as forty-three separate species have been collected in a single epibenthic sledge haul taken at about 2000 m depth in the Rockall Trough.

The INCAL Cruise of R.V. *Jean Charcot* from the Centre Océanologique de Bretagne, Brest, took place in July and August 1976. It was designed to compare the efficiency and selectivity of different collecting gear and methods developed by several institutions, namely SMBA, Dunstaffnage, COB, Brest and IOS, Wormley. A series of stations was worked in the Rockall Trough, followed by others in the Porcupine Bight and Abyssal Plain and the Bay of Biscay. Cumacea were obtained in forty-five of the samples. One hundred and fourteen species were represented, of which probably twenty-three have not yet been described. Seventy-six species were found in the samples from the Rockall Trough and ninety-two in those from further south, fifty-four of these being common to both areas. A further twelve of these species have been recorded previously from both areas, making nearly 60% in common. These numbers demonstrate the high level of speciation that has occurred among the cumaceans in the deep sea.

The species and samples from the INCAL Cruise were analysed by detrended correspondence analysis. The first axis scores for the ordination of the samples (Fig. 1) fall into two groups. The left hand group includes all the samples from depths of less than 3000 m and the right hand group all those from more than 4000 m. The ordination of the species is less clear cut but those obtained almost exclusively from less than 3000 m are clustered to the left while those from more than 4000 m are set to the right. However, most of the samples from less than 3000 m were taken in the Rockall Trough and all those from more than 4000 m in the southern area. The ordination is therefore not simply related to depth but also to geographical location. Since about 60% of the species obtained are common to both areas it may be assumed from the data available that the depth is the more important factor controlling their distribution.

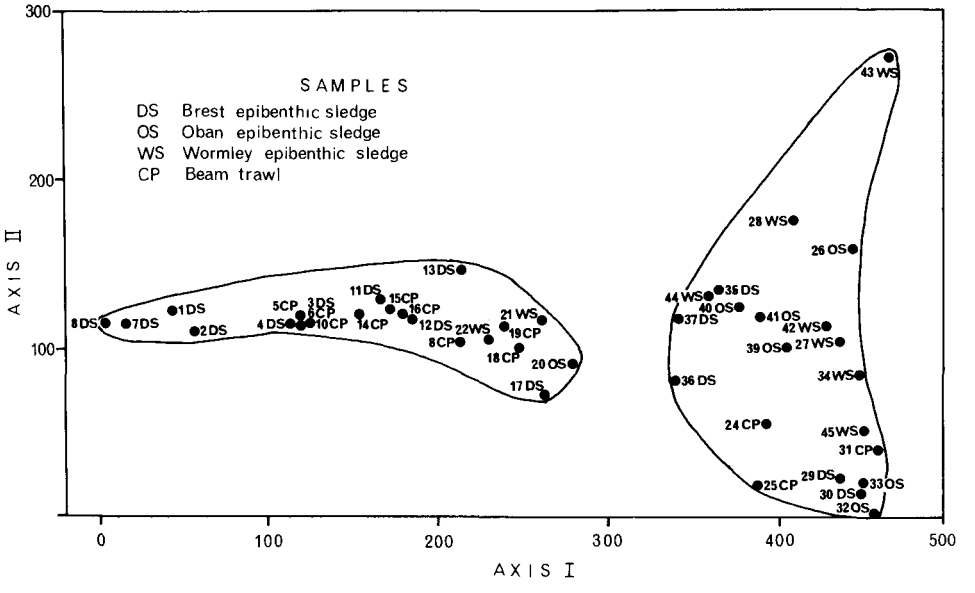

Figure 1. First axis ordination by detrended correspondence analysis of the INCAL Cruise samples.

No significant differences were apparent between the different types of collecting gear for the numbers of species or specimens of cumaceans collected in the southern area where each type of gear was used. The samples were sorted by the Centre National de Tri d'Océanographie Biologique.

A spider crab and its larvae

D. I. Williamson

Department of Marine Biology, University of Liverpool, Port Erin, Isle of Man

Dorhynchus thomsoni Thomson is a small spider-crab (Brachyura, superfamily Majoidea), common on the slopes of the Rockall Trough. The adult resembles *Inachus, Macropodia* and *Achaeus,* (Majoidea, family Inachidae), but the larvae are unique.

Most zoeas of brachyuran crabs have four carapace spines, but examples with fewer spines are not uncommon, and *Inachus, Macropodia* and *Achaeus* have only one. Zoeas with more than four carapace spines are very rare, but *Dorhynchus* has fourteen spines and two blunt processes (Fig. 1). Its telson and appendages resemble those of other Inachidae, although some of the spines are unusually large.

The only other known larvae with a similar pattern of spines are late zoeas of *Homola* (Brachyura, superfamily Homoloidea), a very primitive crab with no close affinities with the Inachidae. Perhaps *Homola* has retained the ancestral form of

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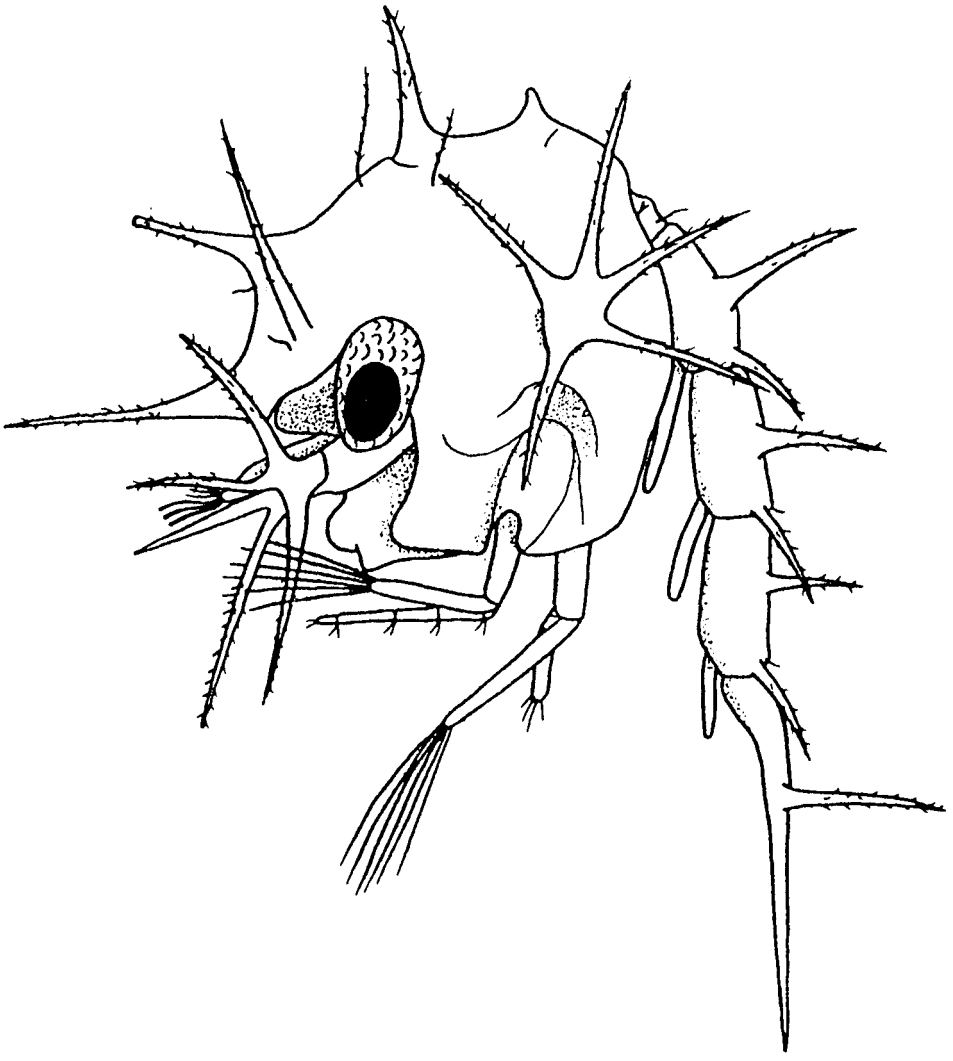

Figure 1. *Dorhynchus thomsoni* Thomson. Zoea II.

brachyuran zoeal carapace. Most crabs might have retained the corresponding genes in a suppressed state, and these genes might have become re-activated in *Dorhynchus*. There are no suggestions as to what might have brought about this postulated re-activation. An alternative suggested explanation involves the transfer of genetic material between animals which are not closely related.

The occurrence of *Trilasmis kaempferi* (Cirripedia, Lepadomorpha) in the Rockall Trough on a previously unrecorded host, *Neolithodes grimaldi* (Decapoda, Anomura)

R. Williams

Department of Zoology, University College of Swansea, Swansea, Wales

Species of the genus *Trilasmis* (five-plated lepadids) are all epizoic on large decapod Crustacea. *T. kaempferi* (Darwin, 1851) has previously been described from several hosts but never on *Neolithodes*. In September, 1983, over 1000 specimens of this barnacle were collected from the Rockall Trough in a single haul of a semi-balloon otter-trawl at a depth range of 1540–1550 m, at 56°33′N, 09°40′W to 56°42′N, 09°34′W during a cruise by R.R.S. *Challenger*. They were attached to the carapace and limbs of the deep-sea anomuran *Neolithodes grimaldi* Milne-Edwards & Bouvier (1895), a spiny stone crab. This is the most northerly record of *T. kaempferi* and only the second report of it from the Atlantic, the first being from the Azores.

Of the twenty-three live *N. grimaldi* in the sample, five did not carry barnacles or other epizoites, no doubt having recently moulted. Some loose crabs' legs in the haul were moulted exoskeleton, but still supported live *T. kaempferi* when sampled. The size/frequency distribution of *T. kaempferi* was determined on four crabs but revealed no distinct size (age) classes in the population. There was a direct relationship between crab size and the largest of its epizoic barnacles (Fig. 1)—presumably as a result of less frequent moulting of older crabs.

A study of the distribution pattern of barnacles on the crabs revealed:

1. On carapaces more barnacles were settled on the anterior halves.
2. On the carapace and abdomen the majority of barnacles were attached to spines, whereas on the crabs' legs they were in the angle at the base of the spine.
3. On the carapace and abdomen most barnacles were situated posteriorly on the vertical spines but on leg spines, which are all directed anteriorly at angles of 30°–60°, were in anterior positions. Therefore the barnacles inhabit the most protected sites on the crab.
4. Barnacles located on spines were approximately halfway between the base and tip of a spine, which could be the result of either selective settlement or elimination.
5. The barnacles were most densely crowded on the crabs' legs.
6. The settlement pattern was non-random, which could be due to heterogeneities in the crabs' surface, but is more likely to result from gregariousness exhibited by the cyprid at settlement.
7. The orofices (and therefore cirri) of the majority of barnacles were facing the surface of the crab.

General examination revealed oocytes in 43% of barnacles from a minimum length of 5 mm. The oocytes were surrounded by yolk in 10–19 mm barnacles. There was no oocyte development in barnacles below 5 mm in length, which

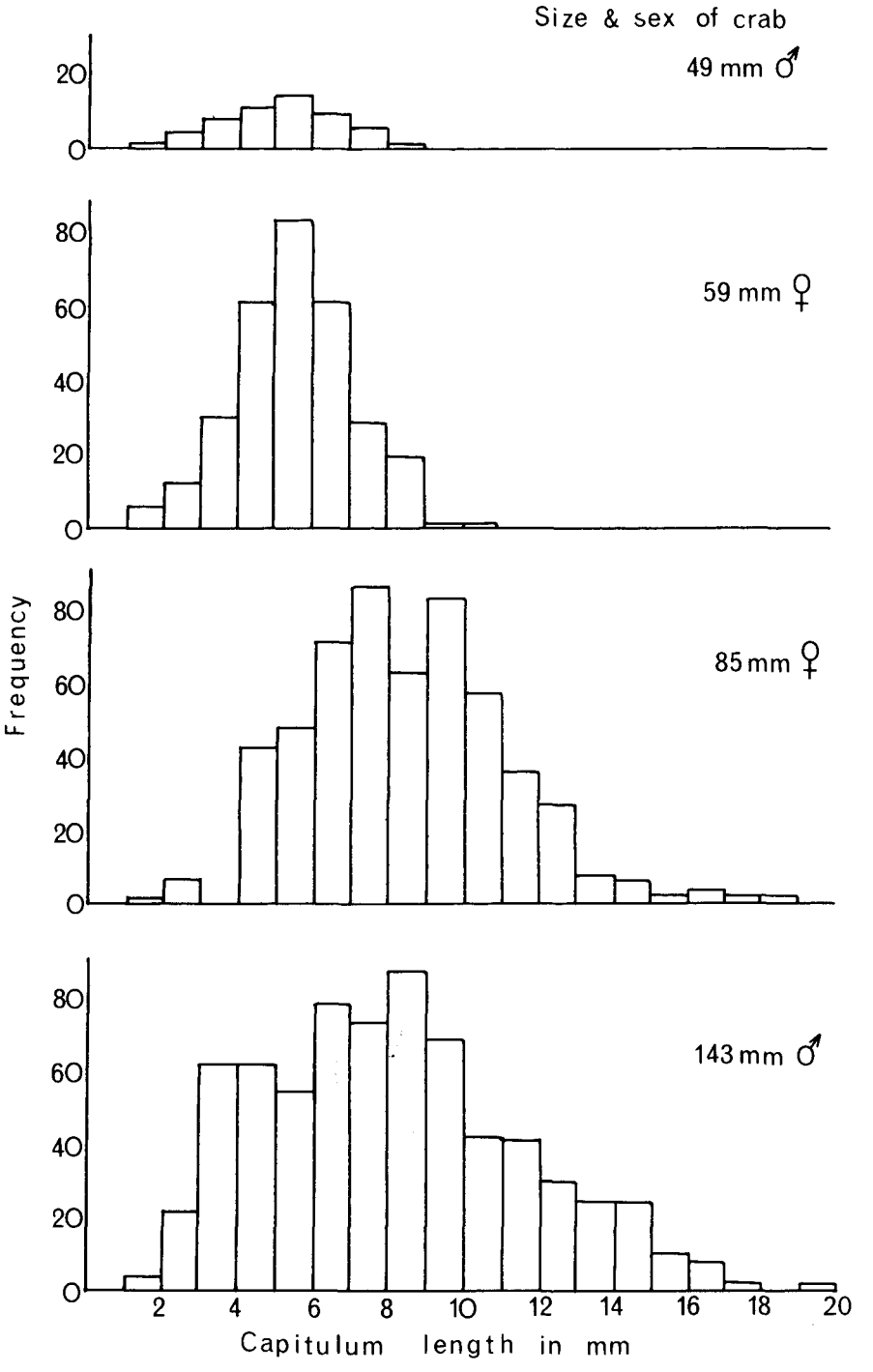

Figure 1. Size/frequency distributions of the barnacle, *Trilasmis kaempferi*, on different sized males and females of the crab, *Neolithodes grimaldi*. No obvious size classes are evident to indicate different age groups in the population.

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presumably had not reached sexual maturity. Only one barnacle (10 mm) contained ripe egg lamellae.

No other hauls from the Rockall Trough have yielded examples of this partnership. This phoretic association presumably affords *T. kaempferi* protection without disadvantaging the crab.

Post-larval morphology of some northwest European ophiuroids

C. Webb

Department of Oceanography, University College, Swansea SA2 8PP, Wales

The early post-larval development of ophiuroids, in general, follows a similar pattern of disc and arm plate morphogenesis. Adult characteristics are developed at some stage in this period, but often well beyond metamorphosis. The transient post-larval morphology present in this intervening period, often differing markedly from subsequent stages, has generally poorly known taxonomic, ontogenetic and functional significance. A brief survey of the dorsal disc and arm morphology in the smallest free-living and settled post-larvae of a variety of N.W. European representatives of the order Ophiurae (*Ophiura ophiura, O. albida, O. ljungmani, Ophiocten gracilis, Ophiomusium lymani, Acrocnida brachiata, Amphiura filiformis, A. chiajei, Amphipholis squamata, Ophiocomina nigra* and *Ophiacantha bidentata*) serves to highlight and explore these aspects. The use of Scanning Electron Microscopy (SEM) proves invaluable in resolving such features.

Primary plate stereom is an intriguing early post-larval feature that may prove to have significance at various taxonomic levels. For example, a distinctive stereom of a regular pattern or round, craterlike fenestrations extending to the plate edge, is observed in the three *Ophiura* species examined and appears to be confined to the genus. Similarly the rounded pentagonal central primary plate and rectangular terminal plate may be other generic features.

Another plate stereom observed is the bordered type observed in *Acronida brachiata, Amphiura filiformis* and *Ophiocten gracilis*. In *Acronida* with 0·4–0·6 mm discs, the thicker central region has an open latticework while the region bordering the plate edge is thin, having its fenestrations partially infilled. Variations of this bordered plate stereom occur in the other two species, but in all cases such borders are confined to the primary plates. Other features of plate development are specific, such as the fenestration size in *Ophiura* or the unique spined stereom of *Ophiomusium lymani*. The functional and adaptive value of ophiuroid primary plate morphology is generally unknown.

The nature of the terminal plate of the recently-metamorphosed post-larva exhibits greater variation between closely-related species, as do other aspects of arm development (i.e. arm segment number, spine form and equality of growth), whose adaptive and functional value may be more readily seen. That allied species with similar adult ecological habit remain distinguishable, may suggest that

functional demands of the post-larval stage in a species' life history (possibly quite different to the adult period) are quite important.

Differences in the relative rate of disc plate and arm development between some direct and indirect species and shallow and deep sea forms are tentatively suggested.

Preliminary observations on the near-bottom ichthyofauna of the Rockall Trough: a contemporaneous investigation using commercial-sized midwater and demersal trawls to 100 m depth

N. R. Merrett and **J. Badcock**

Institute of Oceanographic Sciences, Brook Road, Wormley, Godalming, Surrey GU8 5UB, U.K.

S. Ehrich

Institut für Seefischerei der Bundesforschungsanstalt für Fischerei, Hamburg, Germany

and

P. A. Hulley

South African Museum, Cape Town, South Africa

The continental slope both truncates the distribution of the oceanic meso- and bathypelagic ichthyofauna and provides the headquarters of a diverse assemblage of demersal fishes. While demersal forms are well adapted to such an environment, the morphology of pelagic species differs conspicuously and seems better suited to an open ocean habitat. Submersible observations, together with a small body of near-bottom closing net data and records of pelagic fish in stomachs of demersal species, mainly constitute the scant knowledge of the interactions of these distinct faunal elements.

In May, 1983, during cruise 58 of F.R.V. *Walther Herwig* (Institut für Seefischerei, Hamburg) preliminary investigations were made into the swimming layers of the near-bottom ichthyofauna of the Rockall Trough (56°18′–44′N) using much larger nets than employed hitherto. Over a five-day period, five demersal trawls were made on the Feni Ridge and six on the Hebridean Terrace at approximately 200 m intervals from 200–1000 m soundings, using a 200 foot bottom trawl (200′ BT—nominal mouth opening 22 m × 6 m headline height). In addition, nine Engels midwater trawl (1600 PT—mouth opening 30 m × 20 m high) collections were made in similar localities (Feni Ridge—four; Hebridean Terrace—five) and depths fished with the footrope (0) 3–18 (60) m above the sea bed, together with a set of mid-Trough samples from 100, 400, 700 and 1000 m depth

over 2550–2620 m soundings. Except for three tows of 45–75 mins duration, all hauls were for 30 mins at depth and towed at 4·0 kts.

The total collection yielded some 40,000 fish weighing in excess of 6300 kg (1600 PT—23,000 fish; >300 kg (three samples unweighed): 200′ BT—17,000 fish; 6000 kg)). One hundred and eight species were sampled of which nineteen were peculiar to the mid-Trough catches and only twenty-seven were common to both types of gear. Considering relative abundance, however, thirty-eight species only comprised >3% of any one sample. At this level, consistent differences in overall composition are evident among the 200′ BT demersal slope, and 1600 PT pelagic slope and mid-Trough samples (Fig. 1). The only mesopelagic species to be ranked

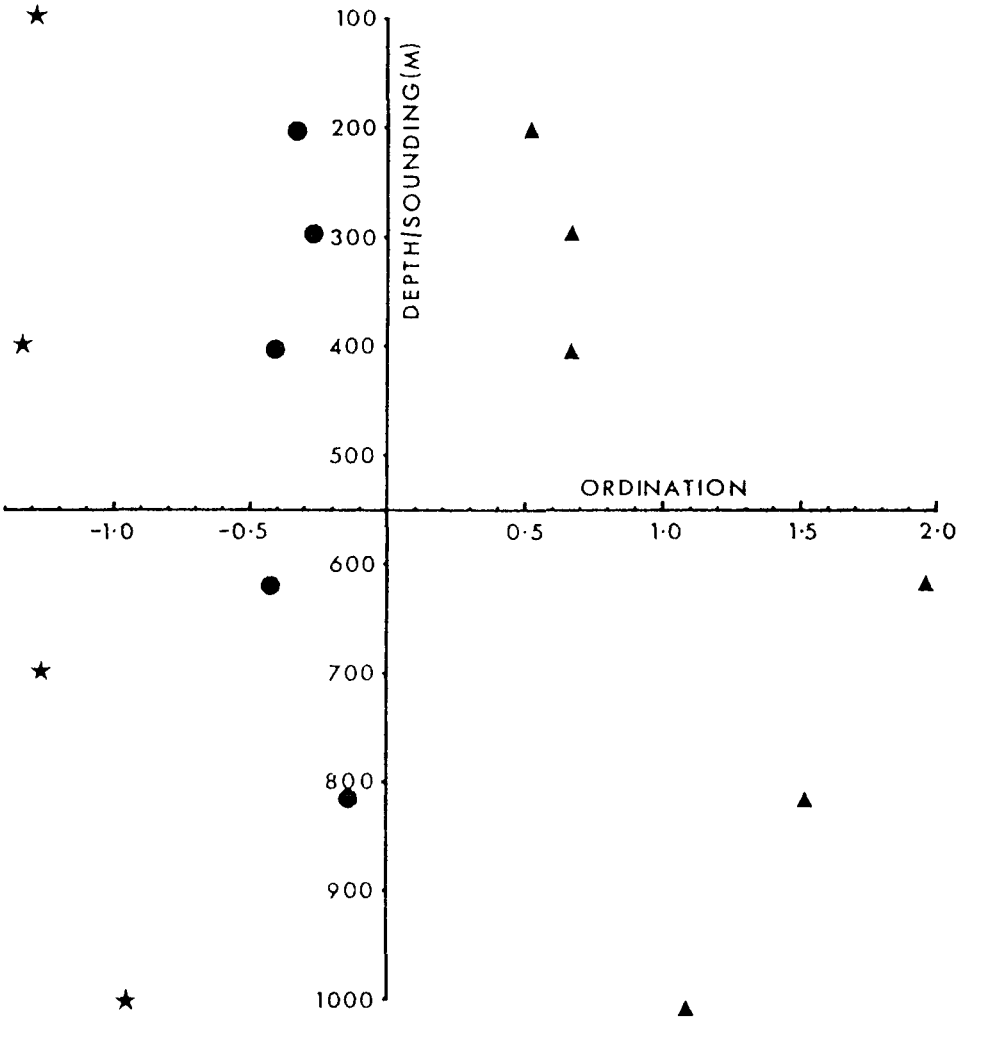

Figure 1. Comparison of the overall composition of the 200 ft BT demersal slope (▲) and the 1600 PT pelagic slope (●) and mid-trough (★) samples. Plot of one-dimensional ordination (by multidimensional scaling) of percentage similarity indices of the trawl sample matrix versus depth/sounding.

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in the results of the demersal tows was *Micromesistius poutassou* (190–200—43%; 280–318—64%; 397–414 m—50%). This is understandable as *M. poutassou* is a predominantly pelagic slope-dweller (300–500 m depth), but with a known tendency to impinge on the bottom where this traverses its depth distribution (Bailey 1982). No demersal species, on the other hand, were so ranked among the pelagic mid-Trough samples. Only in the pelagic tows over the slope were demersal species (three) present in sufficient proportion to warrant inclusion. Remembering the close proximity to the bottom of the pelagic trawl (0–10 m—1 tow; 3–18 m—7 tows; 60 m—1 tow) such a total is noteworthy. This is especially so when the nature of the species is considered. The most important contribution was by *Halargyreus johnsonii* (598–637 m—12%), *Synaphobranchus kaupi* (8%) and *Coryphaenoides rupestris* (3%, both in 794–841 m). Most *S. kaupi* were immediately post-metamorphic juveniles and the *H. johnsonii* were again juvenile, stages when both are more likely to occur well off the sea bed.

Despite the obvious limitations of this preliminary investigation with large nets, this is the first substantial observation that the bulk of the populations of demersal and pelagic species remain separate over the slope, with the swimming layers of the former evidently very close to the bottom. Additional, more detailed investigation would clearly be rewarding.

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Growth rates of deep-sea benthic animals in the Rockall Trough

J. D. Gage

Dunstaffnage Marine Research Laboratory, P.O. Box 3, Oban, Argyll PA34 4AD, Scotland

There has been a prevailing view that life processes are very slow in the deep sea. This is based on rather sparse data from *in situ* studies of the sediment, microbial and fish respiration, and sediment recolonisation. Other *in situ* recolonisation observations indicate that certain species may settle and grow within a year or two. Estimates of age and growth rate of individual species are few, frequently based on few data and present no clear pattern. A well-known study, by means of radiometric dating, providing an estimate of what is thought to be an exceptionally slow rate of growth in a small-sized species of protobranch bivalve is subject to wide confidence limits.

The discovery of seasonal breeding in deep-sea species of echinoderms and bivalves offers the possibility of tracking the growth of age-marked cohorts in a time series of samples. This approach has been applied to a long time series of deep-sea hauls obtained using an epibenthic sledge at the Scottish Marine Biological Association's Permanent Station in the southern Rockall Trough. In order to make estimates of cohort age structure, methods of analysing the modal structure of size-frequency distributions have been applied. However, both because of individual variation in growth rate and because of growth curves resulting in

"stacked" frequencies of older age classes, such methods have only limited value. An approach utilising computer graphics in simulations of the growth and survivorship schedules through the life history of a species showing seasonal recruitment has been found to provide a powerful tool in developing likely hypotheses of age structure of deep-sea brittle stars, such as *Ophiomusium lymani.*

The development of such models is much aided by the discovering of skeletal markers in the form of annual banding in certain species. In the deep-sea echinoid *Echinus affinis* growth zones are evident in the plates of the test and in the jaw ossicles. Banding is present in the plates of even small, pre-reproductive stages. It is likely that such annual banding is the result of a seasonally varying growth rate as a result of the marked seasonal cycle in availability of a fallout of fast-sinking phytodetritus from the surface on which this urchin probably feeds. Counts of growth banding have provided a growth curve that, although indicating a slower growth and longer life span than inshore relatives, is not exceptional among certain other benthic species living in shallow-water.

Preliminary studies of growth rings on the shells of small, seasonally-breeding bivalves that are among the most abundant species living on the bottom, have suggested growth rates and generation times similar to those estimated from inshore relatives.

Overall, the analysis of population dynamics of deep-sea organisms from the time-series sampling offers little support for the notion of growth rates being generally low and life spans being exceptionally attenuated. It would seem reasonable to expect a mix of life-history strategies similar to that found in shallow water, and encompassing both slow and fast rates of population turnover, to occur in the deep sea.

Shelf break faunas on the eastern margin of the Rockall Trough and Faeroe–Shetland Channel

J. B. Wilson and **J. M. Desmond**

Institute of Oceanographic Sciences, Brook Road, Wormley, Godalming, Surrey GU8 5UB, U.K.

Investigations into the sediments and shell-bearing faunas on the upper continental slope, the shelf break and the outer parts of the continental shelf on the eastern margins of the Rockall Trough and Faeroe–Shetland Channel suggest that a distinctive faunal association can be recognised which is restricted to the shelf break.

The distributions of some thirty-seven species of molluscs, echinoderms, coelenterates (mostly corals) and crustaceans (barnacles) have suggested that the association contains three groups of species: shelf species which range over the shelf break and onto the upper slope, continental slope species whose upper depth limit reaches the shelf break and the outer parts of the continental shelf and a third group of species which is largely restricted to the shelf break.

Within the third group are several species including the bivalves *Bentharca nodulosa* (Müller), *Limopsis aurita* (Brocchi) and the gastropod *Solariella amabilis* (Jeffreys). Their presence in this region may be temperature controlled, as they are shelf species in northern Norway whereas in the Bay of Biscay they are found on the middle of the continental slope. Other species present at the shelf break are perhaps near the southern limit of their range and are restricted to the shelf break on the eastern margin of the Faeroe–Shetland Channel. Species in this group include the bivalve *Chlamys sulcata* (Müller) and the gastropod *Troschelia berniciencis* (King). A number of rare species are present at the shelf break. These include the gastropods *Metzgeria gagei* Bouchet and *Volutomitra groenlandica* (Beck) and the coral *Stenocyathus vermiformis* (Pourtalès). The records of *Stenocyathus* and *Volutomitra* are the first live records in U.K. waters. A feature of the shelf break in this region is the extensive development of iceberg plough marks. Samples dredged from the shelf break have a very distinctive appearance and consist of poorly sorted collections of small boulders, cobbles, pebbles, gravel and sand. Observations of the shelf break and upper slope using the Mark III Television and Camera Sledge confirm the highly variable nature of the sediments present.

The regular echinoid *Cidaris cidaris* (Linnaeus) and the bivalve *Astarte sulcata* (da Costa) are very common in these poorly sorted gravels and their presence together is very characteristic of the shelf break. In some parts the poorly sorted gravels give way to more sandy sediments which support species such as the gastropods *Typhlomangelia nivalis* (Loven) and *Cylichna alba* (Brown).

Dead shells of species living in the area during the period of low sea level preceding the Flandrian transgression such as the bivalve *Chlamys islandicus* (Müller) and less commonly *Mya truncata* (Linnaeus) are also present.

Aspects of the zoogeography of some benthic animals in the Rockall Trough

G. L. J. Paterson

Department of Zoology, British Museum (Natural History), Cromwell Road, London SW7 5BD, U.K.

Distributions of certain benthic species in the Rockall Trough are compared to other regions of the Northeast Atlantic. A numerical cladistic package has been applied to classify the distributions of deep-sea (>500 m depth) brittle star fauna. Rockall is compared with the Labrador and Southwest Iceland basins, the Iceland Basin, the Bay of Biscay and the Canary region including the Azores, Madeira and N. Africa. Figure 1A indicates that the Rockall Trough fauna has a greater affinity to the Biscay and Canary regions than the other two northerly basins. These results are consistent with an hypothesis of an impoverishment of the northern basins, possibly related to the effects of the last Ice Age.

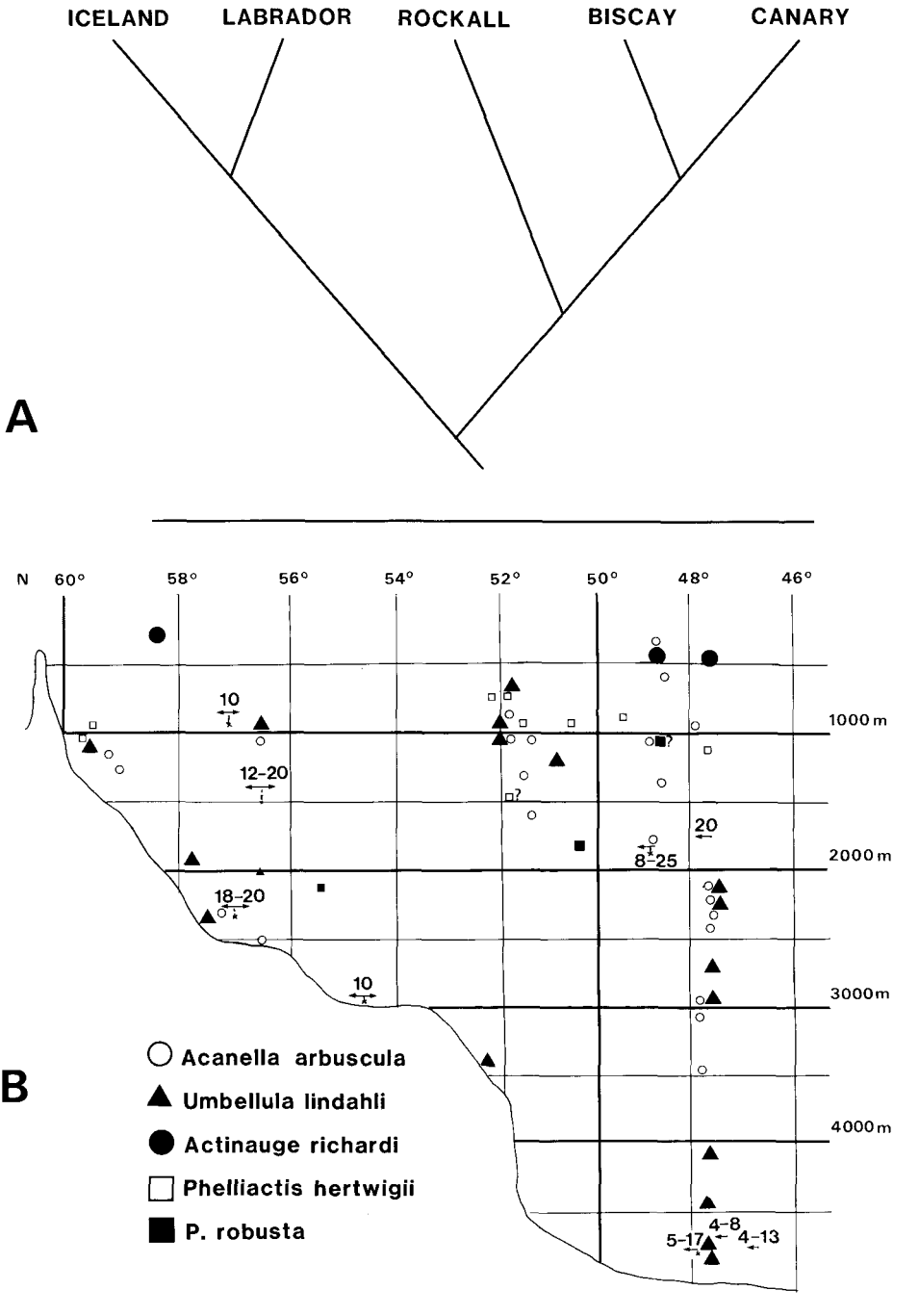

Figure 1. Distributions of deep-sea fauna. A. Cladogram showing the faunal affinities of the northeast Atlantic basins as indicated by analyses of samples of deep-sea brittle stars. B. A strip analysis of the eastern flank of the Rockall Trough showing the distribution of selected coelenterates. Arrows represent current flow and direction, the number associated with the arrow being the recorded current velocity in cm/s.

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Distributions of sessile suspension feeding echinoderms and coelenterates are considered in the light of the physical environment, particularly bottom currents. The method employed uses a graphical approach which is termed Strip or Profile Analysis. The continental margin can be regarded as a strip where depth is the vertical component and latitude the horizontal. This method is effective at assessing latitudinal variation in distribution. Figure 1B attempts to correlate distributions with physical factors such as water movement and temperature. While some trends are indicated there were not enough data to allow more than a superficial treatment. Nevertheless, the records of suspension feeders indicate areas of persistent water movement which might be useful to physical oceanographers.