

Porcupine Newsletter

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EDITORIAL

As you can see from the CONTENTS, this time we have a bumper crop of articles, mostly reflecting the success of the Cardiff meeting in October, but also referring to other matters. Catch-ups from previous meetings are always welcome. I always hope to get at least one item which is not meeting-orientated, and - N.B. - I would like many more, whether short or longer. These will add much to the PORCUPINE NEWSLETTER. Possibly members who cannot get to meetings would like to contribute? Short snippets are very useful to fill up gaps at the bottoms of pages too large for cartoons, I would prefer to do this rather than start larger articles in the middles of pages, which has happened this time, apologies.

The next meeting (A.G.M) is at Scarborough, 17-18 March 1996, a new venue - see First Circular. We also plan to hold a meetings London and in Northern Ireland, see back page.

HARDY ANNUAL: to those of you who do not pay by Banker's Order, please find time to send off your subscriptions to Jon Moore in time for 1 Jan 1996, still a snip at £8 full members, £5 students.

The Hon. Editor and Friend wish you
Season's Greetings
and every success for 1996
Long may your prickles rattle!



SAMPLING AND DATA ANALYSIS: WHAT DID YOU WANT TO KNOW?

By ROGER BAMBER

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There are numbers of techniques/protocols available for the collection of samples from the marine environment and for the analysis of those samples and for the interpretation of the ensuing data. The number of people/publications advising on the use of these various techniques is probably even greater, as may be the resultant confusion. I shall discuss these issues principally in relation to benthic sampling (as that is what I do most of), but the conclusions are widely applicable. I should apologize for the inevitable inclusion of a certain amount of "how to suck eggs" advice; throughout, no personal insults are intended. Suggestions for the criteria to apply in selecting the "right" technique range from the obtaining of data which is most validly representative, or is amenable to statistical interpretation, to that of saving money (!).

However, the first question to be asked in determining a protocol is not "What shall I use?" but "What do I want to know?" (a synonym of "Why am I doing it?").

It is apparent that this question is often not considered seriously. Many researchers would appear to sample with the gear which they have available, at the time most convenient to them (or to their client), identifying animals in a disparity of detail biased to their own expertise, and thereafter undertaking the statistical analysis available in@house, banging the "default" button whenever asked for a decision. This is to some extent inevitable when the undertaking is by people who cannot know enough about the given area of protocol to make a sensible decision (i.e. limited/specialized expertise rather than non-expert).

"WHAT DO YOU WANT TO KNOW?"

Answers fall broadly into two categories in our modern age of commercialism:

1. To find something out
2. To make money

If the answer comes into category 2 only, then the protocol is almost irrelevant. Various people have extolled the virtues of sampling and sample analysis techniques which are "more economical" (for example take smaller or fewer samples; use larger mesh sieves; don't identify to species). In fact, if "saving money" is an overriding criterion, then the best sampling procedure is to not bother at all. If we assume that there is some requirement to obtain an answer based on data, then economics comes into the equation only **at the end** of the decision process.

Initially, any field sampling exercise should be aimed at gathering sufficient data to allow a sensible interpretation, by a technique defined by the organisms being sampled, and thus comes back to the prime question - "What do you want to know?"

Let us assume, for example, that the question is "What benthic macrofauna is living in a given area?". The sampling procedure must therefore sample the macrofauna representatively. Also it has to appreciate that the community being sampled is a dynamic interaction of energy flow between existing niches as exploited by different species or by their different life stages (not all niches may be exploited - contrary to some definitions).

WHEN TO SAMPLE?

All faunas are seasonal in temperate zones (and most are in the tropics). There is a general amount of juvenile recruitment to the benthos through the spring to autumn period, leading broadly to a baseline community represented in the late winter - early spring of mature individuals which have survived what is commonly their most adverse environmental condition. If the baseline community is the aim of the exercise, then maybe March is the time to sample. If seasonality is important then as often as possible. But whatever is done, the resulting analysis **must** allow for this seasonal disparity.

HOW TO SAMPLE?

There are plenty of sensible analyses of sampling gear available, largely aimed at optimizing the collection of quantitative samples - I leave you to them (or vice versa).

The number of samples taken (replication) depends on the fauna. These samples are after all only small subsamples of the environment (usually). Ideally, a presurvey taking a known excess of samples will allow determination of the right number; alternatively, given an idea of the likely variance within the data and knowledge of the limits of detection required (i.e. "What do you want to know?", again) then the requisite sampling density can be determined statistically. Some analyses have shown that a larger number of smaller samples gives better representation (insofar as this approach compensates better for spatial variation). Of course, the sampling gear must be big enough to collect the largest species being studied. Replication must also allow for habitat (e.g. substrate) variability, and the ambit size of the species concerned (How many species do we know enough about?).

SIZE OF MESH

The requisite mesh size relates to the fauna, NOT to the substrate or to the time available or to the number of jars on board! The appropriate sieve mesh size for analysis of marine benthos has been the subject of some debate over the last decade, with some arguments attempting to sacrifice information for the sake of saving money; **this is a false economy**. Data have been presented often in the past showing a natural break in faunal size distribution

at around 0.25 to 0.5 mm - i.e. between the arbitrarily defined meiofauna and macrofauna. Detailed analysis of faunistic fractions by mesh size was presented long ago by Reish (1959).

The benthos of fine sands and gravelly sands incorporates a significant component of interstitial macrofaunal species (for example paraonid polychaetes, tanaidaceans, small syllids), which will be either undersampled or not retained at all in a 1 mm mesh. Elliott & Taylor (unpubl., 1992) noted that in subtidal fine sands, in comparison with a 0.5 mm mesh, a 1 mm mesh may retain as little as 12% of the individuals, 46% of the biomass (the individuals being larger) and only 52% of the species. Indeed, even the 0.5 mm mesh may be undersampling some of these forms. Similarly, finer muds are exploited by a number of infaunal non-interstitial species of smaller size as these are capable of displacing the smaller particles during burrowing. With their smaller ambit, and often lower mobility, these smaller species are likely to be more indicative of the status of the community than are errant megafauna. Normally, these smaller species are responsible for a majority proportion of the energy flow through the community. Thus a 0.5 mm mesh is virtually essential for benthic macrofauna (if this proves a complete pain in the field, then such a mesh should be used for subsamples). The arbitrary rule is a mesh of smaller orifice dimension than the second largest dimension of the required residue.

TAXONOMY

While some authors have indicated that radical changes in a community may be distinguished at a higher taxonomic level than that of species, this ideal falls down on two counts. Firstly, its justification in terms of economy belies the fact that most experienced benthic taxonomists recognize an animal to the species level immediately, and are more familiar with that (definable) level of taxonomy than with arbitrary higher rankings short of Orders in some cases, Phyla in others; equally,

inexperienced workers must often identify to species in order to determine accurately the attributable higher taxa. And, of course, as genera and higher taxa are revised with time (split, amalgamated, whatever) a data set not identified to species becomes increasingly useless and the information irretrievable. Secondly, a change detectable at higher taxonomic levels is simply that - a change; as the functioning of an ecosystem relates to niche exploitation and energy flows, rather than arbitrarily defined palaeological relationships, the cause or significance of such a change can only be determined at the species level.

As an example, the infaunal community of a sandy beach in the Solent (Bamber, 1993) comprised (at last count) 63 species. These fell into 57 Genera, 45 Families, 16 Orders, 8 Classes, 3 Phyla and (no surprise) 1 Kingdom. It would appear that the levels at which significant saving of effort may be achieved are at Class or Order levels. Unfortunately, of the 8 Classes, 2 (Polychaeta and Peracarida) represent 98.4% of the fauna (and therefore all of the "action"), and one of the 16 Orders is Amphipoda representing 56% of the fauna. The loss of information is enormous; in fact the two species demonstrating the most significant changes in the functioning of the community (*Nephtys cirrosa* and *Bathyporeia sarsi*) were, by mere coincidence, both in the only two genera represented by 3 species [two others were represented by 2 species, all the others monotypic in this community], so even generic grouping falls down. Other good examples exist.

In reality, there is more to be said for grouping species trophically (ecologically) rather than taxonomically.

DATA TRANSFORMATION AND STATISTICS

The most realistic data are the raw data! If you find 113 individuals of a species per square metre, that is a real fact; finding that the log of that species presence is 2.053 is in itself meaningless (I do not know what the log of a polychaete is, scatological references notwithstanding). The almost ubiquitous use of data transformation (by log, square root or whatever) is "required" **only** to facilitate easier use of certain statistical techniques, and **should not be assumed to be giving a better interpretation of the data!** Which is not to say that some useful techniques do require data transformation. However, the fact that resulting variances, "F" values, or "stress" levels are "better" is inevitable, as such transformation makes the data more amenable; this fact does not mean that the transformed data are giving a better interpretation *per se*. Transformations can give useful interpretations of data trends in collaboration with raw data analyses. For example, a community trend shown by the raw data which reduces in significance on log transformation will be likely to be an expression of dominance, since that attribute is deliberately reduced by such transformation.

This is not the place to go into all the statistical techniques available, so I shall dip sporadically.

The best statistical test is called : "It is easy to see that ...". Other tests are needed when that one doesn't apply. Numerical analyses of communities are better done on biomass than on numbers (re seasonality). Alas, this can involve losing the material. A simple example is diversity (see Table 1). Generally, if there is something blatantly obvious going on in the data, most tests will pick it up (although they may not give any indication of significance, and will rarely attribute cause).

Of the various more complex multivariate statistics available, classification by similarity analysis is commendable: there are a range of techniques available, including Raabe, MacQuitty, Jaccard and the commonly used Bray-Curtis (for the alternative classification technique, Twinspan, see below).

Beware: ALL will inherently try to split the data! Figure 1 shows Bray-Curtis similarity dendrograms for two sets of data of 12 "samples" and 9 "species". The upper is generated by random numbers, the lower plot is from a pure linear gradient of data. Yet the clusters appear!

Ordination techniques are manifold and have been the subject of some controversy, and in this context must be mentioned Reciprocal Averaging, Decorana, CANOCO, MDS, Canonical Analysis, and Principal Components Analysis. Twinspan and Decorana were derived by Hill at Cornell for vegetation analysis, and thus for the treatment of "semi-quantitative" data. Their inventor himself is of

the opinion that these tests are now applied too widely, and where quantitative data are available, other techniques are more appropriate. Of the remainder, most will give some indication of splitting of the data, largely a 2-dimensional interpretation of a similarity-type matrix. The greater sophistication of such as PCA allows in-depth analysis of correlations within the data set notably including interpretation of the species causing trends between samples by their eigenvector analysis.

Few intercomparisons have been undertaken, and my own did not include CANOCO (of which no more); but analyzing 4-years of monthly samples of a beach benthos, there were three main trends in the community, viz. seasonality, the effects of the warm summer of 1989, and a predation-related time trend (increase in predator, total loss of a prey species). Simple similarity, Twinspan, Reciprocal Averaging, Decorana and MDS (ranked in increasing order of ability to interpret) detected the first and last of these, but all failed to detect the warm summer effect even though it was greater than that from seasonality; only PCA detected all three.

Do talk to objective statisticians (not me), who will be able to describe the limitations of various techniques and their appropriateness to any given data set (which is what most people do for any other statistical analyses, after all). It must be appreciated that the majority of these techniques are not giving a "significant" answer, they are merely re-presenting the data in a form from which conclusions may be derived more easily, often guiding the user towards which facets of the data set are worth subjecting to statistical analyses which can offer tests of significance. In reality, the optimum approach is to undertake at least two techniques of unrelated analysis: if they give the same answer (insofar as they are capable of detecting one), it's probably right.

At the end of the day, it comes back to our prime question - **What did you want to know?** If you only want to detect a change (e.g. pollution gradient), many of these tests will show the obvious, although not if such change is occurring against a background of other, possibly larger, changes, when you **need** a technique which will distinguish these and give as many independent "axes" as possible. If you wish to define the limits of a change, or to relate to the species responding relevantly, the choice is much smaller. If you want to understand cause and effect relationships and broader significance, i.e. interpret what is going on, again you need the best sophistication available (e.g. PCA).

Do not use a test incapable of interpreting possible changes and then conclude that none exist!

RECOMMENDATIONS

(if it is information that is required)

- | | |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Sampling time | When the species or community is at its most representative; as frequently as feasible to interpret temporal change. |
| Sampling grid | To cover the anticipated area of change plus an equivalent area of control if available; in as much detail, and with as many replicates as the <u>animals</u> dictate (as close as possible, and e.g. 3-10 replicates). Allow for habitat variability. |
| Sampling gear | Big enough for whole specimens of the largest animals, deep enough for the deeper burrowing, sufficiently large and reproduceable to be quantitative, small enough to allow sufficient replication (read the books). |
| Mesh size | Small enough for the fauna being studied: 0.5 mm ² virtually essential for benthic macrofauna. |
| Taxonomy | To species wherever possible. |

Data transformation Include raw data analysis: thereafter only transform for further analysis of trends in the data (but not without reason).

Simple statistics There are lots: presence/absence; numerical distribution; appropriate correlation; Shannon-Weiner diversity; use biomass data if feasible. Appreciate the limitations of the technique.

Complex statistics PCA; MDS; similarity analysis; nearest neighbour correlations; use a combination of at least two independent techniques. Appreciate the limitations of the technique, and do not confuse reinterpretations of the data with answers.

CONCLUSIONS

The problem with economic biases of a "middle-ground" approach is that you are likely to discover **WHETHER** something is going on, but not be able to interpret **WHY** or perhaps even **WHAT**.

So do you want to know why or what?
Start by asking - **What do you want to know?**

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TABLE 1. Comparisons of a hybrid benthic community in March and September:

DATE	NUMBERS		BIOMASS	
	Mar	Sep	Mar	Sep
Amphiura filiformis	47	298	141	178
Levinsenia gracilis	88	127	9	8
Prionospio sp	33	63	3	4
Owenia fusiformis	12	11	6	6
Periculoides l.	100	217	1	2
Tanaissus l.	101	87	1	1
Cumopsis goodsiri	17	43	1.5	3.5
Euclymene oerstedii	265	165	156	179
Pontocrates ar.	55	160	0.5	1
Leucothoe in.	8	75	1	3
"d"	1.37	1.26 (-8)	1.56	1.51 (-3)
"H"	2.73	2.99 (+10)	1.47	1.51 (+3)

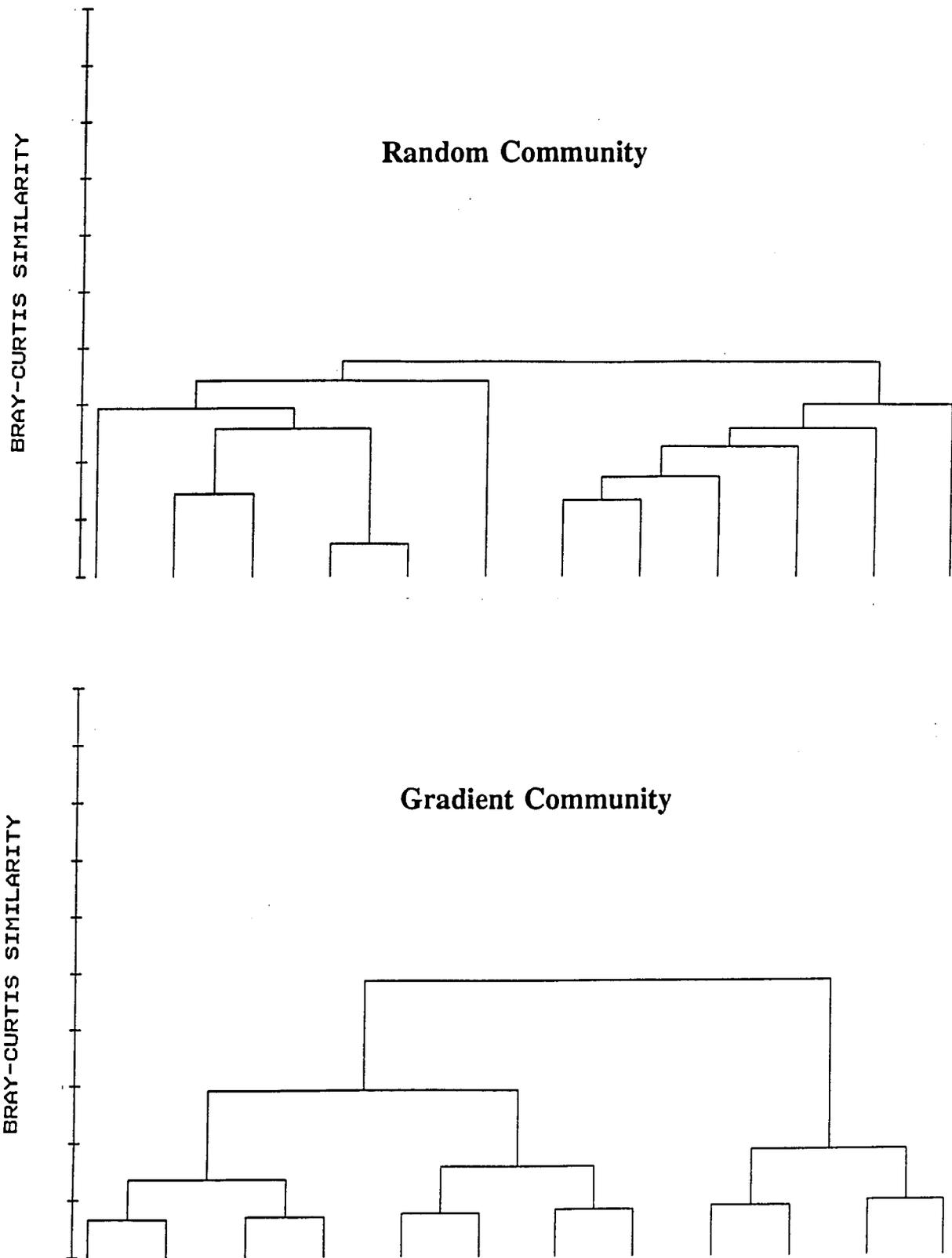


FIGURE 1. Bray-Curtis similarity dendrograms for "communities" generated by random numbers (upper plot) or by regular linear gradient data (lower plot).

SUBMERSIBLE SAMPLING AT DEEP SEA HYDROTHERMAL VENTS

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INTRODUCTION

One of the key problems in biology lies in correctly matching the scale of your sampling or analysis to the scale of the feature or process in which you are interested. When *HMS "Porcupine"* made her expeditions at the end of the last century, the state-of-the-art technology available for sampling the deep-sea fauna was the dredge. Dredge sampling integrates small-scale heterogeneity, but at the time the deep-sea fauna was largely unknown and so dredging provided useful information about what animals were living down there, and dredging continues to do so today. However, our deep-sea exploration since *HMS "Porcupine"* has revealed certain biological communities whose scale and discrete nature precludes dredge sampling from obtaining all but the most basic information about them.

In 1977 the camera sled *ANGUS* obtained photographs of a community of metre-long tubeworms, giant calms, mussels and crabs at 2600m on the Galápagos Rift (Corliss *et al.*, 1979). The density of these animals was unprecedented for such a depth, and the community was later shown to be ultimately dependent on *in situ* chemosynthetic primary production by bacteria, rather than surface-derived photosynthetic primary production (Karl *et al.*, 1980). The bacterial chemosynthesis that supported these communities was fuelled by hydrogen sulphide from nearby hydrothermal vents, also photographed for the first time by *ANGUS*. Since their first discovery on the Galápagos Rift, hydrothermal vent communities have been found throughout the Pacific and in the Atlantic, and sites are continuing to be discovered as the mid-ocean ridge system is further explored. Most of the animals collected have been new species, and they have been the subjects of investigations focussed primarily on their biogeography (reviewed by Tunnicliffe, 1991), physiology (reviewed by Childress & Fisher, 1992) and autecology (Van Dover, 1995).

Vent communities are spatially discrete and occur on the scale of tens of metres, and within a vent community itself there is generally a zonation in faunal distribution related to the influence of the hydrothermalism. Sampling by dredge would integrate fauna from vent and non-vent areas as well as integrating any faunal zonation within the vent community. In fact, one of the most striking features of vent communities is their microheterogeneity, often on a scale of centimetres. Therefore there can be no alternative to actually seeing what you are sampling or measuring when studying vent communities, in order to avoid being confounded by the microheterogeneity. Being able to see and take pinpoint samples and measurements requires the use of today's state-of-the-art technology: a deep-sea submersible.

DEEP-SEA SUBMERSIBLES: MANNED vs. UNMANNED

Deep-sea submersibles can be divided into two types: manned and unmanned, also known as Remote Operated Vehicles or ROVs. Manned submersibles have been used a great deal in vent research so far and there are currently 6 manned submersibles in the world that are capable of operating at depths greater than 4000m. The United States has *ALVIN* and *SEA CLIFF*; the Russians have the two *MIR* submersibles; the French have *NAUTILE* and the Japanese have the *SHINKAI 6500*. With a price tag of around £30 million, Britain does not have a Deep Submergence Vehicle.

At the heart of every manned submersible is a pressure sphere which provides a one-atmosphere environment for the crew. Work on the seabed is carried out using the manipulator arms, controlled from within the sphere. Equipment and samples are carried in a basket on the front of the sub. Observation from the submersible portholes is often limited owing to their small size, but subs usually carry extensive video systems that can be monitored and controlled from within the sphere. Scale can be provided on the video footage for postdive analysis by mounting lasers in parallel a fixed distance apart such that the laser dots are visible on the video. Manned submersibles carry their own power supply in the form of batteries, and these are the factor that limits the endurance of their operations. Dives typically last around 12 hours, and recharging batteries before the next dive can take at least as long.

Unmanned submersibles are similar to manned submersibles in that their work is performed using manipulator arms, they have a basket for their scientific payload and similar video systems. However, ROVs do not need a pressure sphere to accommodate a crew, and instead their key feature is the tether that connects them to the surface ship from where they are controlled. This tether carries the control signals and power to the vehicle and real-time video and other data from it, often using fibreoptics for greater bandwidth. The number of ROVs suitable for biological work at hydrothermal vents is growing. Canada's Institute of Ocean Sciences has *ROPOS*, Wood's Hole Oceanographic Institution has the *JASON/MEDEA* system and the US Navy have the *Advanced Tethered Vehicle*. Japan's Marine Science and Technology Centre (JAMSTEC) have also been developing *KAIKO* to dive the deepest point in the world's oceans. Once again Britain does not feature in this list of submersible asset owners.

The tether system gives ROVs freedom from some of the design-based constraints of manned submersibles. Our human evolutionary heritage has provided us with bodies that are not adapted to function at the ambient pressures of the deep-sea environment, and manned submersible design must take account of this and provide an environment within which we can function. The expense of building a pressure sphere to do this restricts its size to accommodate four persons at the most, in very cramped conditions. As subs generally require pilot and co-pilot for vent field operations, this places a limit of two on the number of scientific observers that can witness and direct operations in real-time. In contrast, there is no limit to the number of scientific observers that can witness and direct ROV operations, because there is no need for them to be accommodated within a pressure sphere. In fact, with satellite communications, the scientific observers do not need to be at sea, and could be scattered among different institutes across the world and still watch and direct sampling in real-time.

ROVs are also dissimilar to manned submersibles in that they draw power from the surface ship via the tether. This means that their endurance is not limited by battery capacity. However, in addition to providing certain operational freedoms, the ROV tether also imposes other operational constraints. Tethers can snag or become twisted, and a kink in the tether can irreparably damage the fibreoptics inside. Precise control of the deployment and recovery of the tether to match the vehicle's progress is crucial, and may require the ship to have dynamic positioning capabilities. Before the next dive, the tether may also need to be reconditioned to remove any twists. Reconditioning the tether is essentially the same procedure as removing twists from a telephone handset cord: it is suspended with a weight to unwind the twists.

Despite these limitations, the advances in ROV technology are rapidly offsetting the traditional advantages of using manned submersibles. Whilst the human eye looking through a porthole is undoubtedly more sensitive than any video system, the latest generation of three-chip charge-coupled device (CCD) cameras can provide sufficient visual information to meet most requirements. Although a human in a submersible uses stereoscopic vision to observe the three-dimensional topography outside, stereo viewing systems have also been developed for ROVs. Virtual-reality technology used to control unmanned vehicle manipulator arms can create what is known as 'telepresence': an experience almost indistinguishable from actually being where the work is carried out. For example, the manipulator arms on the US Navy's *Advanced Tethered Vehicle* have a force-feedback system that allows their controller on the surface to feel the weight of objects being manipulated on the seafloor, and feel the resistance if an arm is resting on an object such as the sample basket.

Although manned submersibles have been the dominant biological sampling platform at deep-sea hydrothermal vents in the past, unmanned vehicles probably represent the future, where it may not be necessary to send humans to the ocean floor for other than romantic reasons. However, it is doubtful that ROVs will lose their tethers, as we lack an alternative means of carrying signals through such a depth of water in real time and with the necessary bandwidth. At present, tether management is one of the major factors limiting ROV operations and may offset their greater flexibility compared to manned submersibles, such that the two types of sampling platform may be roughly equivalent in their effectiveness. Tether management problems can be reduced by splitting the ROV into two units, one of which is smaller, more mobile and carries out the actual sampling and surveying, attached to the other 'mother' vehicle which houses many of the systems and remains essentially stationary in the area being studied. This reduces the amount of tether subjected to stresses by the movement of the vehicle during sampling. The French submersible *Nautile* has a small ROV of its own, controlled and powered from the sub, that can be used to go where the much larger submersible can not.

Currently manned submersibles are better suited to carrying heavy payloads, but as improved tether management reduces the need for reconditioning the tether between dives, ROVs may overcome their payload limitations by being able to shuttle samples from the sea floor in a quick succession of dives, as they have no batteries to recharge. Some ROVs already address the payload limitation by using an elevator/cage system to ferry samples to the surface while the ROV continues working on the bottom.

SAMPLING FROM DEEP-SEA SUBMERSIBLES

Successful sampling from submersibles is essentially dependent on two factors: the suitability and reliability of the submersible's systems, and the skill and ingenuity of their operator. Of these factors, it is usually the former that lets you down and the latter that overcomes it. Manned and ROVs share some similar problems as platforms for biological sampling at deep-sea hydrothermal vents. Both require an adequate navigation system for successful operations and both are ultimately dependent on their manipulator arms to deploy equipment and collect samples.

The most common technique for submersible navigation uses a long baseline transponder array. Upon arriving at a vent site, transponders are deployed on moorings around the site. The submersible can interrogate these transponders with an acoustic signal, and the transponders reply with a signal frequency specific to each transponder. Knowing the speed of sound in water, the return time for this reply is converted to a slant range from that transponder. This therefore defines the radius of a circle on the seafloor around that transponder on which the submersible's position must lie. With slant ranges from two transponders, a position fix is possible, so long as you know which side of the baseline between the transponders you are working on. With three transponders, only one solution is possible.

Although this system is very simple in principle, there can be complications. The topography of the area, combined with the positions of the transponders, can produce regions of acoustic shadow where no signal can be received from one or more transponders. This is particularly a problem at mid-ocean ridges where the topography is much more complex than on the abyssal plain. For example, if a submersible is in a valley at the top of a ridge, and the transponders are positioned down the sides of the ridge, the sub may be unable to interrogate the transponders if the seafloor blocks the signal. To get a position fix in this situation, the sub must therefore rise up in the water column to interrogate the transponders. However, the bottom currents may not be trivial, and it is possible to return to the bottom to find yourself elsewhere. It seems incredible that an eight metre-long submersible can get lost in an area the size of two football pitches, but being navigationally-challenged is a common feature of submersible dives. In such circumstances sonar may be used to look for upstanding projections that could be vent chimneys. Markers placed by other workers are then a useful means of identifying previously visited sites.

Having arrived at a vent, several techniques are available for sampling the fauna and the choice between these largely depends on the nature of the fauna. Small motile animals, such as the vent shrimp *Rimicaris exoculata* from Mid-Atlantic vents, are suitable for sampling by a slurp gun, which is essentially an underwater vacuum cleaner. The animals are sucked up a tube on the submersible's

manipulator into a container in the sample basket. This container may be one of several in a carousel that can be moved round to enable separate samples to be taken from different locations. Use of a slurp gun can therefore provide some spatial resolution in its samples. In the absence of a slurp gun, or to catch larger motile animals such as fish, a skilful operator can collect specimens using a net held in the manipulator claw. Small sessile animals, such as anemones, may be collected by breaking off the rock to which they are attached; larger sessile animals, such as tubeworms and clams from the vents of the East Pacific, may be picked up directly by the manipulator claw. Spatial resolution can be provided by these sampling techniques if samples from different locations are placed in separate boxes within the submersible sample basket.

In addition to collecting animals during a dive, submersibles can be used to deploy traps for motile animals and recruitment arrays for postlarvae. Specialist traps can be used to overcome a rather unique problem in submersible sampling. The vent shrimp *Rimicaris exoculata* possesses a dorsal organ with a photoreceptive layer that has puzzled urophysiologists. Characterising the visual capabilities of this organ electrophysiologically requires undamaged live specimens, but the intense lights of the submersible may damage the photoreceptive layer during their collection. During BRAVEX/94 the *Mir* submersibles deployed "light-tight" shrimp traps designed by Magnus Johnson of the University of Leicester. These traps had an internal baffle with an aperture offset from the trap entrance so that shrimp entering in the period between the deployment and recovery dives would be kept in darkness during recovery. The spectral response of the dorsal organ was determined in a live unblinded specimen collected by this method, whilst no response to light was found from any of the animals captured in conventional traps (Johnson *et al.*, 1995).

One of the greatest limitations of submersible sampling at deep-sea hydrothermal vents is the inability to conduct intensive time-series investigations owing to the expense of submersible cruises. However, equipment can be deployed and left at vents between expeditions to try to overcome this. In September 1994 a time-lapse video system was left at the TAG hydrothermal mound in the Mid-Atlantic to monitor the effects of drilling by the Ocean Drilling Program, due to take place in October. The camera was later recovered by *ALVIN* in April 1995, and had obtained footage of faunal behaviour from before and during the drilling period.

CONCLUSIONS

With its almost absolute technological dependence, one of the key problems in vent biology is not matching the scale of sampling or analysis to the scale of the feature or process in which you are interested, but rather choosing a feature or process to investigate which may be resolved by the available sampling techniques. A prerequisite for success in sampling from submersibles is also flexibility: any *a priori* sampling programme and scheme for data analysis must have room for on-the-spot modification to cope with unforeseen limitations in the submersible's capabilities and possible equipment failures. There is therefore an element of serendipity implicit in submersible sampling at deep-sea hydrothermal vents; however, a similar element of serendipity is common to all deep-sea biological sampling and was present in the dredges made from *HMS Porcupine* over a century ago.

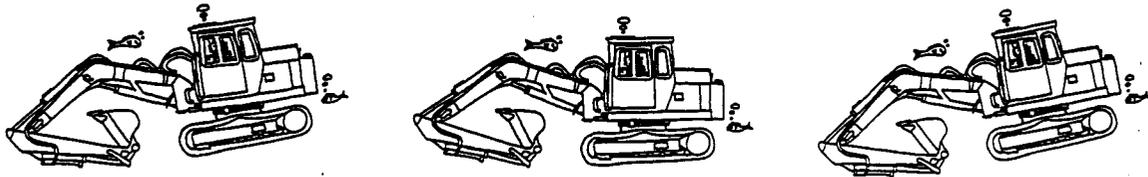
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SOME OBSERVATIONS ON OBSERVATIONS OF MARINE LIFE FROM MERCHANT SHIPS

By FRANK EVANS

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When the Meteorological Office was first established in 1854 under the direction of Admiral Fitzroy, formerly of HMS "Beagle", one of his first actions was to request certain British merchant ships to produce weather logbooks for the records of the new organisation. Recruited ships, to whom meteorological instruments were loaned, were known as Selected Ships and the fleet was designated the Voluntary Observing Fleet. Their logbooks were at first collected for the purposes of research and for climatological studies but with the arrival of ship to shore radio, weather reports began to be employed in forecasting.

At the back of logbooks supplied to the ships by the Meteorological Office there were, and are, separate pages available for the entry of observations of sea surface life and other miscellaneous phenomena such as aurorae and astronomical events. While not every logbook contains a biological observation there exists a substantial body of biological data extending back for almost a century and a half and covering all oceans.

The total number of logbooks currently held at the Meteorological Office headquarters in Bracknell exceeds seventy thousand. With certain exceptions the biological data they contain has not been extracted nor treated in any systematic way, but some have been printed. Since 1924 the "Marine Observer", a journal of records and scientific papers published by the Marine Branch of the Meteorological Office, has carried individual reports of biological sightings, often accompanied by comments from specialists to whom they have been submitted.

As well as being confined largely to surface observations (plus some angling successes), reports are skewed towards what may catch the eye from a ship's bridge many feet above the waves. It might be supposed that earlier observations from slow sailing ships with low freeboards would be more comprehensive, but the opposite appears to be the case, modern seamen appear better informed on natural history than their predecessors; moreover, they nowadays often supplement text and sketches with photographs in a way that was not possible in the last century. When Hardy (1956) wrote of *Veleva*: "Jack-by-the-wind the old sailors used to call them; today I do not suppose the steamship men, travelling fast ever notice them..." he was quite wrong. Indeed, it is only through the numerous merchant ship observations relayed to the Meteorological Office that the vast outburst of *Veleva* across much of the North Pacific each spring has come to scientific notice (Evans, 1986).

Shipping density has fluctuated over the years as has the size of the Voluntary Observing Fleet, but shipping routes have not changed much apart from some tanker routes, so that a fair comparison may be possible of early and recent records. Observations are considered in the following categories:

- (a) Birds. These are commented upon by a representative of the Royal Naval Birdwatching Society, a society which includes both naval and merchant seamen. They are not further considered here.
- (b) Mammals, mostly cetaceans, although pinnipedians and sirenians are also reported. There is currently no specialist reporting on this group, an important lack. In the recent past there was regular expert comment.
- (c) Fish and Invertebrates. Observations on these groups have been sent to me for comment since 1978.
- (d) Red Tides, Discoloured water and other mass plankton phenomena. These are also sent to me, although I am poorly equipped to deal with them.
- (e). Bioluminescence. Since 1975 reports on luminescent phenomena have been sent to Peter Herring of IOS.
- (f) Minor Groups, including reptiles (sea snakes and turtles) and insects(invariably terrestrial, no *Halobates*, being either stowaways or castaways). both these groups have received specialist comment in the past but not at present.

The taxa most commonly recorded have been given as follows (Anon, 1995). Amongst cetaceans, sperm whales are commonest, followed by pilot whales, beaked whales generally, humpback whales, bottle-nosed dolphins, killer whales, blue whales and minke whales. In the case of fish, hammerhead sharks are the commonest, followed by manta rays, flying fish, white-tipped sharks, hatchet fish and sunfish. Amongst invertebrates *Veella* and *Physalia* occur most of all, followed by swimming crabs and squid.

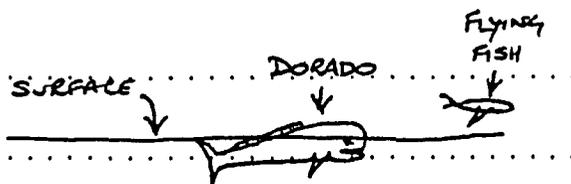


FIG 1.

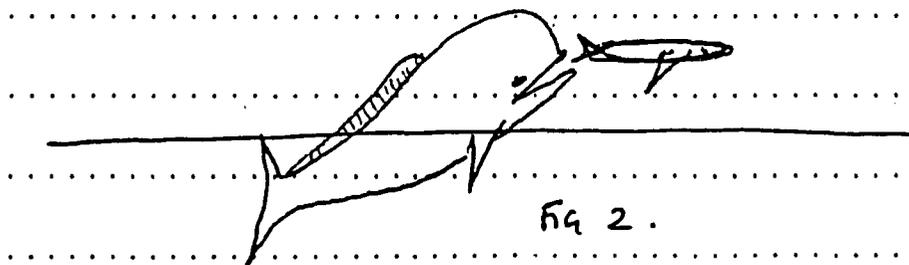


FIG 2.

Dorado, Coryphaena sp., taking a flying-fish on the wing. Drawing and an account of this previously unreported feat, by Paul Burrige, Second Mate of the selected ship RRS "Discovery" in the Arabian Sea, September 1994.

Several attempts have been made to extract biological information systematically from the logbooks. A database has been established by Watson and Herring (1992) specifically to accommodate the observations of bioluminescence, of which there have been many reports. In it are contained all these observations published in the "*Marine Observer*" since its inception in 1924, together with all the reports sent out to specialists since 1963. These together total over 2,300 records.

Within these records special attention has been paid to the curious phenomena of 'milky seas' and 'phosphorescent wheels'. A milky sea can be described as having the appearance of luminescent condensed milk, where the ship's hull, and even fish, appear black against a background of whiteness, and where waves become invisible. Milky seas are reported from many areas but are highly concentrated in the northwest Indian Ocean (Herring & Watson, 1993). Phosphorescent wheels are largely tropical and subtropical but are almost unknown in the Atlantic, being commonest in shallow waters of the Indo-Pacific. They are very varied and bizarre in form, with beams of light sweeping through the sea at great speed and sometimes apparently taking to the air (Herring & Horsman, 1985).

More general biological reports have been extracted by photocopying promising logbook pages from two recording periods, the first over a period of about 20 years towards the end of the last century by Tim Wyatt, formerly of MAFF, the second for about 20 years on the 1950's and '60's by Paul Horsman, formerly of the Marine Society. Both these sets of records are currently held by me. I have set up a data base, using dBASE III, to accommodate records of fish and invertebrates held in manuscript files since it is my wish to extend the computer cover to the extensive archives of Wyatt & Horsman. While the task may prove impossible to complete that is no reason not to make a start.

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PLANKTON SAMPLING

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Making quantitative, and at times even qualitative, assessments about plankton distributions is fraught with difficulties. Firstly there is the inherent variability of the distributions at all scales in time and space. The spatial component of this variability which is induced by the eddy structure of the water, tends to have a linear relationship with time. So in the open ocean an eddy with a diameter of 200m has a longevity of about 24 hours, and one with a diameter of 200km has a longevity of about 2 years. These types of time/space relationships are often depicted as "Stommel" diagrams (Fig 1) named after the famous physical oceanographer Henry Stommel who was the first to point out this relationship. In inshore waters the situation is even more complex because the interaction between tidal currents and bottom topography generates physical features in the water column which have very different characteristics. For example around Britain, the locations at which tidal fronts develop in summer between totally mixed and thermally stratified water columns are determined by the relationship between the maximum tidal flow and the water depth.

Variability also originates from the organisms themselves and the non-linearities in their intra- and interspecific interactions. Predators eat holes in shoals of prey, the prey take evasive action when they detect the presence of predators. Diel vertical migration, which in most cases is a strategy to minimise predation, changes not only the species composition and dominance through at least the top 1000m of many water columns, but also the whole structure of the food web on a daily basis. During the day vertical distributions are often finely structured and layered whereas at night distribution patterns tend to become more random as the organisms lose the visual cues which some of them use to regulate their vertical (? and horizontal) distributions. The migrants often interact passively with frontal systems as a result of the changes in the current shear, and this tends to accumulate them within convergent fronts. At divergent fronts nutrient supplies are often enhanced by local upwelling, so phytoplankton production and standing crop is often enhanced. The more active predators appear to seek out fronts where feeding tends to be better.

Benthic ecologists are just beginning to realise that interpolating from grids of point-samples to map highly variable systems can result in very unrealistic images of distributions, no matter how closely the points are placed. This is "easier" for benthic systems which are essentially 2-dimensional, compared with pelagic systems which are 3-dimensional. Continuous surveying techniques, often of abiotic characteristics of the environment, are now being used to give guidance as to how to interpolate within gaps. In the pelagial, surveys of acoustic back-scatter, especially using systems which insonify swathes of water, are now beginning to provide clearer images of how pelagic species and assemblages are organised in space.

At longer time scales, not only are there regular seasonal successions depending on the frequency and timing of the breeding cycle, but also seasonal migrations are commonplace at latitudes $>40^\circ$. Many planktonic species overwinter deep (maybe 1000-2000m) within the water column usually in a state of non-feeding diapause. How are we to consider these organisms? Are they members of the pelagic "community" since their only interaction is as a food source? The majority of pelagic species also undertake ontogenic migrations; the early stages of their life cycle are spent in the upper euphotic zone and they move deeper into the water column as they mature. Many benthic species are temporary residents in the plankton as larvae. For even longer interannual and decadal time scales, the continuous plankton recorder survey and the analyses of sub-fossil records in varved sedimentary deposits, are revealing complexities which will make the unambiguous recognition of change extremely difficult, and the recognition of change must be one of the science's major tasks.

Another factor that either tends to get overlooked, or there is the tacit assumption that readers of papers and reports are aware of, is that each sample gives a very narrow window of discrimination onto this sea of confusion (Fig 2). The mesh size conveniently extrudes the smaller organisms that are

often so difficult to identify. There are many gelatinous species that are so fragile that they just disintegrate in nets. Despite their fragility some of these species are dominant components of parts of the food web, yet to the planktonologist who never has the opportunity to dive in a submersible they are invisible. No net is really 100% efficient in its filtration of the water. There is always some sort of bow wave, and the net's visibility gives warning early enough for some of the larger more active species to escape from the mouth of the oncoming net. The volumes of water that need to be sampled to give a representative sample give samples that often are far larger than can be efficiently sorted, identified and enumerated. Thus a net sample gives a very distorted reflection of what the real world is like. Maybe every paper on plankton should carry a "credibility" warning that if you believe the data are giving a representation of the real world, you are being sadly deluded.

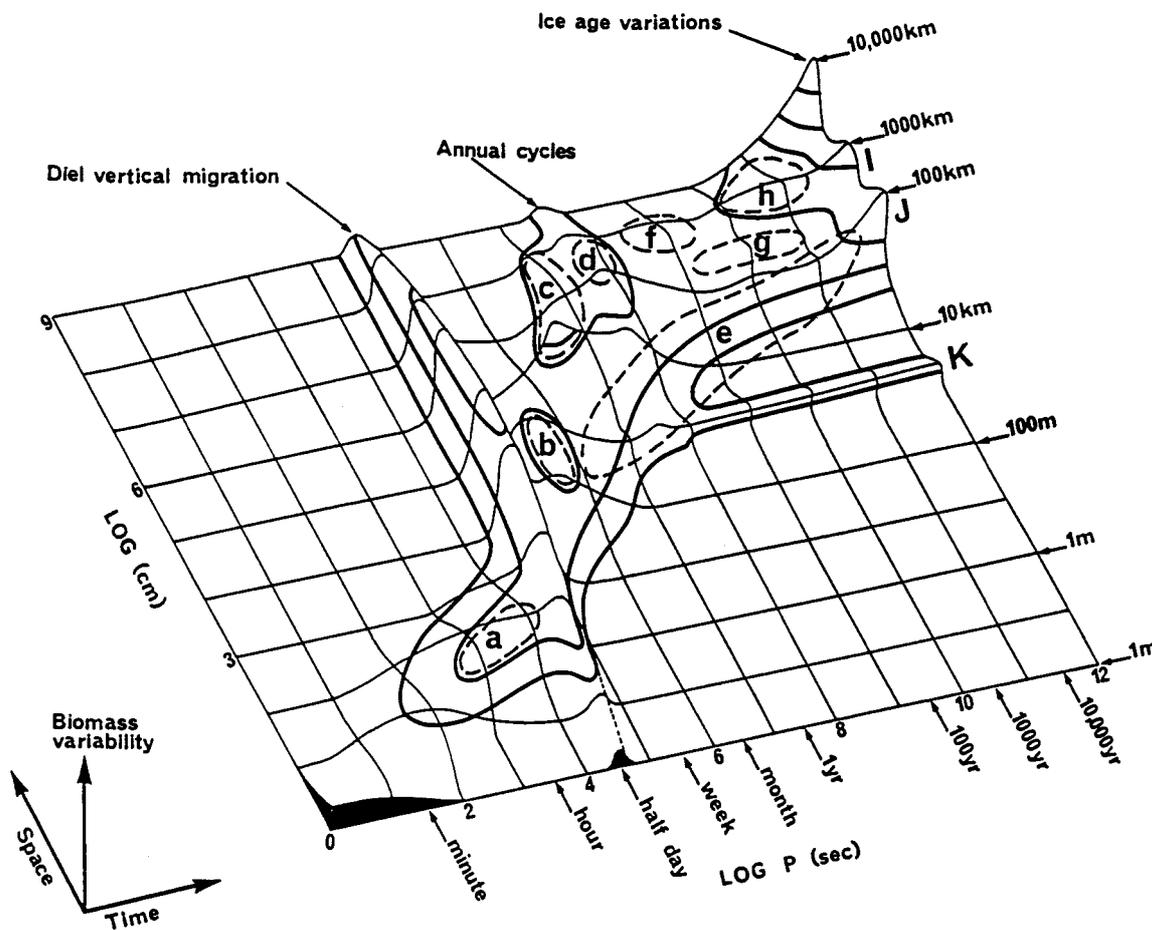


Figure 1. A Stommel diagram showing the time/space variability of the distribution of zooplankton biomass (from Haury, et al., 1978)

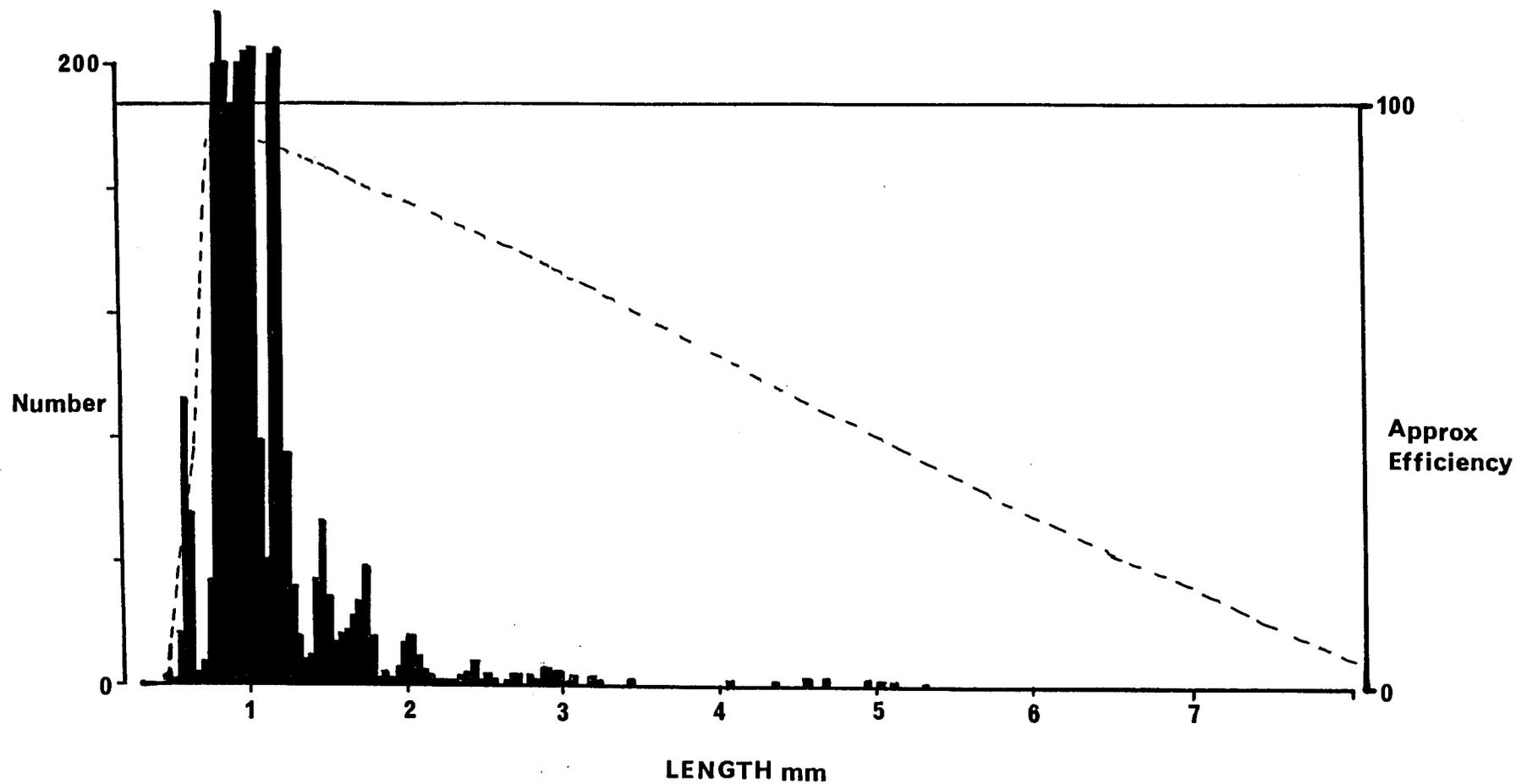


Figure 2. Size spectrum of planktonic ostracods caught at night at a depth of 200-300m at Ocean Acre off Bermuda. The dashed line gives a guess as to the catching efficiency of the net for ostracods of different sizes. The smaller animals get extruded through the 0.32mm mesh of the net, whereas the larger animals have an increasing ability to escape from the path of the on-coming net (based on Angel, 1979).

SAMPLING THE MACROBENTHOS; HOW MUCH WASTED EFFORT ?

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Although methods exist which facilitate the design of faunal surveys that match the precise needs of the user, there is little evidence that full use is being made of them as many scientists and managers appear reluctant to move away from traditional techniques. For many years offshore macrobenthic sampling was carried out by taking small numbers of replicate 0.1m² grab samples and sieving the sediment through a 1mm aperture mesh. After species identification, analysis was performed by searching for changes in maps of communities/dominant species or by the comparison of diversity indices. Both of these methods are insensitive to subtle change and if the results of surveys are to be at all meaningful, huge quantities of sediment have to be collected. This has made benthic biology an expensive option for environmental monitoring and pollution detection work.

Benthic data are collected for many purposes, ranging from the assessment of diversity to routine pollution monitoring and each of these tasks requires a different strategy of sampling and analysis. Ideally, in each sampling strategy the resources expended should be appropriate to the time/money available, the quality of information required and the location to be sampled. To achieve this efficiently, some rethinking of benthic sampling procedures is called for. When assessing routine biological surveys many environmental managers tend to treat community structure as an attribute of a particular place at a particular time and use this information to implement technical decisions in much the same way as they use data on physical or chemical variables. In such cases, very little biology is invoked and only the minimum amount of data needed to address the problem in hand need be provided; here, modern techniques in sampling design and analysis can achieve considerable savings over more traditional methods. At the other end of the spectrum are surveys of infaunal diversity where standard macrobenthic survey techniques over-sample common small bodied animals while greatly under-sampling larger ones. As it is unrealistic to continue digging ever larger holes in the sea-bed simply to collect the rarer species, specific survey strategies must be designed to replace the those currently employed. Between these extremes are a variety of requirements for benthic sampling all of which might benefit from a careful review of the methods used in sample collection and processing. While some revisions might be based on advances in statistical analysis, others might employ ground discrimination techniques or novel methods of sample collection or processing.

Multivariate statistical methods permit a far greater flexibility in the planning of benthic faunal surveys than traditional techniques as they maintain species identity within the analysis and so maximise the amount of information that can be extracted from a species/sites data matrix. As a result, the effective information content of a single benthic sample is far higher than in a similar sized sample analysed using traditional methods. These high levels of information permit flexibility in sampling design and sample treatment. Various authors have demonstrated that the configuration of a multivariate data plot appears to change little as a response either to changing the taxonomic discrimination applied in the analysis of the fauna from species level to that of the family or to increasing the mesh size used to extract the animals from the sediment. When such methods are employed during the course of a survey savings in time and effort can be considerable, but their use cannot be universally recommended. However, in many cases an even greater reduction in sampling effort can be achieved by simply reducing the size of sample collected. Reductions by as much as 90% have had little effect on the multivariate plot configurations from a muddy sand station in Plymouth Sound. While it is acknowledged that such a saving in effort might not be possible with more sparsely populated sandy sediments, even a reduction of 50% would be welcome to the scientist at the bench and those paying him. As an alternative to saving effort, decreasing the size of samples permits a greater number to be taken without an increase in costs. These might be used sample over a wider area to gain a picture of the fauna more representative than that which comes from 5 grab samples or, in surveys where hypotheses are being tested, they would increase the sensitivity of multivariate tests.

RECENT ADVANCES IN SAMPLING DEEP-SEA MEIOFAUNA, PARTICULARLY THE FORAMINIFERA

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The ocean floor is the largest but least known environment on earth. Since deep-sea biology got under way properly in the late 1860's, an area of perhaps some tens of km² has been sampled biologically. A much smaller area, around 50m², has been sampled quantitatively for macrofauna and a recent estimate (Lambhead, 1993) suggests that quantitative meiofaunal samples amount to less than 5m² of the sea floor. Nevertheless, our knowledge of meiofaunal organisms in deep-sea sediments has a long history. Foraminifera, or at least their dead shells, were extracted from small quantities ("about thimblefuls") of mud obtained by a sounding device at depths of between 79m and 4,300m in the North Atlantic (Parker & Jones, 1865), and ostracods were found in samples collected by "Challenger" from more than 5,000m (Brady, 1880). The early (pre-war) deep-sea meiofaunal studies were concerned with taxonomy and distribution and were based on samples collected by dredging and later by various kinds of grabs. Dredge samples are, of course, qualitative, at least for meiofauna, while grabs are notoriously unreliable for quantitative meiofaunal work (Blomqvist, 1990). A particular problem in the case of grabs is the loss of surficial sediment which contains many of the meiofaunal organisms. Grabs were superseded in the 1960's by box-corers, first the Reineck and then, in the 1970's, by the USNEL box-corer developed by Hessler & Jumars (1974). This device has been widely used in deep-sea macrofaunal and meiofaunal research over the past 20 years.

An important advance in deep-sea meiofaunal research was the advent of the Barnett-Watson multiple-corer. (Barnett, *et al.*, 1984; Fleeger *et al.*, 1988). This device, a development of the single-tube Craib Corer, is a "deliberate", hydraulically damped corer which obtains a set of cores (up to 12 depending on the model) in which the sediment - water interface is virtually undisturbed. The ability to collect such cores is of crucial importance in meiofaunal studies since many of the tiny organisms reside in the flocculent, easily re-suspended surface layer. A recent study by Bett *et al.*, (1994) showed that multiple-corer samples yielded metazoan meiofaunal densities which, on average, were about twice those derived from box-corer samples. This disparity is probably due to the sediment-disturbing bow-wave generated by the much heavier, undamped, box-corer. In some respects the results of Bett were puzzling since density differences persisted below the top 1cm of sediment. This subsurface effect is unlikely to result from a bow-wave and possibly reflects different degrees of core shortening. Nevertheless, there is ample evidence from this and other studies to support the claim of Blomqvist (1991) that the multiple-corer is the "best device available for general sampling in open-sea, soft-bottom sediment at present".

In parallel with these developments in sampling technology, the past few decades have seen some major advances in understanding the functioning of deep-sea communities (Gage & Tyler, 1991). In the early 1960's, the ocean floor was viewed as a monotonous, seasonless environment which was home to a stable, low diversity fauna. It is now apparent that the ocean floor is more dynamic, and the communities more variable and diverse, than previously realised. In particular, the deep-sea environment is disturbed by a number of processes including turbidity currents, hydrothermal venting, periods of elevated current activity ("benthic storms") and seasonal pulses of organic matter (phytodetritus) derived from surface primary production. This latter form of disturbance is of considerable ecological importance in the temperate Northeast Atlantic where it has been studied by, amongst others, the benthic biology group at the Institute of Oceanographic Sciences (now part of the Southampton Oceanography Centre) (Billett, *et al.*, 1983; Rice, *et al.*, 1994). In this region, inputs of phytodetritus form a patchy carpet on the sea floor during the late spring and summer. One of the great virtues of the multiple-corer is its ability to retain this light flocculent material. Without a submersible, the only other way to "collect" phytodetritus is photographically.

At abyssal depths, biological activity within the phytodetritus is estimated to account for 60-80% of the seasonal (summer) increase in carbon turnover by the sediment community (Pfannkuche, 1993). The main organisms responsible are believed to be bacteria and small flagellates (Gooday & Turkey, 1990). However, some members of the meiofauna are also implicated. Careful examination of individual phytodetrital aggregates from multiple-corer samples often reveal numerous small (50-200µm sized) benthic Foraminifera, usually the only benthic organisms visible under a dissecting microscope (Gooday, 1988). Unlike the highly diverse sediment assemblages, these populations are characterised by low species richness and high dominance, a population structure typical of systems subject to organic enrichment, for example as a result of pollution. The foraminiferal species which are good at exploiting phytodetritus are probably quick-growing opportunists characterised by dynamic populations which fluctuate seasonally according to the availability of their ephemeral food source. This kind of ecological strategy is very similar to that of some shallow water Foraminifera which bloom in response to the growth of diatom patches (Lee, *et al.*, 1969). Curiously, with the exception of certain monhysterid Nematoda (Riemann, 1995), the metazoan meiofauna appears unable to match the ability of Foraminifera to exploit deep-sea phytodetrital deposits.

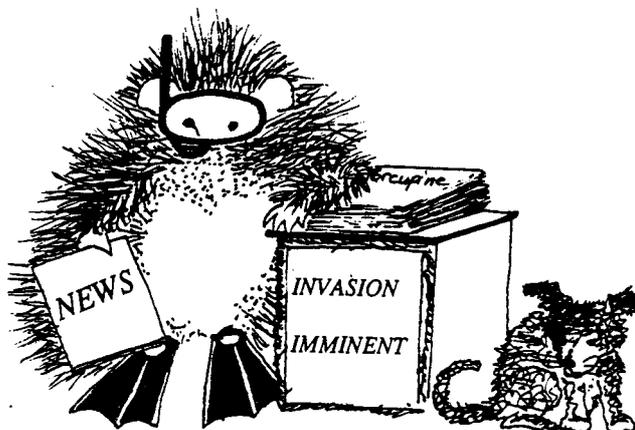
Our new perspective on the ecology of deep-sea benthic communities in general, and of Foraminifera in particular, is a far cry from the opinions expressed thirty years ago. A number of factors have caused this paradigm shift. By no means the least important of these is the ability to raise from abyssal depths pieces of the ocean floor in an intact, undisturbed condition. Although small, these samples are certainly of high quality. At the very least, we can be confident that they are an improvement on the thimblefuls of sounding mud available to Parker and Jones!

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CREPIDULA FORNICATA (L., 1758)
(Mollusca: Gastropoda)
AT TENBY, SOUTHWEST WALES



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Crepidula fornicata (L., 1758), the slipper limpet, was noted from the Conchological Society's Marine Mollusc Recording Scheme Sea Area 21 by Seaward (1990) and marked on the map as being from Dyfed by Minchin *et al.* (1995, p.250). Neither gave any details of locality or date except to presume that the species had been introduced with oysters. On 5 October 1995 while otherwise rather unsuccessfully investigating the rock and boulder shore at Giltar Point, Tenby [51°39.3'N 04°42.7'W], I found one living specimen 26mm long attached to a dead shell of *Buccinum undatum* (L., 1758) which was washed up and lying near low water. I have worked on Dyfed shores regularly since 1982, recording both living Mollusca and dead shells collected from large quantities of shell sand at the strandline, and have never found any other examples of the slipper limpet. Oyster shells are common at Tenby and in Milford Haven, but all I have seen have been extremely old and worn. Has *Crepidula* outlived them, is this a chance example, or is this the start of a new invasion?

Minchin, D., McGrath, D. and Duggan, C. B., 1995. The Slipper Limpet, *Crepidula fornicata* (L.), in Irish waters, with a review of its Occurrence in the North-Eastern Atlantic. *J. Conch., Lond.* 35: 249-256

Seaward, D., 1990. *Distribution of the marine molluscs of north west Europe*. Peterborough. Nature Conservancy Council

Porcupine Newsletter, 6 (3), 1995

WEED WASHINGS

By SHELAGH M SMITH

Woodleigh, Townhead, Hayton, Carlisle, CA4 9JH, UK

I started washing weeds for molluscs many years ago. David Heppell came back from Orkney with some small species which he had washed off *Furcellaria*. I was immediately jealous and from then on hooked. As time goes on and *Anno Domini* takes its toll, this method is also a good way of finding small specimens quickly and easily.

The result has been that I've collected bags and bags of algae, from the Shetlands to the Falklands (not quite South Shetlands), and while the samples have been rather random as regards time and place and indeed shore height, they have been fairly consistent to size and I have kept to the same methodology for the past 20 or so years. Basically, polythene bags 41cm x 28cm are stuffed with *Fucus serratus*, or smaller algae, taken randomly as regards size, species and often height on the shore, thus initially providing a qualitative rather than quantitative result. Emphasis is on the microhabitat offered rather than the role of algae as food. The algae are usually soaked overnight in 9-litre buckets of fresh water, but a shorter period will do, particularly if a small quantity of IMS or wetting agent is added, or in hot weather when fucoids in particular rapidly produce slime in which molluscs stick and from which they are very difficult to get out. The weeds are then shaken well to dislodge entangled or adhering species. Surplus water and algae fragments and other detritus are then decanted out and the residue preserved for careful laboratory sorting. It has been suggested by Dennis Seaward that magnesium chloride added to sea water would have the same effect so that the softer molluscs such as nudibranchs would remain in good condition and not bloat, usually unrecognisably. This disadvantage of this is that shelled specimens will subsequently have to be rinsed in fresh water so that they are less prone to deterioration in long-term storage, particularly under alcohol.

Two useful sets of data may be obtained. The first is qualitative: listing of what species are present for mapping or other distributional purposes. One obtains many records which one cannot get without such attention to detail. The second is quantitative: this has meant a great deal of tedious and time-consuming counting of very small specimens, and setting out of results in tables. However, once done, one can give good estimates of Abundance, which actually render rather questionable the estimates given by people who do not weedwash: they might find a handful of, say *Rissoa parva* and score Occasional, while I will have found perhaps 1600 and score Abundant. I have now a great deal of comparative data and have made repeat samples and many localities. Comparison is best done when the numbers of individuals of species in samples are converted to percentages.

It is possible, by looking at a table of Mollusca from weed washings, to tell to a certain extent what the habitat was, i.e. type of weed, degree of exposure, season of the year, geographical location. Not being a statistician I have yet to sort out these results and make better sense of them. One of the problems is that one is not dealing with a handful of species but many. Generally there are between 20 and 35 species in each sample, but there may be only 5, or there may be 75. Although some species are nearly always present in the same habitat, one cannot leave out the less common or usually rare species because in some situations they are dominant, environmentally indicative, and may account for over 80% of the total numbers. I have hundreds of sets of data and if anybody could make statistical sense of them I would be delighted.

Over the years, I have refined my methods of shore surveying collecting and recording. One learns of more niches to be explored, more about what lives where. But unfortunately time is all too often limited and short cuts have to be made. Ian Killeen is going in for scraping under boulders because weed washing does take up a lot of time and effort, especially in the laboratory. When he asked me to do this presentation on weed washings I decided to do a direct comparison. So, visiting a favourite

TABLE 1. Numbers of species found at Loch Craignish

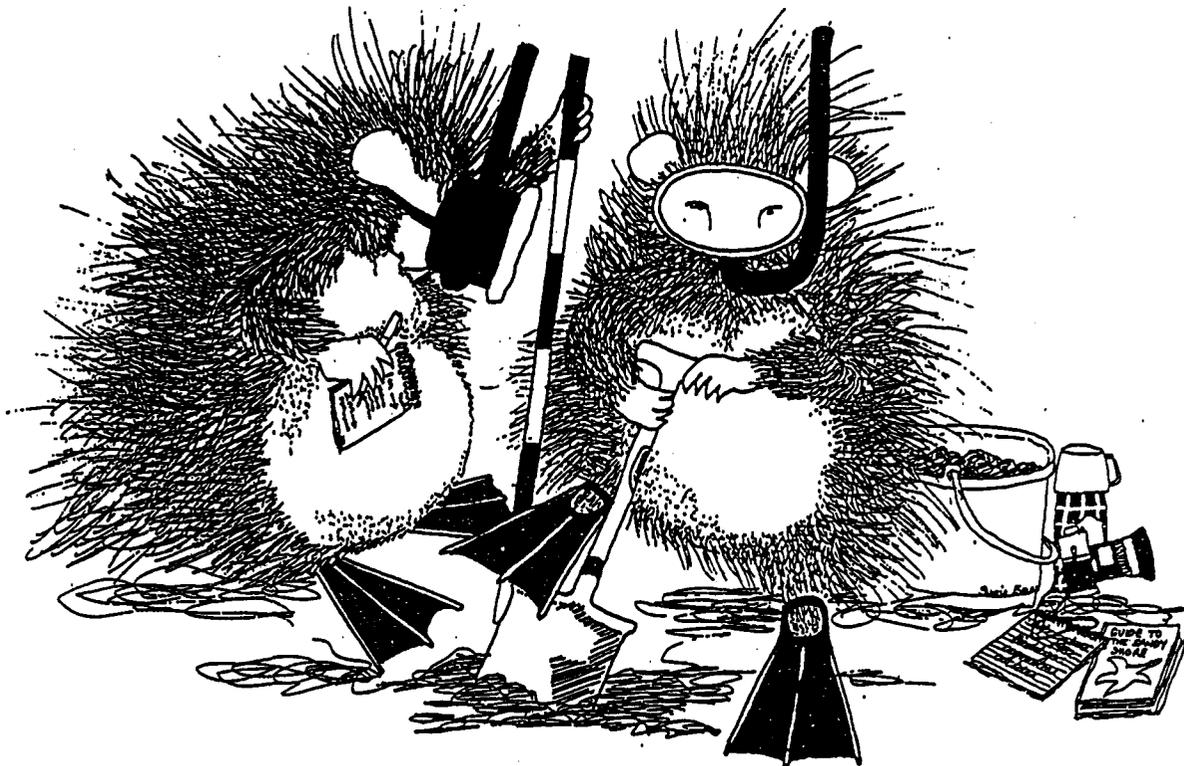
A= boulder scrapes; B = *Fucus serratus*; C= small algae; D = *Zostera marina*; E = *Laminara hyperborea* holdfasts (Cuan Ferry)

	A	B	C	D	E
<i>Leptochiton asellus</i>					1
<i>Lepidochiton cinerea</i>			62	32	
<i>Acanthochitona crinitus</i>					1
<i>Tectura virginea</i>			1	1	
<i>Helcion pellucidum</i>		7	13		5
<i>Margarites helicinus</i> (juv)	55	118	745	18	1
<i>Gibbula cineraria</i>		5	3	1	1
<i>Calliostoma zizyphinum</i> (juv)		1			
<i>Lacuna pallidula</i>	1	227	216	9	1
<i>Lacuna vincta</i>		22	150	137	
<i>Littorina mariae</i>		165	53	12	
<i>Skeneopsis planorbis</i>		223	1169	1	
<i>Rissoa interrupta</i>	5	58	1243	17	6
<i>Rissoa membranacea</i>				29	
<i>Rissoa rufilabrum</i>		4	65	13	
<i>Rissoa parva</i>	5	2	156		
<i>Alvania punctura</i>					1
<i>Alvania semistriata</i>	9				1
<i>Onoba aculeus</i>	108	2	53	217	28
<i>Onoba semicostata</i>	99			13	28
<i>Pusillina inconspicua</i>	2				
<i>Pusillina sarsi</i>		55	1023	319	
<i>Odostomia turrita</i>		3			6
<i>Odostomia unidentata</i>		1			1
<i>Brachystomia eulimoides</i>	14	1			1
<i>Chrysallida obtusa</i>	1	1	2		
<i>Chrysallida indistincta</i>				2	
<i>Jordaniella nivosa</i>					5
<i>Rissoella diaphana</i>	1	4	1085	9	
<i>Rissoella globularis</i>			3	8	
<i>Rissoella opalina</i>		2	206	35	
<i>Omalogyra atomus</i>			73	6	
<i>Ammonicerina rota</i>	1				
<i>Philine punctata</i>			1	1	
<i>Retusa obtusa</i>				1	
<i>Retusa truncatula</i>	6		5		13
<i>Placida dendritica</i>				1	
<i>Limapontia senestra</i>				1	
<i>Elysia viridis</i>			1		
<i>Aegires punctilucens</i>			1		
<i>Adalaria proxima</i>					18
<i>Mytilus edulis</i> (juv)		22	26	1	10
<i>Modiolus modiolus</i> (juv)					1
<i>Modiolarca tumida</i>				2	1
<i>Musculus discors</i>		26	1		2
<i>Chlamys distorta</i> (juv)					1
<i>Heteranomia squamula</i>			1		2
<i>Mysella bidentata</i>					1
<i>Parvicardium exiguum</i>			32		
<i>Cerastoderma glaucum</i> (juv)				2	
<i>Tapes aureus</i>				1	
<i>Venerupis senegalensis</i>				2	
<i>Turtonia minuta</i>		13	28	1	12
<i>Mya truncata</i> (juv)					1
<i>Hiatella arctica</i> (juv)		2	24	2	11
Numbers of species	13	22	30	33	27
Numbers of individuals	307	964	6441	894	160
NUMBERS OF INDIVIDUALS	307	964	6441	894	160

shore, on Loch Craignish in Argyll, Scotland 56°09.6'N 05°34.0'W on 30 July 1995 I scraped several boulders and collected *Fucus serratus* and small algae. As there was a *Zostera marina* bed adjacent I also collected from it, mainly to compare with an apparently similar *Zostera* bed in Linne Mhuirich, some 20km to the south. Although at the Loch Craignish site all the available *Laminaria* was *L. digitata*, whose holdfasts were decidedly devoid of life, for completeness in this present discussion I include the list from *L. hyperborea* collected the next day from Cuan Ferry, about 20km to the north. I did observe that there were fewer species and fewer individuals of the large species of Mollusca on the shore, although the content of the weed washings was much the same as on previous visits about 10 years ago. Whether this be a natural phenomenon or that the larger species are more susceptible to the undoubtedly increased pollution due to the much increased popularity of the marina and anchorages I do not know.

TABLE 1 gives a full list of species and their numbers. This shows clearly several features which are general to weed washings. There are fewer species and fewer individuals on *Fucus serratus* than amongst small algae. *Zostera marina* can be, as in this case, very rich (but it can be very poor!). *Laminaria hyperborea* holdfasts usually have good diversity in low numbers. about half the species are of regular occurrence in these habitats, the rest, usually in low numbers, are what I would confidently hope to find rather than expect. Given a range of weeds from various environments in an area, about half the total species occur in any one sample. What also has been revealed is the very poor result from the boulder scrapes. (I also got equally poor results from other sites that week). Does one continue to scrape?

If one wants to be thorough, the answer is yes, but one also needs to weed wash, because, as the table reveals, the habitats are different and thus contain different species and I think the extra effort is well worth it. Similarly, for a good qualitative shore survey one also needs to collect crevice gunge at various shore levels and wash clumps of mussels, apart from hunting the larger habitats and investigating sediments - which is another story.



**ASSESSMENT OF THE CONSERVATION STATUS OF THE BASKING
SHARK *CETORHINUS MAXIMUS*
(using the 1994 IUCN Red List Categories)**

**By SARAH FOWLER
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THE IUCN RED LIST CATEGORIES

As amended and agreed in 1994, are defined as follows:

- * **Extinct (E)**
- * **Extinct in the Wild (EW)**
- * **Critically Endangered (CR)** facing an extremely high risk of extinction in the wild in the immediate future
- * **Endangered (EN)** not Critically Endangered, but facing a high risk of extinction in the wild in the near future
- * **Vulnerable (VU)** not CR or EN, but facing a high risk of extinction in the wild in the medium-term future
- * **Lower Risk (LR)** evaluated, and not in above categories, but either Conservation Dependant (cd), Near Threatened (nt) or Least Concern (lc)
- * **Data Deficient (DD)** where there is inadequate information to make an assessment of risk of extinction based on its distribution and/or population status
- * **Not Evaluated (NE)** not yet assessed against the criteria

It should be noted that the above definitions of risk of extinction to a species take account of the fact that a significantly depleted species population is likely to have an increased susceptibility to further depletion from other causes. Such causes, whether man-induced, or natural (or stochastic events whose impact is increased by human activities), may lead to further reductions in population level to a point where recovery is no longer possible, and extinction risked.

THE IUCN CRITERIA FOR THREATENED STATUS

Five main criteria are used to assess the threatened status of a species, based on:

- A. Population reduction
- B. Extent of occurrence
- C. Population number (calculated) in decline, related to generation time, fragmentation and number of populations
- D. Population number very small or restricted in area of occupancy/number of locations
- E. Qualitative analysis showing probability of extinction in the wild

Of these, only Criterion A can be applied to the basking shark world-wide, since this fish is very widespread in its distribution with inadequate world population data available to enable the other criteria to be applied. However, for local and regional populations, particularly where these have been fished and good records of catches made, criteria C and D may also be used.

The main evidence used for the assessment of the conservation status of the basking shark is taken from historical records of former fisheries, combined with present-day observations of population levels and what is known about the life history of this and other closely related shark species.

APPLICATION OF CRITERIA TO THE BASKING SHARK

Before starting to evaluate the status of the basking shark, it is useful to explain the terms which were used for this species.

Population: *The total number of mature individuals in the taxon.* Unknown, but probably large, since the basking shark has a very widespread distribution in boreal to warm-temperate waters of all oceans.

Subpopulations: *Geographically or otherwise distinct groups between which there is little exchange.* There is no evidence of genetic subpopulations, but fisheries and sightings and records suggest that the basking shark is very site-faithful to its coastal summer 'basking' and feeding locations, and can be seriously depleted in a period of only a few years, despite the fact that it appears to be highly migratory with seasonal appearances in coastal areas. Population recovery after some seasonal fisheries has still not taken place many decades later. Examples from Ireland include the Achill Island area where average catches declined from 1,067 pa in 1949-58, to 119 pa in 1959-68 and then 40 pa for the remaining years of the fishery, despite a reinvestment programme (McNally, 1976; Kunzlik, 1988). There are now only a few basking sharks recorded in the area each year (Berrow & Heardman, 1994).

Number of mature individuals: No population estimates are available, other than in small areas where observations using tag and resighting or identification of individual markings can be used to provide a minimum population estimate. Probably quite large, since fisheries have been relatively uncommon and localised to the present day. The picture is obscured by the biased adult sex ratios observed in surface fisheries (between 40:1 and 10:1 for female: male ratios). This probably the result of sexual segregation by water depth. The location of pregnant females (not usually caught in fisheries) and of all individuals in the Atlantic out of season is unknown.

Generation period: *The average age of parents in the population.* Size at birth is just under 2m and litter size six. Age at maturity for males is uncertain, but may be between 6-7 years (if biannual calibration of vertebral rings occurs) or 12-16 years (if rings are annual) and a length of 4-5m (Compagno, 1984). Females are mature at the larger size of 8-9m and are presumably older than males at maturity. Suggested gestation periods vary from just over one year to 3.5 years. The latter would be the longest vertebrate gestation period known. It therefore seems possible that female basking sharks may first reproduce at about 10 or nearly 20 years old. The three generation period specified in the IUCN criteria will therefore be a minimum of 40-60 years for the basking shark.

Continuing decline: *A recent, current or projected future decline whose causes are not known or not adequately controlled and so is liable to continue unless remedial measures are taken.* At the present time very few targeted fisheries for the basking shark are known to exist. However, the booming market and high prices paid for shark products in international trade, combined with the serious decline in other fish stocks, suggests that this species could soon become the focus of increased fisheries activities in several locations, including British territorial waters. Without the imposition of effective controls on the fishery for this species (other than a 100t liver quota in EC waters) or legal protection under wildlife legislation, it is considered that future declines are very likely to occur. There are many examples of fisheries for other species of large sharks which have resulted in sudden and long lasting declines in exploited stocks.

ALTERNATIVE EXPLANATIONS FOR DECLINES IN BASKING SHARK FISHERIES

Some alternative explanations for apparent declines in basking shark fisheries have been summarised by Kunzlik (1988). The most important of these are the natural variations in shark migrations from year to year, including the unpredictable nature of basking shark invasions (records from the Scottish Coast between the 1930s and the 1960s show great variation in numbers, locations and to some extent seasonality), and the dependency on fine weather of fishery and sightings records. Without data on catch per unit effort it is also impossible to determine the extent to which declining catches, for example in Norway, are the result of contracting fleet size and effort. Without more information from tagging, telemetry studies and genetic tissue sampling, it will be impossible for the significance of these variations to be determined, or for the precise status of local or regional stocks to be resolved. However, the evidence for very long term declines at the locations fished heavily in Ireland and Canada suggest that such variation is superimposed upon the general pattern of a generally 'site-faithful' distribution, and does not mean that regional stocks can recover particularly quickly. It also seems extremely unlikely that coastal areas which were so very favourable for large aggregations of basking sharks in previous centuries and the first half of the 20th century are now no longer able to support these fish.

Other explanations for failing fisheries are based on marketing and economic difficulties; generally lack of profitability, problems with the erratic nature of seasonal appearances and competition from other sources of fish oil. However, these explanations do not hold true for many fisheries where very large numbers of fish were taken in a relatively short time, followed by very long-lasting declines.

EVALUATION OF THREATENED SPECIES STATUS

Depending upon the extent to which basking sharks begin to re-enter or increase their importance in fisheries over the next few decades, it seems extremely likely that an overall, world-wide population reduction of at least 20% could be met within the next 50-60 years, even if only the result of a somewhat desultory and opportunistic increase in landings. The species is therefore considered to qualify for **Vulnerable** status.

Should rather higher fishing effort be targeted regionally on the species, in a similar way to that documented for Canada and the west coast of Ireland, resumption of fishing pressures similar to those which resulted in those declines would likely result in a regional decline of at least 50% in the number of mature individuals within a short period. Regional populations of the basking shark are therefore considered to be **Endangered** in areas where relatively large-scale fisheries have taken place and are likely to resume, and **Endangered** in areas previously unfished but where fisheries would be viable, even for only a few years. The historical evidence for a decline of close to 80% during the poorly-equipped 19th century Sunfish Bank fishery and the 20th century Achill Island fishery (McNally, 1976), which would have fulfilled the criteria for **Critically Endangered** at the time, is an important factor in supporting this forecast.

The basking shark is protected in at least one small area (in the waters of the Isle of Man, Irish Sea). There have also been recommendations for its protection in the USA, Great Britain, Northern Ireland and around Guernsey. Where protection from targeted fisheries is provided to a population, then its degree of risk should immediately be reduced, although unless it is protected throughout its surface range it will be vulnerable elsewhere. Additionally, the future introduction of fisheries to its unknown wintering areas may also pose a threat. If protected throughout its range, such a subpopulation could be considered to be **Lower Risk** (either **Conservation Dependent** or **Near Threatened**), depending upon the pressures on other fisheries and the likelihood of exploitation should these fish not be protected.

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SHARK NEWS

The following articles are from Shark News 4: July 1995 (the newsletter of the Shark Specialist Group), with kind permission of the Editor, Sarah Fowler, The Nature Conservation Bureau Ltd, 36 Kingfisher Court, Hambridge Road, Newbury, Berkshire, RG14 5SJ.

ELASMOBRANCH RED LIST

The IUCN has recently published its revised Red List categories and criteria (IUCN, 1994). These new criteria make it possible to include long-lived, slow-breeding (i. e. K-selected) species on the global IUCN Red List even where precise data on population size and declines are not available. This is because the new criteria measure population decline in terms of generations, in other words the capacity of the species to recover its number following exploitation. It is therefore likely that a considerable number of elasmobranch species could qualify for listing under the new system. The 1994 IUCN Red List, using the old system of categories, included just three elasmobranchs, but the 1996 List should include many more, several of which are likely to be of high priority for conservation attention.

SHARK BY-CATCH IN LONGLINE AND GILLNET FISHERIES OPERATING FROM THE SOUTH OF SPAIN

A paper recently submitted to the *Fishery Bulletin* (V. Buencuerpo, S. Rios and J. Moron) gives some interesting figures on the importance of shark by-catch in swordfish fisheries in the eastern North Atlantic and Mediterranean Sea. Of 51,205 fish sampled in landings during 12 months from July 1991, 40,198 were sharks, 9,990 were swordfish and the rest other bony fish. A large number of immature sharks were taken. The paper also presents information about the population structure of shark species and suggests patterns of shortfin mako movements from catch data.

The authors suggest that the shortfin mako could be the species most seriously affected by this fishing pressure, although the blue shark is most commonly caught and large numbers of discards of this species at sea go unreported. Thresher sharks could also be very sensitive to fishing pressure because of their low reproductive rate and the small populations in the area. Hammerhead catches appear to have declined, although historical by-catch data are not available for any species of shark.

They conclude that international organisations such as the Tuna Commissions should be involved in the collection of statistics on the by-catch of pelagic shark populations. Studies of gear selectivity and discards are needed to properly evaluate shark by-catch in these fisheries. Management of the Atlantic swordfish fishery should be reorientated to a multi-species approach, with the effect of the pelagic shark by-catch and its economic implications included in the management model. However, the joint efforts of all nations operating longline fleets in the eastern Atlantic are required to provide a full assessment of the status of shark populations in the area. [Nations] might not do so willingly, because of the extra work involved and because it appears to be outside their mandates. However, on this second point there are two reasons why it should be included in their remit.

First, sharks are a significant by-catch of most tuna fleets; with present high fin prices they cannot be disregarded from economic analyses. Secondly, oceanic sharks and tunas school together; a full understanding of tuna ecology and population dynamics cannot be achieved without an understanding of their associations with sharks.

ELASMOBRANCH RESEARCH AND CONSERVATION INITIATIVES

Ocean Wildlife Campaign for the conservation of large pelagic fishes

Large pelagic fish - tunas, swordfish and marlin - are among the most threatened creatures in the oceans. These long-lived, apex predators, who play an important role in the structure and function of marine communities, have been seriously depleted because of relentless over-fishing and chronic mismanagement.

A coalition of US conservation organisations has recently established the Ocean Wildlife Campaign to strengthen management for these species from national to global levels. The aims of the Campaign are to reverse the declines in large pelagic fish populations and begin the hard work towards their restoration. Campaign steering members are the National Audubon Society, National Coalition for Marine Conservation, Natural Resources Defense Council, New England Aquarium, Wildlife Conservation Society, and World Wildlife Fund.

Shark conservation will be one of the primary targets of the Ocean Wildlife Campaign (OWC). The OWC is planning to produce an identification guide to sharks and shark parts (including fins) for species most threatened by international trade. The guide is intended to help shark fishers and fishery managers identify to species the sharks they are catching and monitoring, and to help CITES parties fulfil the recent CITES shark resolution. The Campaign will also provide some sponsorship for the production and expanded distribution of *Shark News*. On a domestic level, the OWC will continue to push for more rational management of the US Atlantic shark fishery, including a reduction in quota for the heavily depleted large coastal shark category.

For more information on the Campaign, please contact David Wilmot, 666 Pennsylvania Avenue SE, Washington, DC 20003, USA. Fax: (+1) 202-547-9022; e-mail: dwilmot@audubon.org

EUROPEAN ELASMOBRANCH SOCIETY

The establishment of the proposed EES has come a step closer with the decision of a government conservation agency, Scottish Natural Heritage, to fund a feasibility study into setting up this European-wide non-government organisation. A meeting of potential national partners in the initiative was in Brussels.

FUTURE MEETINGS

MEETINGS OF OTHER ORGANISATIONS

We are happy to publicise these meetings and would be very pleased if the arrangements were reciprocal. Please send details to Hon. Editor PORCUPINE.

MARINE ENVIRONMENT MANAGEMENT -

REVIEW OF EVENTS IN 1995 AND FUTURE TRENDS

24-25 January 1996, London

Topics include Coastal Zone Management: current policy and best practice; Pollution: Oestrogen mimics; Fisheries; Nature conservation: the habitats directive, Environment agency, sustainability targets; Offshore Oil and Gas. Cost £55.

For details contact: Bob Earll, Candle Cottage, Kempley, Glos, GL18 2BU. Tel: 01531 890415

ESTUARINE AND COASTAL SCIENCES ASSOCIATION

Easter 1996, University of Hull

Humber Estuary and Yorkshire and Lincolnshire Coasts

It is anticipated that many projects carried out under the UK Land Ocean Interaction Studies research topic will feature in the meeting.

Local Organisers: Mike Elliott & Nev Jones, Dept. of Applied Biology, The University of Hull, HU6 7RX

1 - 3 April 1996, University of Plymouth

The Biology of Crustacea

This Symposium is being jointly organised by ECSA, MBA, and SEB, and is being held to mark the retirement of Professor Ernest Naylor. Papers will be presented on aspects of commercial exploitation, biochemistry, ecology and physiology of Crustacea. After refereeing the papers will be published in a Symposium volume.

Local Organiser: Dr M B Jones, Dept of Biological Sciences, University of Plymouth, Plymouth, PL4 8AA

FUTURE PORCUPINE MEETINGS

We are pleased to announce that the dates, venues and themes for the next three PORCUPINE MEETINGS have been arranged. Please make a note of them in your diaries. Circulars for each meeting will be sent out with the Newsletters.

16 & 17 March 1996 University College Scarborough

The North Sea - Past, Present & Future

See the First Circular for details

14 & 15 September 1996 Royal Holloway University of London, Egham

Animal/Sediment Interactions in the Marine Environment

Organisers: Jan Light & J B Wilson, Geology Department, Royal Holloway University of London, Egham Hill, Egham, Surrey, TW20 0EX. Departmental Office Tel: 01784 443581

Meeting hosted by the Geology Department RHUL on behalf of PORCUPINE and the Marine Studies Group of the Geological Society. All accommodation and meals will be provided on site.

22 & 23 March 1997 Portaferry, Co Down, N Ireland

Marine Protected Areas

Organiser: Julia Nunn, Cherry Cottage, 11 Ballyhaft Road, Newtownards, BTY22 2AW, N. Ireland. Tel: 01247 817710

