# PHYSICAL, BIOLOGICAL AND CULTURAL FACTORS INFLUENCING THE FORMATION, STABILISATION AND PROTECTION OF ARCHAEOLOGICAL DEPOSITS IN U.K. COASTAL WATERS

## VOLUME I

**Ben Ferrari**

**A Thesis Submitted for the Degree of PhD**
**at the**
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# PHYSICAL BIOLOGICAL AND CULTURAL FACTORS INFLUENCING THE FORMATION, STABILISATION AND PROTECTION OF ARCHAEOLOGICAL DEPOSITS IN UK COASTAL WATERS

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**VOLUME 1**

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# ABSTRACT

A considerable corpus of information regarding the formation of terrestrial archaeological deposits exists which is not matched by studies of deposit formation in coastal waters. Similarly, there is a disjunction between strident calls for minimal disturbance investigation, with conservation *in situ,* and knowledge of how this might actually be achieved in the marine environment.

The manner in which the investigation of deposit formation can complement the study of *in situ* conservation is considered An approach is proposed which combines selected elements of Schiffer's Transformation Theory with a method of studying changes to deposits outlined by Wildesen. It is suggested that, although sufficient regularities can be detected in the influence of formation processes to allow their influence to be recognised and inference refined accordingly, there are case specific limitations on the extent to which the precise influence of each process can be described and evaluated.

A case study is presented which investigates casual depredation as a formation process. Commercial fishing activity and marine burrowing activity are the subject of detailed consideration. New insights into these processes result from this study and specific recommendations concerning *in situ* conservation of deposits subject to their influence are made. The need to consider fishing practice as well as the mechanical properties of fishing gear in the study of deposit formation and protection is emphasised. The excavation of a 16th century wreck in Studland Bay, Dorset, is used to demonstrate the pervasive influence of burrowing activity and the problems associated with mitigation of this process. Recommendations are made regarding future study of formation processes and the development of policy related to the management of the submerged archaeological resource.

# DECLARATIONS

I, Ben Ferrari, hereby certify that this thesis, which is approximately 95,000 words in length, has been written by me, that it is the record of work carried out by me and that it has not been submitted in any previous application for a higher degree.
12th August 1994

I was admitted as a research student under Ordinance No. 12 in October 1987 and as a candidate for the degree of Ph.D in October 1987; the higher degree for which this is a record was carried out in the University of St. Andrews between 1987 and 1994.
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I hereby certify that the candidate has fulfilled the conditions of the Resolution and Regulations appropriate for the degree of Ph.D. in the University of St. Andrews and that the candidate is qualified to submit this thesis in application for that degree.
12th August 1994

SUPERVISOR

# ACKNOWLEDGEMENTS

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Much of the research presented here was conducted while I was employed by the Archaeological Diving Unit, however, this would not have been possible without the active support of Martin Dean to whom I am especially grateful. I would also like to thank my other colleagues in the ADU, Kit Watson, Steve Liscoe and Ian Oxley for their help and tolerance. I would like to thank Ian Oxley in particular for his continued interest in my work and his readiness to provide assistance, encouragement and accommodation.

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## Referencing and Footnotes

Harvard referencing is used throughout. Long sequences of citations appear as footnotes as do all references to personal communications. Section 10.2 provides details of each source of a personal communication.

Supporting material is included in appendices. Reference to these appendices includes line numbers where such precision is required *e.g.* appendix 9, lines 34-40.

Where reference is made to an archive or documents from an archive, for example the Council for Nautical Archaeology (CNA) Archive, further details of the location of the original material can be found in section 10.1.

In chapter 3 reference is made to video footage in support of observations concerning fishing gear. The footage is contained on the video tape attached to this thesis. All video footage was supplied by Department of Agriculture and Fisheries, Scotland (DAFS), Marine Laboratory in Aberdeen. Copyright remains with this institution. All footage is reproduced with permission and must not be copied or shown in public without written permission from the Marine Laboratory.

Four gear types are presented, a beam trawl, otter trawl ground gear, scallop dredges and a hydraulic dredge modified to collect razor clams. Each section is separated by 15 seconds of blank tape. The commentary presented in appendix 2 is intended for use alongside the video. References in the text identify the relevant section of video and the corresponding section of the appendix.

## Abbreviations

When government papers are cited for the first time, the full reference is given followed by the relevant abbreviation. Subsequently, only the abbreviation is generally used. For example, the *Royal Commission on Trawling* 1885 is abbreviated to RTC 1885. Where reference to a specific statement contained within the minutes of a Government report is made, the number of the question/answer as noted in the relevant report is cited along with the page number; for example (RTC 1885, q.345, 56).

*Fishing News*, a weekly national publication with mass circulation within the fishing industry, is a particularly useful source. The title is abbreviated to FN in this study. Citations include day and year of publication along with the page number; for example (FN, 12 Mar 1991, 16).

Certain journal titles have also been abbreviated in the bibliography. A full listing is provided in section 10.2.

Other, abbreviations utilised, not related to bibliographic sources, include:

| | |
|---|---|
| ADU | Archaeological Diving Unit |
| ASA | Abandoned Shipwreck Act 1987 |
| CFP | Common Fisheries Policy |
| CNA | Council for Nautical Archaeology |
| DAFS | Department of Agriculture and Fisheries, Scotland (now SOAFD) |
| DNH | Department of National Heritage |
| DOE | Department of the Environment |
| DOT | Department of Transport |
| EC | European Community |
| FOOGC | Fisheries and Offshore Oil Consultative Group |
| GPO | General Post Office |
| ICES | International Council for the Exploration of the Sea |
| IFA | Institute of Field Archaeologists |

| | |
|---|---|
| JNAPC | Joint Nautical Archaeology Policy Committee |
| LOSC | Law of the Sea Convention 1982 |
| MAFF | Ministry of Agriculture, Fisheries and Food |
| MCA | Marine Consultation Area |
| MNR | Marine Nature Reserve |
| MP | Member of Parliament |
| MPA | Marine Protected Area |
| MSA | Marine Sensitive Area |
| NCC | Nature Conservancy Council (replaced in England by EN) |
| NFFO | National Federation of Fishermen's Organisations |
| NRA | National Rivers Authority |
| POW | Protection of Wrecks Act 1973 |
| RCHME | Royal Commission on the Historical Monuments of England |
| SFA | Scottish Fishing Federation |
| SFC | Sea Fisheries Committee |
| SFIA | Sea Fish Industry Authority |
| SOAFD | Scottish Office Agriculture and Fisheries Department (replaced DAFS) |
| TAC | Total Allowable Catch |
| UK | United Kingdom |
| UKOOA | United Kingdom Offshore Operators Association |
| US | United States of America |
| WCA | Wildlife and Countryside Act 1981 |
| WFA | White Fish Authority |

# Preface

## Physical Biological and Cultural Factors Influencing the Formation, Stabilisation and Protection of Archaeological Deposits in UK Coastal Waters.

This study is concerned with the investigation of the processes which form the archaeological record and identification of strategies which may assist in ensuring that evidence of the past survives *in situ* for future study. As indicated by the title the area of interest is the coastal waters of the UK. For present purposes, this will be defined as the area within the current 12-mile limit of the territorial sea. Limitations associated with such an arbitrary boundary will be discussed further within the study.

A number of authors have commented on the distinctive qualities of shipwreck deposits, such as the possible contemporaneity of much of the assemblage and the rapid, dynamic nature of many wrecking events.[1] Reduction of the vast range of depositional contexts potentially associated with submerged material will be resisted in this study. However, it is accepted that shipwreck deposits can differ significantly from inundated terrestrial sites in terms of formation processes. In this study, therefore, the main focus of attention will be on ship-related deposits and the vast majority of data utilised will be drawn from such sites. While much of the information presented is equally relevant to other archaeological events on the coastal seabed it should be utilised with due regard to such differences as do exist between shipwrecks and other deposits.

The phrase *archaeological record* appears frequently in the literature. As Stein (1987, 338) notes, while there has been much

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[1] Muckelroy (1978, 56-57); Murphy (1983, 66-7); Gibbins (1990, 382).

debate about the nature of this record, archaeologists have generally come to recognise that it is a contemporary phenomenon with a complicated history.[2] For the purposes of this study the phrase will be used to refer to the manifestations of past societies and events available for study now and in the future.

The formation of the archaeological record can be considered in two main phases; *depositional* and *post-depositional*. The former encompasses the transitional phase where archaeological material passes from being part of an active, cultural system to being part of a system influenced largely by natural processes. *Post-depositional* processes influence material once it has been deposited. Some post-depositional processes (such as scavenging and re-use) can return material to an active cultural system. In the following discussion the term *formation processes* (of the archaeological record) will be taken to refer to a very wide area of study encompassing cultural and environmental processes influencing archaeological material before, during, and after deposition, up to and including the process of discovery.

This study also seeks to contribute to the management of the archaeological record. The term management is used to describe a wide range of activities. Generally, the term is used in a manner which suggests an activity seeking to make wise use of a resource. Firth has argued that the process of management can be viewed in terms of functions and approaches, the former being realised through the latter.[3] Cleere (1989, 1-19) considers the nature of archaeological heritage management at some length. He observes that it is a multifaceted activity with an ideological basis in establishing cultural identity linked to an educational function, it also has an economic basis in tourism and an academic function in safeguarding the database (*ibid.*, 10). Carman (1991) also reviews the nature of heritage management with particular reference to the manner in which legislation can

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[2] For example Rowlett & Robbins (1982, 73) Schiffer (1983, 676; 1987, 4-5) Gifford-Gonzalez (*et al.*, 1985, 803) Sabloff (*et al.*, 1987, 203).

[3] Firth, pers.comm.

structure approaches. He stresses that it should not be seen as a separate, marginalised, administrative function superimposed onto research based archaeological endeavour. Rather, he argues that anyone who makes any decision about archaeological material is involved in the process of management; a process which is intimately involved in the attribution of value to component parts of the resource and very much concerned with the nature of the archaeological record itself.

The management function which defines the primary concern of this study is conservation of a database that will support viable academic research into the future. This is not to deny the public interest in management of archaeology. Approaches discussed in this study require acknowledgement of public perceptions of archaeology and demonstrate the need to reconcile archaeological priorities with the interests of disparate users of both the resource itself and the environment it occupies. The term used to refer to management-related activities in this context will be archaeological heritage management, a term which is gaining general currency in Europe in preference to the broadly equivalent North American term, cultural resource management (*c.f.*, Cleere 1993, 400).

The emphasis placed on conservation in this study reflects the current professional view of the archaeological record as a finite resource with preservation *in situ* the preferred option. English Heritage, the major funding body of English terrestrial archaeology, has stated that its primary objective is to secure the preservation of archaeological remains and to consider excavation only when this is not feasible (English Heritage 1991, 1). This approach is enshrined in the planning process through Planning Policy Guidance note 16 (DOE 1990; Wainwright 1993). A policy statement issued by The British Archaeological Trust, an independent pressure group, also stresses the primacy of *in situ* preservation and promotes the frugal use of the available resource (*Rescue News*, No. 54, 1991). Likewise, *The Institute of*

*Field Archaeologists (IFA) Code of Conduct*[4] (as amended 1988) states that the archaeologist has a responsibility for the conservation of the archaeological heritage (principle 2). Where destructive investigation is undertaken, the archaeologist shall ensure that it causes minimal attrition of the archaeological heritage consistent with the objectives of the project (principle 3). As Fowler (1982, 3) states:

"...All legal and other means should be used to protect and conserve extant archaeological remains for the future rather than simply collecting or excavating."

In referring to archaeologists working underwater the IFA code of conduct affirms that the same underlying principles apply as on land - the prime concern is the conservation of the seabed heritage which should be used economically and in such a way that reliable information may be acquired.[5] However, until very recently, it has not been possible to detect a substantial tradition of concern for *in situ* conservation of archaeological material on the seabed at Government level in the UK. This research, therefore, has been substantially shaped by the present culture in professional archaeology and a perceived need to raise awareness of the lack of information pertaining to *in situ* conservation in the marine environment.

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[4] The Institute of Field Archaeologists was founded 1982 with the aim of forwarding the practice of archaeology through the establishment and maintenance of proper professional standards and ethics (for example, see Colcutt 1993, 172-4).

[5] Croome (1989); JNAPC (1989; 1993); McGrail (1989); Firth (1990); Flinder (1990); Firth & Ferrari (1991). The *Archaeology Underwater Proceedings* of the Society for Historical Archaeology Conference, held annually in North America, form a substantial record of developments in the management of wreck material over the past 15 years. For example, Delgado (1988, 46-59) Giesecke (1985; 1989).

# 1 Introduction

> "...The cultural past is knowable, but only when the nature of the evidence is thoroughly understood." (Schiffer 1987, xx).

In the last 20 years a broad consensus has emerged in terrestrial archaeology on the need to study the formation of the archaeological record as a prelude to drawing inferences based on archaeological data; an inference being a statement supported by relevant principles and relevant evidence. Schiffer (1987, 3-11) suggests that a line of development in general conceptions of the influence of formation processes can be traced; an initial assumption of continual reduction in the quality and quantity of data over time has been replaced by 'modern' views which, to a greater or lesser extent, hold that because formation processes act in a patterned way these patterns can be detected and inference refined accordingly.

A substantial corpus of research related to the formation of the archaeological record exists. For example, Gifford-Gonzalez (*et al.*, 1985) offer a detailed treatment of a single process (post-depositional trampling) while Miksicek (1987) considers processes affecting a specific class of evidence (the archaeobotanical record). Reviews of evidence relating to general categories of process are also available. Wood and Johnson (1978) discuss disturbance processes while Nash and Petraglia (1987) present a collection of papers investigating environmental formation processes.

Within this corpus a number of major themes are identifiable. Investigations of the link between behaviour and deposition are numerous; that is, do specific activities result in assemblages with characteristic content and distribution of material. Related to this is investigation of the processes which transform the assemblage as deposited into the assemblage observed by archaeologists.[1] A third area of concern is the development of analytical techniques that account for the variability introduced into the archaeological record by formation processes.[2]

General agreement currently exists regarding the potential significance of natural formation processes and the nature of appropriate techniques for their study. However, fundamental disagreements characterise approaches to the investigation of the cultural and behavioural element of the formation of the archaeological record and the nature of inferences concerning behaviour which can be drawn (Renfrew & Bahn 1991, 405-434). Indeed, the general question of what is truly verifiable about the past has been highlighted as one of the core elements of archaeological debate over the last two decades (Kelley & Hanen 1988, 11).

It has been stated that excavation of the Cape Gelidonya Bronze Age Wreck by Bass in 1963 heralded the arrival of archaeology underwater as a viable sub-discipline (*e.g.* Watson 1983, 24). In the 29 years since then, has a corpus of research relating to formation processes underwater developed comparable to that noted above? Can a coherent approach to this area of research be detected? The answer to both questions must be a qualified 'no'. However, other developments in terrestrial archaeology have been mirrored in archaeology underwater.

The conservation ethic is one of the most influential factors in contemporary terrestrial management policy and fieldwork practice (Wildesen 1982; Greeves 1989). The archaeological record is now clearly defined as a finite resource which should be exploited with great care. Preservation of archaeological material

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[1] For example, Binford (1972, 1981b, 1983a) and Schiffer (1976). Koch's 1989 volume *Taphonomy: A Bibliographic Guide To The Literature* illustrates the range and quantity of such research while Brain (1981, 266-74) demonstrates the fundamental value of detailed characterisation of bone accumulations in South African caves - although Marean (*et al.*, 1992, 122) considers that his work lacks systematic control.

[2] For example Sullivan (1978); Rowlett & Robbins (1982); Schiffer (1983, 1987); Butzer (1982, 77-122); Schofield (1991); Kristiansen (1985).

*in situ* is confirmed as the option of first choice and where excavation is deemed to be necessary effort is made to restrict the area disturbed. Allied to the injunction to extract as much information as possible from the archaeological record without undue attrition is a rise in interest in surface distributions of material.[3] A number of related problem areas have been identified (*c.f.*, Lewarch & O'Brien 1981, 14; Boismier 1991, 14-150). They include the identification of surface formation processes; the study of the influence of surface formation processes on intra-site structure; the development of analytical techniques which can assist in distinguishing between patterning caused by formation processes and other forms of patterning. The need for minimal disturbance site assessment techniques is emphasised by a current large-scale effort in the UK to afford legal protection to a comprehensive sample of evaluated monuments and sites (Darvill *et al.*, 1987; Startin 1993).

A considerable amount of published information relating to site stabilisation and preservation *in situ* on land is available. Much of this has originated from Federal agencies in North America (for example, Thorne 1990a; but see also ICCROM 1986; Berry & Brown 1994). Such information has been collated in at least two computerised data-bases (Hester *et al.*, 1987; Thorne n.d; Thorne 1994, 37-8). A gazetteer of stabilisation techniques has been produced (UAE 1990) and regular updates concerning new methods appear in the journal *Federal Archaeology Report* (see Thorne 1991). Intentional site burial has received considerable attention (Mathewson & Gonzalez 1988; Mathewson 1989a) and related research has included substantial experimental work (Mathewson *et al.*, 1992).

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[3] Lewarch & O'Brien (1981) discuss developments in the perception and study of surface assemblages. Schofield (1991, 3-8) reviews literature relating to this area of study. Haselgrove (*et al.*, 1985) presents a number of papers dealing with the theory and method of studying surface material while Schlanger & Orcutt (1986) also consider the question of inference drawn from such assemblages. Redman (1987) reviews developments in surface collection sampling and research design.

The conservation ethic[4] and a developing official and professional interest in a co-ordinated management policy are also evident in relation to archaeology underwater in the UK and elsewhere. As Firth (1990, 16-17) notes:

"The site-by-site approach may have been acceptable when first demonstrating the range and quality of underwater remains, but now it tends to cause duplication, preoccupation with detailed site-specific questions and concentration of capabilities while the rest of the resource is ignored."

Some information is available relating to *in situ* preservation of material submerged in riparian and reservoir environments (UAE 1990, X-1 & X-2; Nordby 1982; Lenihan 1981) and ship finds on land have been stabilised (Reinders 1984, 109).[5] In addition, a corpus of observations on processes affecting submerged and semi-submerged archaeological material is developing within the framework of North American cultural resource management reports (*e.g.* Carrell 1987, 151-7; Lenihan 1989, 117-156). Little information has been published concerning the preservation *in situ* of a range of archaeological materials in coastal waters (see Jespersen 1986; Meucci 1986). However, there is clearly awareness of the need to characterise physical, biological and chemical processes as an element of managing submerged archaeological resources (McCarthy 1982, 49; Oxley 1992; Stephenson 1985, 97-99).

Thus, in the marine environment, there is a disjunction between the strident calls for minimal disturbance investigation with conservation *in situ* and knowledge of how this might actually be achieved. Equally, as emphasis on the use of surface remains on

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[4] Dean (*et al.*, 1992, 20-23); JNAPC (1989, 12). See Firth (1993) for a general account of management of archaeology underwater in the UK.

[5] Major monitoring programmes have been instigated on large steel vessels involving efforts at stabilisation (Lenihan *et al.*, 1989; McCarthy 1988; MacLeod 1987; MacLeod & North 1986); the process of corrosion, its monitoring and prevention, has been a major focus of attention for example Brown (*et al.*, 1988) and Rogers (1989).

the seabed for both research and management purposes increases, so too does the need to determine what data they contain. This study is substantially shaped by the perceived need for information on these matters (*c.f.*, Watson & Gale 1990, 190-2). It will be argued that the investigation of formation processes, particularly post-depositional processes, and development of site management strategies are in fact closely related (*c.f.*, Mathewson 1989b, 10; Firth 1990, 5). Exploration of the nature of this link will form a central theme of this study.

In the following discussion, the development of the study of formation processes is considered. Recognition of differences in regional and local environments is essential to the detailed study of site formation (*c.f.*, Muckelroy 1978, 160; Parker 1980, 42). However, a review of broad concepts need not respect geographical divisions and work undertaken in a variety of countries is discussed together.

# 1.1 The Study of Formation Processes in Terrestrial Archaeology

The work of Binford[6] and others involved in what became known as New or Processual archaeology in the late 1960's and early 1970's gave considerable impetus to the study of formation processes on land. This movement, most influential in North America, was highly critical of the perceived failings of 'traditional archaeology' - regarded as particularist (see South 1977, 8-12) and obsessed with description as opposed to explanation. The phenomena of interest was identified as the *process* of cultural change rather than the *history* of specific changes.[7] The proper goal of archaeologists was deemed to be the establishment of general laws of human behaviour which crossed cultural and temporal boundaries but contemporary methodology was judged to be woefully inadequate for rigorous archaeological investigation.

Methods of reasoning, particularly the hypothetico-deductive approach, were adopted from the philosophy of science in the quest for more objective 'knowledge claims'.[8] Apologists for the movement state that no single method was intended to be seen as 'correct and applied with unthinking formality (Watson 1991,

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[6] Many of Binford's most significant early papers have been collated and re-printed under one cover as *An Archaeological Perspective* (Binford 1972). Later papers have also been collated as *Working At Archaeology* (Binford 1983b) and *Debating Archaeology* (Binford 1989).

[7] Contemporary and retrospective commentaries are plentiful, for example Raab & Goodyear (1984, 4); Watson (1972, 210-12); and Binford (1983a, 95-108). Trigger (1989, 289-328) outlines the social and political origins of the movement, he includes a useful bibliographic and suggests (*ibid.*, 295) that the polemical style of much of the related literature disguised the extent to which there was in fact consensus as regards the general direction in which American Archaeology should evolve (*c.f.*, Willey & Sabloff 1974; Wylie 1993, 20-21).

[8] Gibbon (1989, 61-117) provides an incisive review of the nature of the New Archaeology and its foundations in the philosophy of science. Chalmer's (1982) review of the philosophy of science is a useful guide to any exploration of the literature of the New Archaeology, see also Kelley & Hanen (1988, 1-59).

277-278). Binford himself (1985, 582) maintains that rejection of *ad-hominem* judgement and reasoning was at the core of the New Archaeology. He distances himself from 'poor arguments' about the exact form that scientific reasoning should take (Binford 1983a,107).[9] Conclusions, he maintains, should be evaluated on the quality of analysis presented, not by considering reputation or claims to rare and special insight.

Fundamental to this search for 'scientific rigour' was a concern to understand the nature of the evidence utilised. Thus ethnoarchaeology or 'actualistic studies' were given pre-eminence with the aim of establishing correlates between observed social behaviour and material culture which can be used to interpret the archaeological record. This involves uniformitarian assumptions. Because the New Archaeology emphasised the study of patterns, spatial and statistical, in archaeological material, the study of how such patterning might come about or be distorted was eventually given considerable prominence (Cordell *et al.*, 1987, 567; Gibbon 1989, 4).[10] Knowledge of formation processes was thus established as the foundation of rigorous inference based on explicit reasoning rather than being employed as a buttress to conclusions drawn through an un-structured, implicit thought process.

Judgements on the specific achievements of the New Archaeology have not been kind. Binford (1977, 9-10) concludes that, at best, an anti-traditional archaeology emerged rather than a fresh direction - this has been linked to the fact that the theoretical position adopted was, from the outset, considered outmoded by contemporary philosophers of science (Kelley & Hanen 1988, 29). Further, concentration on the study of the 'mechanics' of site

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[9] Binford's low opinion of the degree to which other prominent figures in the debate grasped the essential elements of rigorous research is evident (Binford 1985; 1989, 102-105). Such rancour appears to typify the sociology of New Archaeology.

[10] Cowgill (1970); Collins (1975). Raab & Goodyear (1984, 259) summarise the essential tenets of the approach to formation processes adopted by the New Archaeology.

formation in the 1980's has been interpreted as a symptom of failure of confidence in the generalising programme, in effect a retreat from attempts to deal with broader theoretical issues (Hodder 1991b, viii). Yet, the aim of lending some rationality and rigour to research is surely praiseworthy and theory can now be set against over two decades of published research addressing the subject of the archaeological record and its formation. This is in no small part due to the influence of the vigorous debate surrounding the New Archaeology - the value of which is acknowledged by even the fiercest critics of the programme itself (see Shanks & Tilley 1992, 30).

### 1.1.1 Schiffer and Transformation Theory

Schiffer has emerged from the Processual debate as a leading figure in the study of the formation of the archaeological record- his work has been consolidated in the form of Transformation Theory. Schiffer holds that the archaeological record is a transformed or distorted reflection of artefacts as they once participated in a behavioural system; formation processes are the agents of such distortion. Formation processes introduce patterning unrelated to past behaviour. However much evidence is present, behaviour cannot be inferred directly from patterns in the archaeological record. Yet, because formation processes exhibit regularities in terms of their physical effects, which can be expressed as laws, they can be identified (inferred). Such biases as are introduced by formation processes can be rectified by using the appropriate analytical and inferential tools built upon knowledge of the laws governing these processes (Schiffer 1987, 10). Schiffer constructs a hierarchy of knowledge relating to formation processes and refers to principles of formation processes as testable, low level, often statistical, laws. He defines the term 'law' as an atemporal, aspatial statement relating two or more operationally defined variables with no implicit suggestion of immutability (Schiffer 1976, 4-5; 1987, 22).

Schiffer appears to anticipate, subsequent to the development and testing of sufficient principles, the establishment of higher theories of formation processes, presumably having more general validity. The possibility of achieving this has been questioned (Raab & Goodyear 1984, 261).[11] Others consider Schiffer's approach to be overly regimented and not an adequate reflection of the actual diversity of formation processes (Sullivan 1978, 201; Cordell *et al.*, 1987, 566). In addition, doubts have been raised as to whether any laws relating to formation processes, which are not trivial, have yet been developed or applied in a way that modifies inference (Davidson 1989, 387-388). Schiffer's approach will be discussed further in section 2.1.

### 1.1.2 The Post-Processual Debate

The suggestion that regularities, often covered by theories embedded in the natural sciences, can be detected in natural formation processes is widely accepted (Patrick 1985, 50-51). A lack of such consensus regarding the study of cultural formation processes partly reflects recent (largely European) developments in archaeological thinking which emphasise the diversity of human behaviour. Loosely grouped under the banner of Post-processual Archaeology (Hodder 1985) such developments have been characterised as deriving unity from opposition to previous approaches rather than advocacy of a single, ongoing programme:

"Post-processual archaeology is united in its criticism of positivist, functionalist, adaptational models of the past which emphasise a scientific , objective, hypothesis testing approach and which appear to limit archaeology to the analysis of technology, economy and the effects of physical and biological processes - 'middle-range' theory. The post-processual critics have variously

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[11] Binford (1981a, 199-200) questions Schiffer's view of C (cultural) transforms as distortions of the archaeological record if they occurred while the material in question was still in a dynamic cultural context. For example, is the process of removing ash from a fire a distortion (it separates the ash from its origin spatially) or simply tidying up and therefore an aspect of the behaviour being studied? That is, the archaeological record cannot be a distortion of itself.

proposed Marxism, symbolic anthropology, hermeneutics, structuralism and post-structuralism - or mixtures of these as alternatives." (Engelstad 1991, 502)

Hodder argues for recognition of the fact that material culture is 'meaningfully constituted'; that is, it plays an active role in society rather than simply reflecting adaptation to environment or other external factors. The role of the active individual in material culture and cultural change is emphasised as opposed to universal processes. This promotes a historically oriented concern for detailed studies of specific cultures rather than a generalising approach (Hodder 1987; 1991a, 109-20). Cultural activity and change is regarded as highly complex and the problem of equifinality (different activities or processes producing indistinguishable physical results) is regarded as pervasive. The uniformitarian assumptions of Processual Archaeology are also questioned.

In the face of such complexity, Schiffer might be considered optimistic in the degree to which he appears to believe that biases and distortions in archaeological data can be rectified. He does recognise (Schiffer 1987, 265) the problem of dissimilar events producing similar traces but is at variance with some commentators in appearing to regard the problem as a factor to be considered rather than as a fundamental characteristic of the evidence. Hodder (1991a, 185-6) affirms the importance of studying formation processes and accepts the need to test theory against data. However, he casts considerable doubt on the level of certainty which is achievable in explanations of human phenomena in the past.

In addition to reducing emphasis on methodological progress as a means of moving toward archaeological 'facts' of demonstrable validity, recent debate highlights the inherent subjectivity of much archaeological endeavour (Trigger 1990, 778-9). Critical Theory (Leone *et al.*, 1987) has played a significant role in shaping much Post-processural literature. The social context of explanation is emphasised in promoting an appreciation of the way that interest groups can shape the interpretation of the past for their own ends (*c.f.*, Mithen 1989, 490; Gilchrist 1991, 496-7; Shanks and Tilley 1992, 263-5). Hodder too (1991b 21-22) emphasises that archaeology is always socially engaged. Significantly, therefore, the major problem confronting those wishing to make valid inference about the past may not be conceived in terms of methodological questions surrounding formation processes but in terms of the cultural context of the research itself.

Binford (1989, 27-40; and see Schiffer 1988, 468; Watson 1990, 280) has been a particularly fierce critic of Post-processualism and what he appears to view as a libertarian denial of the need to decide between alternative interpretations. He remains an advocate of a 'learning process (about the past) which can be subjected to evaluation.'[12]

Renfrew and Bahn's (1991, 41-60) review of the discipline of archaeology separates out a discussion of the study of formation processes from general discussion of archaeological theory and explanation. The implication appears to be that such research is now an essentially (but not purely) methodological domain that has relevance to inference drawn within a range of theoretical frameworks. In this respect the term 'middle-range' has gained currency as a description of a distinct set of ideas and techniques required to bridge the gap between raw archaeological evidence and the generalisation based upon it.[13] While the development of middle-range activity has been promoted by, among others, Binford (1977, 6; 1981b, 21-30) the concept also appears to have found favour with workers holding markedly different views in relation to theoretical issues (*e.g.* Saitta 1992).

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[12] Binford, Euro-TAG Theoretical Archaeology Group conference, Southampton, 14th December 1992.

[13] In current usage the term has become closely identified with the study of formation processes. This narrowly methodological implementation of the concept has been criticised as a failure to recognise middle-range theory as part of a wider theory building process (Raab & Goodyear 1984, 258). Schiffer (1988, 462-3) offers a critical commentary regarding the application of middle-range theory to archaeological problems

Recognition of the need to undertake such work has spread far beyond researchers in North American, anthropological, behavioural pre-history - although it must be said that much debate still focuses on pre-historic archaeology. There are indications of a concern for explicit consideration of method and theory amongst workers in even the most 'traditional' of areas - such as the archaeology of Roman Britain (Scott 1993). Yet it would be overly optimistic to suggest that terrestrial archaeology is currently conducted to a consistently high analytical standard (*c.f.*, Sabloff *et al.*, 1987, 204). Reynolds and Barber (1984) highlight both the primacy of analytical approaches to field research and the degree to which analytical concepts can be acknowledged without actually informing the fieldwork itself. Indeed, Schiffer (1983, 675) contends that despite significant advances in knowledge of formation processes, such advances have only rarely been incorporated into the recovery, analysis, and inference stages of investigations.

## 1.2 The Submerged Archaeological Record

Exploration of generalising approaches also served to stimulate research into formation processes underwater. The most wide-ranging contribution has come from Muckelroy who, in his volume *Maritime Archaeology* (1978, 221-230), highlights anthropological concerns in his treatment of the scope and archaeological potential of shipwreck sites. Anthropological paradigms also provide the main impetus for papers by Lenihan and Murphy (1981), Murphy (R.J., 1981) and a volume edited by Gould (1983a) *Shipwreck Anthropology*.[14] Contributions to the latter exhibit many of the concerns of 'late-phase New Archaeology' (Gibbon 1989, 81-87); notably the promotion of an 'explicitly scientific' archaeology (Gould 1983b, 21-22)[15] and a concern for deriving behavioural data from observed patterning in the archaeological record in a way that can be extended to reliable generalisation (Murphy 1983, 69).[16] Attaining this latter goal is perceived to require close attention to analysis of formation processes and their influence on the creation of such patterning (*c.f.*, Gould 1983b, 7-8).

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[14] *Shipwreck Anthropology* (Gould 1983a) is a collection of papers presented at a seminar in 1981. The general theme is a demonstration of how shipwreck archaeology could be brought into the fold of mainstream North American generalising anthropological archaeology and could, in effect, be cast as a social science. Some of the contributors to this volume were closely involved in the debate surrounding generalising method and theory in land archaeology, for example Gould (1980) and Watson (*et al.*, 1971).

[15] Muckelroy (1978, 5) suggests that scientific archaeology is characterised by the disciplined search for knowledge which will exhibit clear problem-orientation. His North American contemporaries appear to define the term more precisely to include the application of specific, formalised methods of reasoning (Gould 1983b, 21-22).

[16] For example L. Murphy, L., (1981, 70-1); Murphy, R. J., (1981, 140-141); Gould (1983b, 7-8); Watson (1983, 32).

### 1.2.1 Muckelroy

Gibbins (1990, 378) has noted the influence of Clarke's (1968) *Analytical Archaeology* on Muckelroy. Yet Clarke's 1973 paper, *Archaeology: The loss of innocence,* seems to foreshadow Muckelroy's approach to the study of formation processes most clearly. Clarke argues for the development of a general theory of archaeology. He presents interrelated layers of theory, including pre-depositional and post-depositional theory which must be explicitly rather than implicitly applied as a means of introducing greater rigour to the process of inference (Clarke 1973, 16-17). Muckelroy (1978, 23) considers his 1978 volume to be concerned expressly with the development of a general theory of Maritime Archaeology. The study of site formation is itself of limited intrinsic significance, its importance is perceived to lie in the link it provides between the remains investigated and the original vessel (*ibid.*, 165). Links to those involved in the New Archaeology and its aftermath on land can also be discerned. Comparisons have been drawn both directly (Sabloff *et.al.*, 1987, 203, Renfrew & Bahn 1991, 412) and indirectly (Isaac 1981, 202) between the intent and influence of work by Clarke and Binford in the late 60's and early 70's.

Muckelroy's description (1978, 157) of fundamental regularities in the phenomenon of the shipwreck has some similarities to Schiffer's concept of C (cultural) and N (non-cultural) transforms (see Gould 1989, 19).[17] He investigates correlation between environmental aspects of sites in UK coastal waters and preservation and distribution. He concludes that the major factors affecting preservation are topography and sediment type; a 5 tier classification of wreck sites, ranging from 'coherent' to 'scattered' is also proposed (Muckelroy 1977; 1978, 157-182). Despite recognised weaknesses (Muckelroy 1978, 164-5) this work has done much to dispel simplistic 'good' and 'bad' treatments of deposits by emphasising that most sites will be of an intermediate

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[17] Such considerations make Lenihan's (1983, 49) comment that Muckelroy has done an excellent job in confronting theoretical issues in an almost complete vacuum, difficult to comprehend.

nature in terms of preservation. Such variability is revealed as an inherent characteristic of deposits rather than a source of 'exceptions to the rule'.

No useful purpose would be served by a detailed critique of research that was cut tragically short by Muckelroy's death. In general terms, however, it may be suggested that, while indicating the potential complexity of site formation, Muckelroy appears to oversimplify some issues; for example his comments on the unified and predictable suite of processes in operation during site formation underwater (Muckelroy 1978, 158).[18] In addition, specific assertions made by Muckelroy have been questioned - often as a result of research prompted by his own work. Keith and Simmons (1985, 424) question Muckelroy's assumption (1978, 158) of the low level of human interference as a 'scrambling factor' underwater. Ferrari and Adams (1990, 139-142) demonstrate that the potential effect of the marine equivalent of burrowing fauna in terrestrial contexts must be at least considered (*c.f.*, Muckelroy 1978, 181). Lenihan and Murphy (1981, 73) dispute Muckelroy's suggestion (1978, 217) that the general patterning of shipwreck events does not represent any element of cultural selection; indeed Garrison (1989, 15-18) using spatial and statistical analysis of wreck events demonstrates a close correlation between wreck distributions and historical-cultural and natural factors.

It would be wrong, however, on the basis of the above, to suggest that Muckelroy's research has been thoroughly evaluated and tested as he was adamant that it should be (1978, 165).[19] Green (1977, 90-1) applies the parameters of Muckelroy's analysis of environmental factors to 3 sites and finds discontinuities between deposits in apparently similar environments. He concludes that

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[18] Murphy (1983, 82) also appears to be overly-optimistic in his comments on the lack of disturbance processes which are likely to affect sites underwater.

[19] Further research into environmental characterisation is currently underway (Oxley 1990). Support for elements of Muckelroy's general approach and classificatory scheme can be identified Owen (1991, 333-4); Gregory (1992); Garrison (*et al.*, 1989, II-77 - II-83).

more work is required on the subject of 'wreck break-up' but his analysis is, in his own words, superficial. Smith (*et al.*, 1981, 352-355) describes a research project designed to develop Muckelroy's work through testing hypotheses relating to correlation between preservation of material and environment; however, no specific results are presented. In addition, a number of projects, apparently prompted by Muckelroy's work but without necessarily sharing his theoretical orientation, have included a substantial environmental report as an aid to interpretation rather than as an isolated appendix.[20]

Other workers have independently shown awareness of factors highlighted by Muckelroy.[21] Keller (1974, 15-16) acknowledges the need to evaluate archaeological evidence rigorously. He presents a framework consisting of the 'transmitter', 'filter factors' and the 'receiver', all of which can introduce biases. Keller's approach is broadly compatible with the 'sampling bias' conception of formation processes as discussed by Cowgill (1970) and refined by Collins (1975). Keller (1973) also investigates the nature of stratigraphy in harbour sediments, finding that objects, rather than being sorted by density or specific gravity, may retain chronological ordering. Although the interelatedness of method and theory is not explicitly emphasised in Keller's work, Muckelroy (1978, 248) seems overly harsh in dismissing it as of no more than 'operational utility'.

Hodder (1993a, 13-14) argues that the systems approach to the analysis of social and economic process enshrined in New Archaeology led to concentration of effort on the study of settlements and settlement patterns. Methodology (sampling, area survey, study of surface assemblages) developed rapidly in response to demands for particular data sets. This is not paralleled in research underwater. To expect a similar quantity

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[20] For example Adams (1985, 284-7) Gibbins & Parker (1986, 300-1); Kenchington (*et al.*, 1989, 116-7) Gould (1991, 147).

[21] Martin (1978, 33-40; 1979a, 33-34; 1983, 135-6); Parker (1980, 47). Oxley (1992) has highlighted the need to study site environment, see also MacLeod & Killingley (1982).

of research may be unrealistic considering the great disparity between the number of projects conducted on land as compared to underwater.[22] It might, however, be argued that similar progress did not result because there was no equivalent research orientation to channel effort (save the rather vague concept of 'shipwreck archaeology'). Rather, activity can largely be characterised as isolated instances of projects conceived with specific research aims in view (see section 1.2.3). Shipwreck research has also been somewhat episodic and reactive - the location and nature of research effort often being dictated by chance discovery and the success or otherwise of efforts to obtain funding for appropriate fieldwork.[23] This situation has been exacerbated, in the UK at least, because agencies charged with funding archaeological investigations on land have, until recently, not routinely made funds available for shipwreck research underwater (JNAPC 1989, 22-24). A significant percentage of investigations over the last two decades have therefore, occurred within the framework of commercial or semi-commercial ventures. This has hampered refinement of methodology and developments have frequently been technical in nature; for example, better designed tools and application of advanced technology to deposit location.

Research since the 1960's has not, in general, been characterised by explicit concern for method and theory, stemming from generalising paradigms or elsewhere. The following discussion, therefore, considers the nature of approaches to archaeology underwater which do appear to have been influential in the past and which can be seen to continue to inform much fieldwork today. The implications for the future development of the study of formation processes are highlighted.

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[22] In addition, a review of the development of any aspect of archaeology underwater must take into consideration factors such as the relatively recent availability of scuba (*c.f.*, Muckelroy 1978, 10-23; Lenihan 1983, 37-49).

[23] In 1993 the announcement of plans to investigate vessels connected with the Spanish Armada off the coast of Southern Ireland were prompted by the existence of a surplus in certain European Union funds (*The Guardian*, 31 Dec 1993).

## 1.2.2 Assumptions of Inferential Value

*Assumptions* of limits to the type of data that can be retrieved from certain ship-related deposits on the seabed persist; most notably spatial organisation is often assumed to be totally lacking in shallow, 'scattered' sites. Such 'common-sense' views of the archaeological record often involve an implicit assumption of continuing deterioration and loss of data - the 'disaster and degeneration' viewpoint. As Schiffer (1987, 8) has noted, Ascher's concept of 'time's arrow' progressively and inevitably reducing the quantity, quality and organisation of evidence in the archaeological record has some validity. Yet Ascher (1968, 52) does not suggest that meaningful analysis cannot be attempted. Unmodified presumption of entropy can have a particularly insidious effect in certain circumstances. Murphy (1990, 2) describes how, by following 'wreckage trails' with random excavations, treasure hunters in Florida reinforce rather than test assumptions that shallow wrecks are hopelessly jumbled and therefore inferentially valueless. Thus a self-supporting fallacy allows such salvors to claim performance of a public service by retrieving material before it is lost forever.

Assumptions of high inferential value are equally unhelpful. The possibility of contemporaneity of elements within shipwreck assemblage provides a distinctive strength of shipwreck archaeology.[24] Yet, this strength may reduce the perceived need for explicitly analytical method (*c.f.*, Gibbins 1990, 382). Even Muckelroy, an advocate of rigorous, mathematically based spatial analysis, concedes that on occasion much can be deduced by simple visual inspections of plotted find locations (1978, 187-8; 190). However the dividing line between those deposits which are and those which are not considered suited to such treatment appears to be a fine one and the criteria on which judgement is based seem subjective and unsatisfactory.

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[24] Muckelroy (1978, 56-57); Murphy (1983, 66-7).

Early scepticism concerning the reliability of associations within apparently well preserved sites can be found in reports concerning the preliminary stages of work on the *Mary Rose* by McKee:[25]

> "It is now clear that in the Solent area at least wooden wrecks may remain substantially above the seabed 150 years or more, and that they will serve as automatic collection points for all kinds of anchorage artefacts...it means we must be increasingly critical of the evidence afforded by material found apparently in association with a wreck."

Parker's (1981) consideration of problems posed by contamination of apparently sealed 'time capsules' is also a major contribution to a more accurate, and flexible characterisation of context. Systematic investigation reveals blithe assumptions concerning the security of apparently sealed deposits and the low value of 'scattered' sites as equally untenable positions. A particular strength of *some* marine deposits has inhibited adequate archaeological treatment of the *full range* of ship-related archaeological events. Approaches must be developed which respect the difference between, for example, a ship wreck, a deliberate scuttling and an abandonment.[26] Application of analytical methods to a range of situations will eventually allow researchers the benefit of using well preserved assemblages of *demonstrated* inferential value to aid in the interpretation of less well preserved deposits (Parker 1981, 316-32).

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[25] Progress Report, First Year of the Mary Rose (1967) Committee, A. McKee. (CNA Archive, Dept. Trade and Industry Wrecks , Misc., Folder).

[26] *c.f.*, Keller (1974, 31-33); Crumlin-Pedersen (1985, 221-226); Gibbins (1990, 384).

### 1.2.3 Particularism

Particularism has been identified as the dominant characteristic of wreck-based research in North America.[27] Evidence can be found of a similar tradition in the UK.[28] A review of particularist *archaeological* (as opposed to salvage oriented) research reveals explicit consideration of aspects of site formation. This may indicate that there is no necessary connection between the dominance of this approach and the perceived lack of such knowledge.[29] Indeed, it is arguable that the very nature of particularist research promotes acute observation and recording of relevant phenomena without necessarily having the investigation of formation processes as an explicit or primary objective (Bass 1983, 97; Snodgrass 1985, 33).[30] However, such a review also produces support for the suggestion that study of the formation of the archaeological record is often restricted to the investigation of a narrow range of processes perceived to be relevant to resolution of specific problems.

This is well illustrated by the pioneering work of Frost in the Mediterranean. Pre-eminence is given to the study of well preserved hull structure - sites are referred to as 'good' or 'bad' in terms of the degree to which they offer this single class of evidence (Frost 1963, 125). Consideration of site formation is largely restricted to discussion of conditions influencing the

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[27] Lenihan & Murphy (1981 69-71); Lenihan (1983, 43-44); Watson (1983, 27-8); Murphy (1983, 70).

[28] The Committee for Nautical Archaeology, one of the first formalised bodies specifically concerned with maritime archaeology in the UK, was formed in 1964 (Marsden 1986). Early statements of research priorities reveal a general concern for a range of maritime related deposits but a largely historical perspective, with a focus on elucidating problems relating to ship construction and trade, can be discerned. (CNA Archive Wrecks Survey Folder). A wreck survey was planned to obtain data to progress this programme and the sphere of interest was initially described as wooden vessels pre-dating 1800 (CNA Archive HF/28.9.66 - Wrecks Survey Folder).

[29] For example, Adams (1985, 279-287; 1990, 210-11); Bass & Van Doorninck (1982, 6-7, 87-97); Gawronski (1986, 29-31).

[30] Note Martin's (1979a, fig 14-15, 29-30) observations on marks on timbers from the site of *La Trinidad Valancera*, (see also Shomette 1981, 188-91).

preservation of hull and cargo as a coherent deposit (Frost 1962, 84-86; 1963, 124-5); the ability to predict where accessible examples of such deposits may occur is the apparent goal (Frost 1963, 121). Aside from brief consideration of some aspects of the dynamics of deposition (Frost 1962, 84) the viability of less coherent deposits for inference or indeed the nature of intra-site associations within a 'good' site are not substantially discussed. However, that Frost's approach developed as the discipline became more fully established is also indicated by her important contribution to the study of scattered sites (Frost 1969). The work of Dumas exhibits a similar concern for investigation of site formation in terms of facilitating location of 'useful' sites (Dumas 1962, 4 & 16-29). 'Scattered' sites are considered of little interest as assemblages (Dumas 1972, 32).[31]

Cederlund (1980, 102-3; 1983, 20) identifies 9 factors involved in the preservation of wreck material in the Baltic and 2 broad zones of differential preservation - although no substantial discussion or analysis of the various factors is offered. A 4 part categorisation of wrecks is presented, but this is based entirely on the coherence and preservation of structure (Cederlund 1983, 57). Concern for structural evidence, particularly the timescale of structural decay, also dominates Throckmorton's resourceful investigations at Methone (1965, 305). This research produces indications of the complex interaction of factors which may create variable preservation within an apparently homogeneous deposit but the line of enquiry is not developed (*ibid.*, 311 & 314).

Martin seeks to elucidate a specific historical event (the Spanish Armada of 1588) through analysis of archaeological material (Martin 1979a, 13; 1983). Special reference is made to the nature of the ordnance involved and ship construction - field work undertaken on Fair Isle is perhaps the most explicitly particularist in conception (Martin 1972, 59 & 63). Treatment of

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[31] Dumas (1972, 34) was also clearly appreciative of the wide range of potential variables involved in preservation and of the preliminary nature of his suggestions. Nesterof (1972) exhibits similar concerns as well as promoting an explicitly interdisciplinary approach.

formation processes is shaped by the requirement to demonstrate that the sites under consideration were indeed associated with the Armada of 1588. Documentary evidence and local tradition are combined with considerations of the dynamics of deposition and natural processes to allow cross referencing between observed distributions and accounts of specific losses (Martin 1979, 16-20). The potentially biasing effect of salvage on the surviving assemblages is addressed in some detail and is used to qualify comparisons between historical records of armament and the items noted on site (Martin 1972, 62; 1983, 160-4). More general analysis of material is also informed by appreciation of the influence of environment and other processes (Martin 1983, 178, 182-3).

It is evident that highly significant contributions to knowledge of formation processes can be found embedded in particularist research, yet it is often in the form of undeveloped, singular observations. A frequent lack of explicit and consistent method in the study of such processes means that reliable comparisons with observations made elsewhere cannot easily be drawn. Thus the contribution of particularist research to the establishment of an evaluated data base of knowledge relating to formation processes has not been consistently cumulative; although a number of researchers may touch on similar issues, substantial advances do not necessarily result. Rather progress is sporadic, uneven and intimately linked to the skill and inclination of individuals. Alternatively, it might be argued that focusing analysis of formation processes on site specific problems is an effective means of avoiding giving undue prominence to minor mechanisms. As Muckelroy notes (1977, 48) there is little value in elevating the bath water to the status of the baby. However, until a process has been described and evaluated in a number of situations with some measure of formality, can its significance or otherwise be assessed reliably?

## 1.3 Conclusions and Thesis

Reactions against 'common sense' reasoning have produced advances in the way that seabed distributions are surveyed and analysed. The potential complexity of formation processes has been indicated but limited progress in relation to their detailed study has resulted. There are indications, however, that more effort is currently being directed towards structured consideration of deposit formation and the methodological problems associated with analysis. Murphy (1990, 53) investigates preservation in a high-energy coastal environment; the work of Muckelroy is acknowledged but theoretical orientation is derived from Schiffer. He proposes two principles of formation processes, one of which relates to barrier island migration and its influence on the preservation of inundated land sites. The second relates to shipwreck material; artefacts whose specific gravity is greater that the surrounding sand, which are deposited in sand deeper than the wave base, will migrate downward to the wave base and stabilise. This latter principle is broadly supported by Roberts (1987, 34-5). In addition, elements of middle-range theory have been applied both to focus research effort (Gibbins 1990) and as a means of deploying modern survey technology within an explicit analytical framework (Anuskiewicz 1992).

A shift away from certain methodological priorities which may be associated with Post-processual archaeology was discussed in section 1.1.2. At the 1990 Society for Historical Archaeology Conference a number of papers were presented which applied elements of Post-processual and Critical Theory to maritime archaeological research.[32] Elements of Critical Theory have substantial value as a counter to some of the excesses of, for example, Processual approaches. But the juxtaposition of two extremes is far less productive when there is no substantial body

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[32] These ranged from general considerations of the role of such an approach (Gould 1990; Orser 1990; Spencer-Wood 1990) to discussions of the need to consider gender roles (Smith 1990).

of methodological expertise to occupy the middle ground and dampen the force of swings between opposed theoretical positions.

The dangers posed by promotion of Critical Theory can be overestimated.[33] Past calls for refined method and theory, no matter how strident, have largely been ripples on the surface of a discipline which in many areas remains essentially pragmatic in terms of fieldwork. Any failings in this respect are not restricted to archaeology underwater. Recognition of the general lack of integration between theory and practice in archaeology as a whole is widespread (Champion 1991, 147-151).

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[33] Indeed, Firth has argued that evidence of maritime activity can provide researchers with a valuable critical perspective. Such data can offer fresh insights when insinuated into interpretation of subsistence and settlement patterns in certain areas (Firth, Theoretical Archaeology Group conference, Durham, Dec 1993).

### 1.3.1 Thesis

The nature of the 'Great Divide' between descriptive and generalising approaches has been thoroughly explored (Renfrew 1980; Snodgrass 1985). Once problems created by jargon and semantics are resolved, there appears to be little reason to rule out productive discourse (*c.f.,* Bass 1983; Watson 1983, 30-36; Lenihan 1983, 62). Gawronski (1990, 53; Gawronski *et al.,* 1992, 15-19) demonstrates that a project largely conceived in particularist terms can also embrace wider concerns. Similarly, Lenihan and Murphy (1981, 71) recognise that data collected during a project with an ideographic bias can contribute to generalising research aims. Keith and Simmons (1985, 420-423) provide an example of an investigation conceived in terms of historical particularism but employing a concept of site formation developed in a generalising tradition by Muckelroy. Data recorded by Martin in a particularist context was later re-examined by Muckelroy (1978, 188-195). The original interpretation of artefact distribution on the *Dartmouth* (Martin 1979a, 33-40) was enhanced rather than refuted by self-consciously analytical treatment.

Gibbins (1991, 377) and Parker (1979, 7) both appear to regard work related to study of deposit formation and context characterisation as cutting across theoretical boundaries in archaeology underwater, a view endorsed in this study. Carver (1989, 669) has suggested that certain excavators believe that there ought to be a science of retrieving archaeological evidence which has nothing to do with the interpretations which are subsequently made. Yet, while some elements of Critical Theory may be discarded by many, the notion of a neutral archaeology, based on the systematic collection of data with minimal interpretation, must surely have had its day (*c.f.*, Murray 1993, 105). Indeed, the possibility of neutral observation of 'facts' is broadly rejected in current treatments of the philosophy of science (Chalmers 1982, 22-37). It is almost a truism that those who claim to hold no theoretical position apply elements of theory implicitly rather than explicitly.

This study, by considering the analysis of formation processes underwater, seeks to contribute to an "...independent discipline, neither art nor science, neither history nor anthropology, but archaeology" (Champion 1991, 130). This must be an archaeology which can support a variety of approaches and does not deny the active role of the archaeologist as a member of society. The lack of a succinct characterisation of the 'Post-processual movement' might well be seen as proof that a wide range of ideas can contribute to learning about the past rather than as a demonstration of the muddled state of a particular research programme. Indeed, it is to be hoped that the currency of labels such as Processual, Post-processual, Generalising and Particularist will diminish as indicators of allegiance to approaches which must be accepted or rejected wholesale rather than as descriptions of starting points in a continuing, constructive debate.

This study also seeks to contribute to the conservation of the remaining archaeological resource. The current determination to extract the maximum information from available evidence while exploiting it as parsimoniously as possible derives partly from an acute awareness of the rate at which a finite resource is being consumed.[34] A direct link is drawn between refining understanding of formation processes and the ability to make better use of remaining archaeological material. In summary, if the circumstances surrounding the preservation of specific data sets are understood, then research can be more effectively directed at deposits likely to offer the required information (*c.f.*, Schiffer & Rathje 1973, 171; Smith *et al.*, 1981; Schiffer 1983, 696).

Gibbins (1990, 384) emphasises the need to treat apparently scattered sites as an integral and valuable part of the data-base. This is allied to a pragmatic acceptance that shallow (often

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[34] Calls for explicit research design and controlled sampling are intimately associated with this question, for example, Parrent (1988, 32-4); JNAPC (1989, 6-8).

scattered) sites are logistically easier to investigate (*c.f.*, Parker 1980, 46; Green 1975, 56). The development of analytical procedures and research into formation processes are seen as a corollary to the success of such research. It may also be relevant to note Green's (1990a, 264) paraphrase of Bass "...it is pointless trying to do maritime archaeology in deep water (with concomitant expenditure) if we are not able to do it properly in shallow water."

The above-noted concerns clearly have the potential to focus considerable interest on formation processes. Yet problems will result if the active study of the past, aided by comprehension of site formation, is overshadowed by the primacy given to preserving material evidence *in situ*, with only incidental contributions to refining inference. There is no necessary reason for such difficulties to arise. Detailed understanding of factors involved in the formation of the archaeological record can assist in the identification of processes which tend to reduce the range and quality of archaeological material in a deposit. This knowledge can then be utilised to develop strategies for enhancing preservation of material *in situ*. This general point is illustrated by *The National Reservoir Inundation Study* (Lenihan 1981). This was undertaken by The National Parks Service in the United States with the aim of assessing the effects of inundation on terrestrial sites and investigating strategies for *in-situ* conservation. The results, however, also contribute to improving understanding of general site formation processes.

An approach will be proposed within which the study of deposit formation and deposit conservation are complementary.

# 2 Method

In this chapter the manner in which approaches developed to analyse site formation and enhance deposit conservation on land can be modified and applied to submerged deposits will be considered. A case study will be presented in order to expand on specific points. The proposed structure of this study will then be outlined and the subject areas chosen for detailed examination will be described.

## 2.1 The Study of Formation Processes

The basic elements of Schiffer's Transformation Theory were reviewed in section 1.1.1.[1] The following points, largely reflecting Schiffer's approach, are regarded as central to the analysis of formation processes in this study.

As a prerequisite to virtually all inference, the archaeologist must identify the processes which created the deposit from which data is to be extracted. Schiffer defines the term deposit carefully and considers it to be the fundamental unit of study (1987, 265-6). In this instance the term is used in a general sense, to describe a three dimensional area whose limits are definable containing associated archaeological material and related sediments (see also Stein 1987). Deposits can be subdivided into contexts *etc.*

Formation processes are held to be identifiable because they have regular and predictable physical effects. These traces can be used to infer the influence of the process.[2] Emphasis is placed on

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[1] A full discussion is provided by Schiffer (1987 265-303).

[2] See Sullivan (1978, 194-210) for a discussion of the acquisition and analysis of traces.

establishing criteria for the *routine, practical identification* of formation processes as a *prelude* to analysis; identification of formation processes as an end in itself merely has curiosity value.

Deposits are formed through the combination of a number of processes. The combination of processes and their influence will vary from deposit to deposit and so a case by case approach must be adopted.

Once relevant processes have been identified (inferred) this knowledge can be used to assist in the selection of appropriate methods for analysis of the deposit. The influence of specific processes may preclude or modify the application of specific analytical techniques.

The approach proposed in this study also exhibits a number of significant departures from Transformation Theory. The aim of this research is to describe low level regularities in the physical effects of specific formation processes which might allow the past influence of these processes to be inferred with a degree of confidence. There is no expectation, however, that validated, absolute regularities will necessarily be established. Indeed the possibility of actually achieving this in a wide variety of instances is questioned.

Schiffer has proposed a simple division of formation processes or 'transforms'. Cultural formation processes (C transforms) are defined as the processes of human behaviour that affect or transform artefacts after their initial period of use in a given activity. Four main types of C transform are described, reuse; cultural deposition; reclamation; and disturbance. Non-cultural (environmental) or N transforms are any and all of the events and processes of the natural environment that impinge on artefacts and archaeological deposits. Transforms can be divided in terms of the scale of their influence *i.e.* on the artefact; on the site; and on the regional archaeological record (Schiffer 1976, 12-19; 1987, 7).

Cultural formation processes in particular are unlikely to be amenable to consistent, detailed description due to the diversity of behavioural phenomena. Even supporters of generalising approaches now appear ready to admit the need for moderation with regards to seeking regularities in human behaviour. For, example, Gould (1989, 24) regards the challenge facing ethnoarchaeology today to be the establishment of "...general, law-like principles of human behaviour which conform to acceptable uniformitarian expectations," while allowing that some aspects of the archaeological record are structured by particular culture-historical traditions.

The problem of equifinality is regarded as particularly significant. Two separate processes might not, in fact, produce precisely the same physical result. However, researchers may not have the techniques available to recognise or measure the difference that exists. In analytical terms therefore, this apparent equifinality, created by inadequate methodology, will be as problematic as actual equifinality.

An additional, pervasive problem is that of complexity introduced by interacting and interdependent processes. The possibility of consistently recognising the physical evidence for individual processes from within a complex system and determining their precise input to the formation of a deposit is questioned; for example natural processes may mask or alter traces left by cultural processes and *vice versa*.

## 2.2 Deposit Conservation

Wildesen (1982, 52) presents a wide ranging review of the study of the impact of various processes on terrestrial archaeological sites. An *impact* is defined as a measurable change in a characteristic or property of an archaeological site. Wildesen (1982, 77) promotes the study of the component parts of an impact in order to understand the regularities exhibited by its physical consequences. In this her basic approach can be seen to have much in common with Schiffer. Once regularities in the physical consequences of specific processes have been established appropriate strategies may be developed to reduce or prevent damage to the archaeological resource.

Great stress is laid on quantification of changes (Wildesen, 1982, 66). The desirability of quantification (with appropriate margins of error) is not doubted. However, numerous variables may determine the precise influence of a process. Given that every variable is highly unlikely to remain constant, can a measured change within one deposit ever represent more than an estimation of changes likely to occur within another?

Precise quantification may be perceived as necessary to bolster archaeological credibility in the eyes of developers and funding bodies and to facilitate 'scientific' treatment of data. Yet the complexity of measuring the changes wrought by a number of interacting processes will surely impose case specific limits on the extent to which such quantification can actually be achieved. The complexity of the interrelationships that characterises change within an archaeological deposit has lead some workers to defer attempts to develop a strictly quantitative, generic model for site decay. Rather, separate analysis of the influence of biological, physical and chemical changes on each class of site component and spatial relationship is held to present opportunities for progress (Mathewson 1989c, 227-238; Mathewson & Gonzalez 1988, 522-525).

In considering the management of archaeological resources Wildesen (1982, 56) stresses that it is the integrity of the resource which must be conserved, that is, its ability to provide reliable data to answer significant research questions. This general concept will be utilised. However, it is evident that research questions deemed to be relevant now, may be outmoded and considered trivial in the future. Therefore, for the purposes of this study, it is assumed that a commitment to conserving integrity must, *in ideal circumstances*, extend to preserving all elements of a deposit equally in all their various relationships (*c.f.*, Mathewson & Gonzalez 1988, 521). Further, the various deposits which comprise the actual resource on the seabed of UK coastal waters can be divided conveniently into three broad categories: known; unknown; and unknown but suspected. Few deposits are known in detail. There is a broad consensus that the number of sites of potential archaeological interest and requiring management is far greater than the number whose location is known (JNAPC 1989, 25-27). If the concept of integrity is extended beyond individual deposits to refer to the ability of the resource as a whole to function as a research database, then it should follow that strategies must be developed which allow consideration of the unknown as well as the known resource.

Points raised in the preceding discussion will now be illustrated by means of a brief case study. Casual depredation (as opposed to organised salvage) will be considered and will be used to illustrate the difficulties involved in attempting to isolate a single process for study from within a complex set of interrelating mechanisms. The analytical problems associated with the investigation of cultural and behavioural elements of formation processes will also be highlighted.

## 2.3 Casual Depredation

Salvage of wreck material is no recent phenomena. Gores (1972, 3-8) notes various classical accounts which suggest limited salvage through breathhold diving. Lehmann (1991, 9-11) describes salvage-related activity in 15th and 16th century Italy while Franzen (1960, 26-8) illustrates the relatively crude apparatus with which guns were salved from the *Wasa* in the 17th century.[3] McKee (1968, 3-49) and Evans and Bevan (1990) present an account of early salvage work and the development of diving apparatus in the mid 19th century. The potential influence of this reclamation process must be considered at some stage in many, if not most, investigations.

The documentation resulting from the regular, indeed near inevitable, involvement of lawyers and accountants in commercial salvage expeditions is a boon to researchers. The salvage work undertaken on the *San Estaban* , lost in 1554, provides a case in point (Arnold & Nordby 1987, 14-20). The cargo being gold and silver destined for the Spanish royal coffers, salvage operations were meticulously recorded on a day to day basis by a royal notary. These records include information that might be helpful in interpreting distributions through predictable consequences of certain actions. For example, a seabed drag, operated by a windlass on shore is described (Arnold & Weddle 1978, 151) the use of which might tend to distort distributions in a consistently shoreward direction.

Physical traces can also be left - features on surviving timbers have been identified as saw or cut marks (Crumlin-Pederson *et al.* 1980, 203). Occasionally salvage becomes an additive process and new artefacts are deposited on-site as a result of recovery operations. Evidence of the shore camp created by the contemporary salvors of the *San Estaban* was discovered as well

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[3] See Roddie (1976) for an account of salvage work around the British Isles in the 17th century.

as modern debris left on site by more recent scavengers (Arnold & Weddle 1978, 325; Arnold & Nordby 1987, 16-18). A lead-soled boot from 19th century diving dress has been found on a 17th century wreck in the Isles of Scilly.[4] An inspection of the site of the *Queen of Sweden*, Lerwick Sound (Joffre 1982) by the Archaeological Diving Unit[5] revealed numerous artefacts added to the site by recent salvage efforts. Equally, negative evidence can be utilised; the rows of empty gun carriages on the gundecks of the *Wasa* suggest both the activity of salvors and the type of objects which might be recovered as a priority.[6]

In this study, casual depredation rather than commercial salvage is considered. The dividing line between organised and 'casual' salvage is not always clear but might be defined by reference to scale and organisation.[7] Casual depredation is characterised by individual acts involving only basic equipment rather than co-ordinated effort. Due to the small-scale and un-official nature of casual recovery of material, relevant documentary evidence tends to be less abundant as compared to records of formal salvage efforts. However, the boon to small or isolated communities represented by the loss of a vessel in an accessible area is well attested in historic sources (Muckelroy 1978, 167; Whalsay Book, Shetland Museum, 36-7). The circumstances surrounding the loss of a vessel in 1912 near St. Andrews, Fife, provide an opportunity to assess the potential significance of this process and

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[4] Heslim, pers.comm.

[5] See appendix 3, lines 58-76.

[6] Ross (1981, 69-73) presents an analysis of removal of material from the 18th century vessel *Le Machault*. Tools recorded through archaeological excavation are analysed in terms of functional category. The absence of specific functional groups, such as navigation, medical, religious and gunnery related items is used to infer structured, contemporary salvage by survivors of the vessel's loss.

[7] See Benham's account (1980, 16) of the activities of the 19th century 'scropers' of the Essex coast (fishermen turned salvagers-lifeboatmen). The 'beachmen', operating on the East Anglian coast, appear to have much in common with the 'scropers' although exhibiting a more established organisational base (Higgins 1987). The litigation associated with the activities of both communities ensured that substantial written records of their practices survive.

also to consider briefly the degree to which its influence may be detected in an archaeological study.

### 2.3.1 The Loss of the *Princess Wilhelmina*

"Fishing boat and Barque wrecked at St. Andrews, twelve lives saved, splendid work by St. Andrews lifeboat." So read the *St. Andrews Citizen* on October 5th 1912, four days after the rescue of the crew of the three-masted barque *Princess Wilhelmina* of Halmstad, Sweden.[8] The vessel left Kime, Finland on the 12th September with a deck cargo of wood consigned to Langlands and M'Ainsh, boxmakers of Dundee. She was a wooden ship of 'modern build', 29 years old and registered as 366 tons. Captain Jonsson was in command. She reached the Tay light buoy on Monday morning with a pilot flag flying but the rough weather prevented a pilot from coming out to meet her. Due to worsening weather the captain decided to make for the Firth of Forth.

Early on Tuesday morning, local coastguards observed that a barque had become embayed in St. Andrews Bay. A strong north easterly gale was now blowing and the *Princess Wilhelmina* drifted to within a mile of the shore where her anchor held. The rocket brigade was made ready but the anchor cable parted and the vessel 'drifting helplessly before the wind' headed shoreward.

Word of an impending tragedy spread and a large crowd gathered (fig. 1). It appeared that she was being carried onto the rocks below the old castle (see fig. 3). Reports state that the ship would have disintegrated had it hit the rocks when the tide was making. Fortunately, the vessel appears to have brushed against the rocks on an ebbing tide. All the crew were saved by the lifeboat. and were taken into the care of the Shipwrecked Fishermen and Mariners Society.[9]

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[8] *St. Andrews Citizen*, 5 Oct 1912, 5; *The Scotsman*, 2 Oct 1912, 9; *The Scotsman*, 4 Oct 1912, 9.

[9] *Fife News Almanac* 1913, 36.

The tide began to flow again in the afternoon. A crowd gathered to watch the waves breaking up the barque, but with the rising water she drifted westwards bumping against the rocks. It was reported that her back was broken and her mainmast lost. Eventually, on Wednesday, she grounded near the Pole Rock opposite the Bruce Embankment on the West Sands (see figs. 2 and 3). The wreck began to settle in the sand although there were no immediate signs of her breaking up. Large quantities of the cargo of wood were washed ashore and were collected and built up in heaps on the Bruce Embankment.

The loss of the *Princess Wilhelmina* was to contribute to social, cultural and economic aspects of the local community. The wreck is reported[10] to have been extensively photographed and painted by local and other artists. A poet commemorated the event in verse and cinematographers from Edinburgh reconstructed the rescue; an operation described as considerably more dangerous than the original event.[11]

The local picture house, then on South Bridge Street, donated the proceeds of a special programme to the Royal National Lifeboat Institution.[12] The proceeds from a subsequent special programme, featuring Mr. Kingsley a 'wonderful handbell player', were donated to the Shipwrecked Mariner's Society, St. Andrews Branch.[13]

The owner of the Picture House was Mr. 'Jock' Spence, a local businessman, builder and entrepreneur. He bought the wreck[14] and cargo and eventually advertisements for firewood and

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[10] *St. Andrews Citizen*, 12 Oct 1912, 4.

[11] *St. Andrews Citizen*, 26 Oct 1912, 4.

[12] *St. Andrews Citizen*, 12 Oct 1912, front cover.

[13] *St. Andrews Citizen*, 16 Nov 1912, 5.

[14] Christie, pers.comm. No official record of the sale or disposal of material has been located during the course of this study.

souvenirs from the wreck appeared. The wood was 'principally pitch pine and oak, in logs or loose' and orders were to be lodged by letter.[15]

A tragedy from the point of view of the vessel's owner, captain and crew became a diversion for the artistic set, entertainment for the townsfolk and a potential source of income to a local businessman. Mr. Spence's daughter, now Mrs. Kinnear,[16] still lives in St. Andrews. Her recollection of the events surrounding the wrecking and subsequent salvage show that far from profiting from the incident her father actually made a considerable loss. His interest in salvaging the wreck lay mainly in providing work over the winter for the gang of labourers he retained. The plan was for a leisurely disassembly of the vessel with the resulting lumber being sold off as firewood and souvenirs. Unfortunately, by the time Mr. Spence began to sell the timber he found that the local people had already removed sufficient for their needs from the wreck on their own account. Mrs. Kinnear remembers the social awkwardness she faced in having to meet and deal with people she knew had burnt and made furniture out of wood that had been stolen from her father's wreck. Mr. Gordon Christie, whose grandfather worked for Mr. Spence, recollects that a major timber, the 'king post', from the wreck was used as the base for an anvil in the family's garage business. He also confirms Mrs. Kinnear's suspicion that a number of pieces of furniture in the area have their origin in the wrecking of the *Princess Wilhelmina.* However, it would appear that the final destination of most of the material from the wreck is unrecorded.

Local tradition holds that a single timber projecting from the West Sands, visible at low tide, marks the remains of the *Princess Wilhelmina*. This is disputed by some who feel that the wreck now lies under a carpark and that the timber is a part of the

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[15] *St. Andrews Citizen*, 16 Nov 1912, 5. The same notice appears on 30 Nov & Dec, on the front cover.

[16] Now married to the Rev. Kinnear.

remains of Second World War beach defences.[17] A geophysical survey conducted around the timber during this study suggests the presence of a significant magnetic anomaly beneath the sand (see fig. 4). The excavation that would be required to provide more substantial evidence of the nature of the timber is unlikely to occur in the near future.

### 2.3.2 Formation Processes and the *Princess Wilhelmina.*

Contemporary photographs provide a pictorial record of processes influencing the *Princess Wilhelmina* during the storm and once she came to rest on the sands. They show the interacting mechanisms which determined the nature of the surviving deposit.

First, consider the extent of the 'site' created by this event. As figure 3 shows, the initial point of impact (A) was some way from the vessel's final resting place (B). Between the two locations the mainmast was lost as were, in all probability, other elements of the vessel. In figures 5 and 6 the vessel lies beached, but essentially intact on the West Sands. The effect of the environment on the hull remains is illustrated in figures 7 and 8, the latter showing the cargo scattered away from the vessel. Figures 9, 10 and 11 show the cargo apparently randomly scattered, then in the subject of more orderly collection and finally stacked on the Bruce Embankment.

Figure 12 illustrates the beginning of the break-up of the hull structure. Although the vessel was reported as having broken her back when first aground on the castle rocks, the photographic evidence suggests that she remained substantially intact until after beaching on the West Sands. The gross distortion of the hull evident in this image is not detectable in previous photographs. The forward and stern sections of the structure appear to be

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[17] Dobson, pers.comm.

settling more deeply than the mid-ship section. This is further emphasised in figures 13, 14 and 15. The latter two figures show the vessels with the masts cleared away. Structural weakness associated with the loss of the main mast may have influenced the manner in which the hull broke up when finally beached; the weight of the two remaining masts forcing the structure apart. More extensive settling at the stern and bow may have led to more substantial survival of those structural elements.

Figures 12 and 15 also indicate the manner in which the presence of the hull altered the local environment. In the former image, a pool of water surrounds the hull in an otherwise dry area. This indicates the formation of localised scour as the structure settles into the sand. Such scour may itself promote the preservation of material which is displaced into it and thus more readily buried. In figure 15 water from this scour appears to be draining away. Figures 16, 17 and 18 also show structural remains apparently settling into localised areas of scour. A comparison of the height of the vessel's name board above the sand in figure 8 as compared to figure 16 indicates the potential depth of surviving structure and the extent of the settling process.

No accurate indication of the time span between events shown in figures 1 and 18 has been obtained. Mrs. Kinnear[18] believes that the hull remained substantially intact for a 'good few weeks'. She feels that the two photographs are probably separated by several months. The point in time at which material was no longer accessible to salvagers or townsfolk has not been ascertained.

The wreck was influenced by the environment. However, the wreck itself also influenced the local topography in a manner which may have contributed to determining the nature of the deposit finally buried. The structure can be seen to be breaking up unaided, possibly in a manner part determined by specific events in the wrecking event. It is also shown being deliberately

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[18] Mrs. Kinnear identified the figure standing directly above the name plate in figure 16 as her father, Mr. Spence.

dismantled - the latter process may well have influenced the former. The cargo was dispersed by natural processes, but it was also collected on both an organised and casual basis.

Potentially significant variables can be highlighted. The use of a horse and cart in the collection of material is revealed by several of the images. This would help to determine the nature of the material salvaged - how quickly it could be removed and how far it was taken before being dumped in a secondary concentration. Would the surviving deposit be different if a horse and cart had not been available?

Salvage was organised as a strategy to keep workers employed and was thus envisaged as an extended project. Retrieval of vital or scarce material was not the prime aim. How different would the archaeologically observable deposit be if those organising the work perceived the wreck as providing specific resources not available in the locality? Might a more rapid, intense process have resulted in the eventual burial of less substantial remains?

A common element running through many of the photographs is the presence of townspeople. That casual removal of material was sufficiently extensive to have prevented the organised salvage from making a profit has been established. It therefore affected the social and economic significance of the wreck event. Yet the human element may be one of the most difficult to account for archaeologically. Could casual depredation be identified, amongst other interacting processes, as having been responsible for specific associations or specific absences of material? The organised salvage of the cargo resulted in secondary concentrations of material which might be detectable in some form; whether they could be firmly associated with a specific wreck event given the distance between the hull remains and point of deposit is another matter. Casual removal is unlikely to leave similar evidence. Where documentary evidence such as that used above is not available, is it possible to do more than simply acknowledge that such activity may have occurred?

Broadening the discussion to consider the formation of the regional archaeological record, does the narrative of the loss provide any relevant information? The *Princess Wilhelmina* was lost because she was embayed. The contemporary newspaper reports state that with the spread of steamships, independent of wind and tide, the citizens of St. Andrews seldom witnessed the tragedies that seem to have occurred regularly a generation or two previously. Thus technological progress, which freed vessels from the wind's caprices, influenced the formation of the regional archaeological record in terms of loss location and frequency. Regularities identified in the likely location of losses are given boundary conditions by the technology employed at the time. Hypotheses utilised to investigate one phase of the formation of the regional record become irrelevant when new variables are recognised. Further complexity is introduced by the fact that sail and steam power co-existed.

While observations relating to other deposits might be based on this episode, no other site will have been influenced by precisely the same combination of processes and circumstances. Furthermore, at no point is it possible to identify a single process acting in absolute isolation. Of those processes which can be identified, and this may be far fewer than were actually influential, how many will leave unambiguous physical traces which can be utilised to refine study of the deposit?

### 2.3.3 Casual Depredation and Archaeological Heritage Management

Similarities in the analytical problems posed by the casual depredation described above and the removal of material from archaeological sites underwater by sport divers can be highlighted. Disquiet in the archaeological community regarding such activity is evident[19] and appears to extend to some sectors of the diving community:

> "British divers are gaining an unenviable reputation as wreckers. We are, it seems, obsessed with the ambition to unscrew, unbolt or otherwise detach anything that can be taken off a wreck, whether or not it is saleable or useful." (Editorial, *Diver*, Apr 1985)

But it is necessary to move on from simply expressing concern about the process. Analysis is required to determine whether or not regularities exist which can be used to refine inference and inform management strategies. Schiffer (1987, 114-120) and Wildesen (1982, 68-72) review evidence relating to the nature and impact of pot-hunting on terrestrial sites. Schiffer (1987, 115-117) suggests that the activity follows predictable patterns. Larger, diagnostic artefacts are most often removed (for example, decorated sherds, projectile points of other 'formed' materials) although small plain sherds are removed from heavily depleted sites. However, it is stressed that the factors which determine which object will be removed at any time are highly variable. Proximity to roads and vegetation cover are significant factors in terms of the vulnerability of a site to depredation. Sites close to roads (that is, easily accessible) tend to have low surface densities of smaller artefacts.[20] It is also acknowledged that traces of

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[19] For example, Cockrell (1981, 215-220; 1982, 124-9); Crysdale (1982, 80-82); Gregory (1987, 4-5)

[20] Other workers have observed that difficulty of access to sites is not necessarily a deterrent unless use of motor vehicles is inhibited (DesJean & Wilson 1990, 8).

pothunting that occurred years ago may be very subtle or attributed to other processes.

Wildesen stresses (1982, 68) the lack of quantitative data relating to the extent and nature of such depredation although, in some areas, a third of known sites are believed to have been affected. Studies are cited which have established some common elements as regards the 'type' of person responsible for such activity[21] and ease of access is highlighted as a significant factor. Initiatives within the US National Park Service may allow more rigorous investigation of the nature and extent of the process on land in the future.[22]

A working hypothesis might state that diver depredation will result in some material being removed and that some material will be disturbed and moved around without being removed. These changes will mostly influence surface or very near-surface material both directly (Skowronek 1984, 149-50) and through erosion triggered by disturbance to the deposit (Fischer 1984, 146). More detailed evaluation of this hypothesis might include consideration of whether particular types of material are more likely to be affected than others. For example, Middlewood (1972, 114) notes that on an 18th century cannon site, pieces of pottery, particularly the necks, were subject to undisciplined removal by souvenir hunters.[23] If an index could be established which indicated the material most likely to be disturbed by divers then

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[21] The profile suggests that a 'typical' souvenir hunter/vandal in the United States will be over 30, male, from a small town (population less than 25,000) will have travelled less than 100 miles to commit the act of removal or vandalism and will be a 'repeater' (Wildesen 1982, 69).

[22] In Alaska, 'vulnerability indexes' are being developed to assist in predicting which sites are the most likely targets in order to allow for more directed management effort (FAR 1989, 2.3, 9-12). Other initiatives include a central database detailing behavioural aspects of vandalism and looting (*ibid.*, 15).

[23] This observation is further supported by the fact that an inspection of the site in 1991 (at which the author was present) using the 1970 survey for guidance revealed that recorded concentrations of vessel neck and shoulder sherds were no longer present.

this might be used to help establish measures of confidence in observed seabed distributions and associations.

The results of a questionnaire distributed as part of this study indicate both the potential difficulties attending collection of such information and the fact that some progress may be possible (appendix 1, 40-52). The majority of divers in the sample stated that they would select material for removal, or disturbance without removal, on the basis that they recognised what it was.[24] Cannon and musket balls were particularly popular. Objects made of specific materials such as brass or precious metal also figured prominently.[25] A desire to obtain a 'good souvenir' may be detectable although motivation was not explicitly investigated. Where removal has occurred the material was usually exposed on the surface of the site; only a minority of divers used tools or dug into the deposit.[26] An element of selection on the basis of size and portability might be inferred. A significant observation in terms of this study is the fact that material appears to be disturbed and moved within a deposit more frequently than it is actually removed.[27] These results might support the suggestion that casual depredation can have a serious impact on the distribution of surface and near-surface material. It must be noted, however, that the sample analysed was small. It has been stated, for example, that divers may disturb or remove material quite randomly and that recognisable form does not play a major role in the selection process.[28]

Further work to establish an index of preferred items for removal could involve inspection of museum collections which include material donated by divers. In addition, study of material amassed in the homes of sport divers will provide an empirical

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[24] See appendix 1 section 3.2 question 6e, 46.

[25] See appendix 1 section 3.2 question 3, 43; figure 163.

[26] See appendix 1 section 3.2 question 6b & 6c, 45.

[27] See appendix 1 section 3.2 question 4 & 5, 44.

[28] Dean, pers.comm.

basis for predictions concerning the influence of casual depredation. Attempts have been made to recreate assemblages by contacting divers but problems were encountered because artefacts from individual deposits had been subsumed into general collections and identification of items of interest was unreliable (Blot 1981). The permit systems employed in parts of North America to regulate collecting seem likely to provide access to useful data but similar opportunities do not currently exist in the UK.[29]

When such information is collected, significant difficulties may inhibit application of the data to the analysis of an observed surface distribution. The action of removing material from a wreck site is often referred to as, or associated with, vandalism. However, a distinction can be drawn, for example, between acts of vandalism and souvenir collecting. The motivation related to the latter may include curiosity and aquisitorial impulses rather than delinquent or purposely anti-social behaviour. The problem of equifinality has already been highlighted (section 2.1, 30). It may be relevant to consider whether the influence of an avowed vandal on a surface distribution could be reliably distinguished from the influence of a souvenir hunter deeply interested in the past; particularly if the pre-impact character of the assemblage is not well known.

In order for distinct behaviour patterns to be distinguished, it would be necessary to establish that material removed through one process was sufficiently different in some way to material removed or altered due to the other for this difference to be recognised consistently. Collection of data from sources mentioned above should include detailed consideration of motivation as well as quantification of types of object involved. In addition, the history of the collections studied would have to be accounted for. What material has been raised and either disposed of deliberately or lost through deterioration due to lack of appropriate conservation treatment?

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[29] See appendix 1 section 3.3, 49-50 & section 3.2 question 7, 47.

This is not to seek to deny the possibility of an analytical approach to such matters. Rather it is intended to emphasise variability in behaviour and the potential limitations of tools available for its study in such circumstances. Moreover, in accordance with the assertion that studies of deposit formation and conservation are closely linked, the need to appreciate this variability in behaviour, and indeed perceptions of behaviour, extends to the design of management strategies.

Consideration of approaches to dealing with the removal of material from terrestrial archaeological sites in North America indicates a clear consensus that legislation and education both have a role to play (Carnett 1991, 11; Wilson & Blackburn 1990). This stems in part from pragmatic acceptance of the fact that achieving voluntary compliance with some form of regulation may be more cost effective than vigorous policing of draconian legislation. However, it also reflects an appreciation that not every one who damages a site does so intentionally.

A review of initiatives directed at managing sport diver activity (Giesecke 1985; 1989) reveals a number of common elements.[30] Educational programmes figure prominently as do efforts to involve sport divers directly in archaeological survey and project work.[31] Despite this, even the most enthusiastic advocates of education appear resigned to the fact that a minority of divers will not respond to such initiatives and that enforcement of legislation is necessary (Albright 1985, 146-51). Permits for artefact collection or other investigations, usually including an obligation to report, are also widely used.[32] Considerable emphasis is given to the value of 'shipwreck reserves' and organised trails (Miller 1989, 54):

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[30] These reviews are of some interest as they occurred before and shortly after the implementation of the Abandoned Shipwrecks Act 1987 (ASA 1990).

[31] For example, Dethlefsen (*et al.,* 1982, 53-62); Hopkins (1985, 39-40).

[32] For example, Hundley & Hughes (1989, 41-2) Bradley (1989, 42-3).

"Many divers now perceive all wrecks as potential future preserve sites and accord them an equal level of respect, interest and 'hands off' treatment." (Peebles & Skinas 1989, 51).

A similar approach is detectable in the UK and the Republic of Ireland.[33] The results of a questionnaire (appendix 1, section 2, 4-39) designed to gather data on sport diver attitudes to archaeological material in UK coastal waters might suggest that this is appropriate. The survey indicates that introducing information about legislation at an early stage in the diver training process could be beneficial.[34] A degree of sympathy for some form of protection for some material is clear but a level of dissatisfaction with protective legislation which limits access to sites is also indicated.[35] Within the sample questioned, only a minority claimed to actively seek out new wreck material but a slightly stronger inclination towards the individual's right to profit from wreck material was, perhaps, detectable among this group.[36] A significant level of general interest in history and archaeology was evident within the whole sample.[37] This might indicate that attempts to involve such divers in constructive projects could pay dividends. However, there was also an indication that an element of the diving population does not have any sympathy with a conservation-based policy and that some divers may not respect 'look but don't touch' marine parks.[38]

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[33] The Department of National Heritage has (1992) grant aided a training scheme which aims to introduce sport divers to archaeological concepts and practice (DOE 1991, 129). The scheme is described by Dean (*et al.*, 1992, 302-307). Kelly (1993) describes a blend of legislation and education which has delivered promising results in Southern Ireland.

[34] See appendix 1 section 2.2.2, 15-16.

[35] See appendix 1 sections 2.2.3, 17 & 2.2.4, 18-19.

[36] See appendix 1 section 2.2.5, question I, 24.

[37] See appendix 1 section 2.2.1, questions A, B, K, 11-15.

[38] A survey of divers in Australia lead Lester (1983) to conclude that possession of an attractive souvenir is rated higher than monetary reward and that a minority of unco-operative divers exists. The need for education to accompany legislation is also affirmed.

When a diver encounters archaeological material on the seabed, the data does not necessarily indicate that there is likely to be significant peer group pressure for it to be left *in situ* or reported and dealt with systematically rather than on a 'finders keepers' basis. However, the survey might also indicate that to treat every diver who removes material from a deposit as a deliberate vandal would be an oversimplification of a complex situation.

It is probably true to say that public perceptions of archaeological material underwater are dominated by reports of treasure hunts and major projects such as the recovery of the *Mary Rose* (Rule 1982). Indeed perceptions of archaeology in general are believed to be characterised by excavation (Cleere 1989, 11-12). If this is accepted, then to expect ready support for proposals centred on conservation of material *in situ* may be mistaken. Such proposals may even be regarded as eccentric to a public familiar with the idea of material rescued from the depths for display. If the material is conserved on the seabed then it is not available to them (as non-divers) to enjoy. Even where material can be observed, if properly protected, access may be restricted (Knoop 1993, 442). Survey data suggests that the most popular way of finding out about a local site is by visiting it independently or through a guided tour (Merriman 1989, 162). This is allied to a strong desire to experience the past through personal discovery, or 'finding material in context' (*ibid.*, 167).

For shipwreck sites in particular, the relative difficulty involved in gaining access to them and the exclusiveness of interest which for some (notably sport divers) this implies, may increase public interest in their amenity value. Indeed, this might justify consideration of a very different tradition of 'monument use' as has been experienced on land. The symbolic, fenced-off monument which is by implication worthy of some respect, has little or no currency. For sport divers, the barrier to access may be conceived as largely environmental rather than deriving from existing official controls which may be difficult to apply in the field.

Allowing management strategies to be informed by a simplistic view of behaviour and an assumption of the primacy of *in situ* conservation will cause substantial difficulties. In a similar vein, 'Jock' Spence may well have viewed the actions of certain citizens of St. Andrews as an intrusion and possibly as theft. The people themselves may have regarded the taking of firewood as a harmless activity, ignorant of the cumulative effect of a large number of individual actions. Alternatively, they might have appealed to notions of local custom and tradition which they perceived as overriding any legal niceties. Some may have removed wood to burn because it would save scarce money, others because they wanted a souvenir of the event. The study of the loss of the *Princess Wilhelmina* confirms Clarke's (1973, 18) view that 'text-aided experiments' offer great potential for the archaeology of historic periods and the study of formation processes (*c.f.*, Deagan 1982, 167-8; Muckelroy 1976; Martin 1983, 13). But, as with the activities of differently motivated sport divers, to what extent would the behavioural factors noted above be detectable through consideration of archaeological evidence alone? Are they of interest? It can be argued that such a high resolution of detail is not ultimately necessary for analysis of the deposit and that sufficient regularity can be found within the general process of reclamation to allow analytical treatment. Such an admirably pragmatic view might be considered as support for the suggestion that there are clear limits to the confidence with which some behavioural phenomena involved in site formation can be reconstructed and studied - the act of removal might be inferred but knowledge of the intention behind the act seems likely to remain elusive.

## 2.4 Structure and Sources

The structure which will be applied to the consideration of selected processes will now be described.

### 2.4.1 Description

The process under investigation will be described through analysis of its component parts. The intention is to consider the changes to a deposit which result from its influence. Whether these changes are later analysed in the context of management problems or site formation is merely a question of temporal perspective. Much of the same data will be used in both situations.

Wildesen's (1982, 53-4) suggested categories for describing changes resulting from an impact will be adopted; namely burial, removal, transferral, alteration. Schiffer (1987, 13-23) identifies four basic dimensions of artefact variability within which formation processes are considered to have pervasive and significant influence: formal (weight, size, colour); spatial (locational); frequency (number of occurrences of a particular artefact); relational (patterns of co-occurrence of artefacts, associations). As can be seen, these two schemes overlap substantially. Changes can be a *direct* or *indirect* result of the influence of a process. For example, a direct impact would be the breaking of a pot by a plough, an indirect impact would be the erosion of a feature during a rainstorm due to a loosening of the soil structure by ploughing undertaken several weeks before.

The *description* of a process will, in effect, be used to generate a number of propositions which can be explored in later sections and in further research. A full characterisation of the influence of a process will include an indication of the *amount*, *extent* and *duration* of change resulting as well as an assessment of the nature of the change.[39] It is anticipated that such information will become available as the result of cumulative research into specific processes and is unlikely to be available in detailed form at this stage. Perceived limits to the precision with which the *amount* of change can be quantified have already been noted (see section 2.2, 31).

An *effect* is a positive/negative judgement on a change. Information derived from the description of a process will be utilised to arrive at a preliminary assessment of its *effect*. If the process under consideration is thought to have an adverse effect on the integrity of the resource then strategies will be considered which may reduce its influence (see 2.4.4 below).

### 2.4.2 The Practical Identification of Formation Processes

Schiffer (1987, 267-287) describes simple and complex properties of artefacts which are considered useful in terms of identifying formation processes. Simple properties include size; density / specific gravity; orientation and dip; use-life factors; damage; accretions. Complex properties of artefacts include; artefact quantity; artefact inventory; vertical or horizontal distribution; measures of disorganisation; artefact reassembly and representation of parts. Other attributes of deposits which may have value in the practical identification of formation processes include sediments; ecofacts and other intrusive materials; geochemistry and site morphology (*ibid.*, 288-292).

Case studies will be presented which examine the influence of specific processes on simple and complex properties of artefacts. Techniques suited to the study of such properties and the implications for practical identification of the process will be considered.

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[39] The character of change can be defined by rapidity of onset, reversibility and whether or not the impact was intentional.

### 2.4.3 Implications for Inference and Methodology

Considerable emphasis has been placed on the degree to which the influence of specific processes may require modification of the manner in which a deposit is analysed. An attempt will be made to isolate potential general problem areas and specific implications for inference.

### 2.4.4 Mitigation

Information derived from the above sections will be utilised, along with additional material, to assess management options for those processes judged to have an adverse effect on the integrity of the resource. Attention is directed towards establishing the general nature of appropriate options rather than any attempt to offer detailed, technical information. It is emphasised that the successful management of any resource is likely to result from a number of complementary initiatives. Strategies specific to problems considered here will require implementation within a co-ordinated programme.

As noted in section 2.2 (32) an *ideal* strategy would result in conservation of the integrity of the unknown as well as the known resource. In addition, strategies applied to individual deposits would conserve all material and spatial relationships equally. Mathewson and Gonzalez (1988, 520) have highlighted some important considerations. First, all change within a deposit will not be stopped but the rate and severity of changes wrought by natural and anthropogenic processes may be reduced. Second, the strategy adopted to achieve the above result may itself change the deposit and is likely to have a differential effect on various types of material and spatial relationships.

## 2.5 Processes Selected for Study

A number of workers have reviewed the range of factors that may influence the preservation of deposits (Robinson 1981; Gregory 1992, 10-52; Garrison *et al.*, 1989, II-9 - II-126); Muckelroy's contribution to this area of research has already been discussed (section 1.2.1). The potential influence of environmental characteristics such as water depth and water movement; sediment type and mobility; dissolved oxygen levels and water quality; nature of marine flora and fauna have been highlighted by these researchers. Such factors can be divided into broad groups; namely physical, chemical and biological. A variety of other factors have also been noted in the preceding discussion including reclamation of material by souvenir hunters and salvage workers. To this might be added large scale disturbance mechanisms such as marine aggregate extraction (Fox 1993). A list of processes of potential interest would be very extensive. However, this study does not aim to provide a comprehensive account of all the mechanisms that might influence any given deposit. In addition, this study is not concerned with the development of an explicitly systems based approach to the analysis of formation processes. Consideration of environmental factors in operation at the Bronze Age site at Moor Sand (Muckelroy & Baker 1979) demonstrates Muckelroy's appreciation of the need to refine his general conclusions. The Moor Sand project also begins to address one of the major limitations in his previous work - the lack of attention to the study of the mechanics of individual processes as opposed to the description of the *form* of deposit resulting from the complex interaction of several factors. The nature of this study reflects the importance attached to that line of enquiry.

Fishing activity and burrowing activity will be considered in detail. In accordance with Schiffer's taxonomy (1987, 7) commercial fishing activity can be regarded as a C transform involving disturbance and reclamation. Burrowing activity can be viewed as an N transform. The choice of these processes is intended to facilitate demonstration of the adaptability and usefulness of a certain approach.

## 2.5.1 Commercial Fishing Activity

A review of available evidence indicates the potential extent and general nature of the interaction between fishing gear and archaeological material. Elements of ship's structure were not uncommonly raised in the nets of sailing trawlers (Murie 1903, 220). A Board of Trade inquiry (RBT 1888, 5) heard that several kettles and saucepans, a gridiron and the bottom part of a bedstead were raised at one haul in the Thames Estuary. Trawls have been used to deliberately retrieve objects from the sea bed, in 1851 some 400 hundred smacks were engaged daily in dredging stone for Portland cement off Harwich and Walton (Benham 1948, 44-5). Indeed, fishing gear has been used to conduct crude salvage of artefacts from historic shipwrecks for profit.[40]

The retrieval of archaeological material by fishing gear has served as the catalyst for a number of surveys and projects (Riccardi & Chamberlain 1992, 1; Gamkrelidze 1992, 103; Barag 1963). However consideration of the nature of the influence of fishing gear has largely been dominated by uncritical reference to anecdotal evidence.

Primary sources utilised in this study include unpublished technical reports derived from Government and commercial research into the behaviour and efficiency of fishing gear. Video footage of fishing gear in use, made for research purposes, is also utilised. Relevant clips are provided on the attached video cassette. A commentary on the footage is included as appendix 2.

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[40] US Civil War artefact collectors persuaded local fishermen to deploy dredges on the site of the Confederate vessel, CSS *Florida,* in the James river, Virginia, to retrieve historic material for sale. Those involved were eventually prosecuted for disturbing a site on the Federal Register (ASA 1990, 50145). They were apprehended after having advertised the availability of the material in nationally circulated magazines (Waldbauer, pers.comm.).

There have been a number Government sponsored investigations into the fishing community, including several Royal Commissions. These have resulted in detailed records of the testimony of a large number of expert witnesses. Extensive use is made of this primary evidence due to the light it throws on fishing practice, particularly in the 19th century.

Information on gear design and the current concerns of the industry can be found in the fishing press. *Fishing News*, a weekly national publication with mass circulation within the fishing industry, is a particularly useful source. The title is abbreviated to FN in this study. Oral testimony also forms an important primary source. Interviews were arranged where possible but, when gathering information from some fishermen, less formal meetings were sometimes more appropriate.

Secondary sources include published works on fishing communities. These contain much information relating to the manner in which various types of gear are deployed and the changes which have occurred in fishing effort over time. The selective use of such material is justified because the main concern of this study is not the sociology or material culture of fishing communities but the nature of the impact of fishing gear on archaeological material on the seabed.

### 2.5.2 Burrowing Activity

The second topic selected for detailed study is the burrowing activity of the macro benthos. The decision to investigate this process derives from the acknowledged influence of burrowing fauna within terrestrial sites (Wood & Johnson 1978, 318) and a consequent search for parallel activity underwater.

Knowledge of burrowing organisms underwater has advanced considerably since Muckelroy (1978, 181), having noted the potentially destructive effects of burrowing crabs, stated that in the marine environment "...no burrowing creatures analogous to moles or rabbits have been noted." However, little attention has been paid to applying this increased knowledge systematically to archaeological problems. Collins and Mallinson (1984) consider the colonisation of wreck sites by marine fauna and flora and note some burrowing activity. Ferrari and Adams (1990) present a preliminary review of burrowing activity and Murphy (1990, 43-44) highlights both the potential of such activity as a site disturbance process and the need to develop techniques to assess its influence. Isolated observations of burrowing activity have also been reported. Mckee (1982, 108) notes burrowing activity within trenches left open on the site of the *Mary Rose,* over a winter. Several workers have noted that the distribution of ceramic sherds can be affected by the house-building instincts of the octopus in Mediterranean waters (Parker 1981, 312; Bass 1976, 295-6). Riccardi and Chamberlain (1992, 150) suggest that the distribution of closed forms of pottery at the *Varazze* wreck site was affected by the fact that such forms were used by octopi as habitats. Conger eels preying on the octopi dragged the animal and ceramic habitat away from the site into the upper entrance of their dens, thus producing a distinct group of artefacts separated from the main deposit.

Considerable research has been conducted into organisms which bore into timbers (Coughlan, 1977; Jones & Eltringham 1971). Such activity will not be discussed directly although it is recognised as a significant factor in the biological degradation of exposed wood in suitable environments.

Primary sources utilised include data collected through monitoring programmes instigated as part of this study which included excavation of monitored areas.

Secondary sources include observations on burrowing, bottom-dwelling organisms and the environments they occupy made by marine biologists both *in situ* (Main & Sangster 1985) and in aquaria (Nash 1980*a*). A considerable corpus of published material is available for study.

# 3 Commercial Fishing Activity

This chapter is concerned with the influence of fishing activity on archaeological material. The main area of study is the coastal waters of the UK. However, the distinction between practices which can be considered coastal fishing and those which take place further from shore is not easily defined. The terms of reference for the inquiries preceding a 1914 report on the inshore fisheries were based on aspects of social organisation and working practice, not technical assessment of gear or boats:

"It might naturally be thought that the term (inshore fishery) would be correctly and appropriately applied to the area of sea within the 3 mile limit, but the evidence shows that many fishermen who clearly come within the description of inshore fishermen are constantly engaged in various kinds of fishing beyond these limits, so that any such limitation of 'Inshore Fisheries' would be inaccurate and misleading."[1]

While it may be true to say that the inshore industry is slower to adopt the newest technology as compared to vessels working more distant waters, it is difficult to provide a precise specification for 'coastal' craft.[2] For the purposes of this study attention will focus on the generally smaller boats and lighter gear which are taken to broadly characterise the fishing prosecuted within the 12 mile limit of UK territorial waters. Estuarine methods are included in this discussion as they have a potential influence on material in the foreshore-subtidal boundary.

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[1] *Report on the Inshore Fisheries. Report of the Departmental Committee on the Present Condition, the Preservation and the Development of Inshore Fisheries*, 1914 (RIF 1914, v).

[2] Current legislation does restrict the use of vessels over 10m in some inshore waters (Tarvit, pers.comm.).

This study is aimed at the investigation of archaeological problems. The statements made concerning various gear types are not intended to be definitive. General accounts of modern and historic fishing methods are readily available.[3] When a specific type of gear is mentioned for the first time, references to works describing its use in detail are provided. Minor design alterations can have significant effects on the performance of gear types and most references are to general design categories rather than specific variants unless otherwise stated. In addition, the magnitude of changes derived from the influence of fishing gear will vary with factors such as tidal stream and the power of the vessel deploying the gear, both in terms of main engine and winches.

Sub-division of the wide range of equipment referred to as fishing gear will contribute to clarity in the following discussion. In this study gear will be divided into two broad groups, mobile gear (trawls, dredges *etc.* engine and wind or hand powered) and static gear (set nets, baited lines and traps) (*c.f.*, Davis 1958, 5). The use of specific gear types has varied regionally and over time. The literature cited contains such information and it is not repeated in detail here.

The broad categories within which any specific impact can be described were reviewed in section 2.4.1. They comprise burial, removal, transferral and alteration. The International Council for the Exploration of the Sea (ICES) classifies damage to the seabed inflicted by fishing gear under the following headings, scraping, penetration and pressure (ICES 1988, 20) to which might be added 'pulling strain' for the purposes of this study. These terms will be utilised in the description of specific changes subsumed by the broad categories noted above.

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[3] Davis (1958) provides a profusely illustrated survey of gear types, covering many that have now fallen out of use. Nedelec (1975) and Bridger (*et al.*, 1981) describe gear in use in modern fisheries.

# 3.1 Mobile Gear

The category of mobile gear can usefully be subdivided into two groups; trawls and related gear and dredges. Distinctions are drawn between gear towed by sail, gear deployed from motorised vessels and gear propelled by hand.

## 3.1.1 Trawls

Figures 19 and 20 show the two main categories of trawl, the beam trawl and the otter trawl.[4] Beam trawls preceded the otter board variant. The latter became widely used when steam power began to dominate the fishing industry in the late 19th century; sail power was not suited to maintaining the constant momentum required to keep the doors of an otter trawl moving and the net mouth open; figure 21 shows a beam trawl towed by sail. However the beam remained popular in countries such as Holland. It was never completely abandoned by UK inshore fishermen and now appears to be regaining popularity. This is partly due to superior performance on rough, or unknown, ground but also because the UK plaice quota has been consistently under-caught and beam gear is selective in favour of this species.[5]

The origins of trawling are obscure. An established method by the 17th century it may have developed in Brixham or the Thames Estuary (Graham 1956, 12). Charles I made attempts to regulate fisheries and during the concomitant investigations one group of fishermen described their gear which consisted of a beam

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[4] March (1970, 56-102) provides a detailed descriptions of beam trawling under sail. Holdsworth (1874) is also an important source of information on early trawling. The minutes and appendices of the *Trawling Commission* of 1884/5 offer detailed first hand accounts of both sail and steam trawling practice (RTC 1885). Graham (1956) Garner (1977) and Strange (1981, 2-12) describe modern trawling gear and its deployment. Sainsbury (1986, 75) and Thomson (1978) present accounts of pair trawling and seining.

[5] Tarvit, pers.comm.

roughly 6m long supported by two iron bound trawl heads. A sketch on the back of a state paper of 1635 seems to refer to this description (*ibid.*, 14). The gear is very reminiscent of a beam trawl (see fig. 22).

It is significant that the earliest records of such gear are accompanied by contemporary complaints concerning damage to the seabed (de Groot 1984). The general extent of trawling grounds before the major increase in trawling activity in the mid 19th century was fairly limited (Robinson 1989).[6] Even after this increase, much activity was still concentrated in discrete areas within broad zones (March 1970, 47-55). This was party due to the limitations of sail powered vessels. Lack of manoeuvrability made small areas difficult to fish and smooth ground and a favourable tide of moderate strength were also essential for trawling; the gear was always towed in the same direction but a little faster than the tidal stream (*ibid.*, 49 & 89). When the wind was dead against the tide it was impossible to work at all (Holdsworth 1884, 264). Despite this, speculative trawling and dredging over wider areas to identify the productive grounds must have occurred.

It was the advent of steam-powered trawling towards the end of the 19th century (*circa* 1880), not the expansion in trawling *per se*, which facilitated the exploitation of every available piece of suitable sea bed; greatly increasing the potential influence of this process on archaeological material. Aside from facilitating the shift from beam to otter trawling, motorisation provided greater manoeuvrability and allowed access to areas of ground which could not be trawled by sail (Anon 1884, 336). Exchanges noted in the records of the 1885 *Royal Commission on Trawling* (RTC 1885) suggest that the introduction of 'company money' and the profit motive may also have been significant in shaping the influence of trawling during the early

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[6] Robinson (1989) and Kentchington (1990) review the reasons for this expansion which is commonly associated with the discovery of the prolific fishing ground known as the 'Silver Pits' off the Dogger Bank in 1844.

expansion of powered fishing - fishermen becoming less circumspect when fishing rough ground:

> "(q) You do not trawl on foul ground?
> (a) No sir, it will not allow it. But the steam trawlers belong to companies, a class of men that have plenty of money, and as a consequence they are not particular as to working amongst rocks, so that they can catch fish.
> (q) They go and trawl right upon the rocks , and tear their nets and everything?
> (a) Oh yes; they are not particular about ruining a few nets in that way".
>
> (RTC 1885, q.9716-9718, 265)

Mr. Walker, a trawlerman, when asked about the benefits of steam power stated that the major gain was "...in constant trawling. We can go down with one tide, lift our net and trawl back again." (RTC 1885, q.1485, 39.). The introduction of marine diesels in the early 20th century gave further impetus to these trends. Early steam engines were generally too large for the smaller inshore boats and it was the more compact internal combustion engine which permitted extensive motorisation in the early 20th century. Peak (1985, 78) states that the introduction of engines to the Hastings inshore fleet (*circa* 1914) meant that fishermen could "...trawl whatever the wind, and could even occasionally pull across the tide."

Today, pressure on known fishing grounds is leading to the continued exploration of new or seldom-visited areas. This is, of necessity, carried out on a trial and error basis. Mr. Cartwright, who fished out of Whitstable, believed himself lucky to have been befriended by a local fisherman who provided him with information about obstructions *etc.* on the seabed when he first began fishing. He stated that this saved him thousands of pounds and weeks of lay-off through not having to learn the new grounds in the 'usual way'.[7] Pressure on grounds has also prompted the building of new boats; versatile 'rule beaters' designed specifically to circumvent technical regulations and thus qualify for fishing in inshore areas which would otherwise be

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[7] Cartwright, pers.comm.

closed to them. Many are beam trawlers, able to fish grounds that are too rough for otter trawls.[8]

Exploitation of previously unfished areas of seabed has obvious implications for archaeological material formerly protected through being surrounded by 'foul' ground. But developments in electronic position fixing equipment, such as Decca, might serve to moderate the scale of fishing related influence on material on the seabed through enhanced ability to avoid known obstacles (Thomson 1969, 83). Formerly, fishermen believed that the wreck of HMS *Pathfinder*, a WWI light cruiser lost in the Clyde area, was intact and gave it a wide berth. With the aid of Decca they realised it was in fact broken into 3 sections and trawling now continues between them.[9] Even more accurate, satellite based, position fixing equipment such as the Global Positioning System has recently become available (Akroyd & Lorimer 1990). Yet, while a trawler may successfully avoid the main part of a site registered as an obstruction, the dispersed nature of many deposits means that gear may still contact significant archaeological material.

Methods of trawling have developed which are likely to have influenced a significant proportion of the coastal seabed on which such equipment can be deployed. However, trawling is not conducted in a random fashion. Detectable trawling patterns do exist in many areas, a phenomena considered highly relevant to this study which will be discussed further below. Figure 23-6 and 27-8 show recorded otter trawling and beam trawling effort for recent years in Scottish waters. The extent and intensity of such activity is clear as are shifts in patterns of exploitation - yet these figures by no means account for all fishing in the areas concerned. In 1977 it was estimated that, in the Dutch North Sea, every point of some of the 30 mile grid squares shown in figure 25 was trawled 3 to 4 time a year (Lous 1977, 5). A new design of beam trawl with greater cross-species catching power may prompt an

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[8] FN, 14 Dec 1990, 10-11; FN, 19 Nov 1990, 7.

[9] Tarvit pers.comm.

increase in effort (FN, 6 Apr 1990, 10). What then, are the specific changes to a deposit that derive from the influence of these gear types?

### 3.1.2 Beams and Trawl Heads

Figures 19 and 21 illustrate the general differences between the trawl deployed by sailing vessels and the modern variant. In place of the single beam used by sailing trawlers, modern beamers often deploy one beam either side of the vessel (fig. 19). Beams up to 12m in length may be used but in the English Channel beam lengths of 4-8m are common.[10] Experimental work has demonstrated the potential severity of damage inflicted on obstructions, notably concrete covered oil pipes, by beam gear.[11] This suggests that upstanding wooden structure would also suffer significant trauma on impact.

Obstructions may also be pushed ahead of the beam and trawl heads. In sailing trawlers the wooden beam was generally held 1-1.5m off the seabed (March 1970, 85). Modern gear is constructed with less clearance; largely because catching effort is directed towards flatfish which stay close to the seabed when disturbed. Video clip 1 (see video tape) shows modern beam gear in action. The accompanying commentary (appendix 2 section 1) expands on points made above and is not repeated here.

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[10] The typical dry weight of a 4m beam with heavy ground gear is 3, 500kg while a large Dutch beamer's gear may weigh 6000kg (Fowler 1989, 3).

[11] Gjorsvisk & Kjeldsen (1975); Kjeldsen & Traetteberg (1976).

### 3.1.3 Otter Trawl Boards

Trawl boards have the potential to cause considerable physical damage to upstanding structure and artefactual material. Variations in angle and point of strike and board design will influence the results of an impact and the subsequent behaviour of the board (Main & Sangster 1979, 14; table III,11). Traditional flat boards (see fig. 30) tend to strike obstacles, rise quickly and land 'toe first'. Two damaging contacts on a structure or deposit would result (fig. 31). Other designs, such as the Vee boards, can pass over obstructions relatively easily (fig. 32). The wire rope which connects the boards to the net may also cause severe damage to upstanding structure both by cutting into it and by imposing severe pulling strain.

During videos trials, boards have been seen to push rocks ahead of themselves (Main & Sangster 1981). Vortices created by the passage of some trawl designs are also powerful enough to pick up and move small stones and objects. Density is likely to be more relevant than size in determining what will or will not be displaced in this manner.

### 3.1.4 Ground-gear

As figures 19, 20 and 21 show both the beam and otter trawl employ various types of ground-gear, to disturb fish from the sea bed so encouraging them to swim up and into the oncoming net, and to raise the net over obstructions. Early sailing trawlers mounted one or two tickler chains for the former purpose as do many inshore trawlers today. However, some inshore trawlermen in the Thames Estuary find that they cannot use chains due to the amount of debris uprooted and passed into the net.[12] Modern beamers may deploy 15 chains totalling 2000kg in weight (de Groot & Appelton 1971, 1). These can cause scraping and penetration damage but can also push objects ahead of

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[12] FN, 15 Mar 1974, 9.

themselves (Margetts & Bridger 1971, 5) Some variants of ground gear, such as the chain mats, used by beam trawlers for fishing very rough ground (see fig. 19), will act to prevent larger objects being displaced through entering the net. However, anecdotal evidence indicates that chain mats can be responsible for displacing irregularly shaped, larger objects which become entangled.

A diver's report on the track of such an array of chains revealed many dislodged or overturned stones (Bridger 1970, 7). However some relatively fragile organisms appear to survive such contact with little or no visible damage (de Groot 1984, 184). The result of the passage of such chains on material lying flush or nearly flush with the sediment surface may be determined by a complex relationship between morphology and density of object, degree of burial and nature of substrate (which may determine the depth of penetration of the chains). In comparative trials (Houghton *et al.*, 1971; Burd & Vince 1979, 5) beam gear caught more of the targeted flatfish than otter trawls but also recovered more debris. This effect is thought to be linked to the use of heavier arrays of tickler chains by the former (de Groot & Apelton 1971, 1).

Ground lines and bobbins are designed to guide the bottom of the net over obstructions and have been observed pushing material ahead of themselves (Main & Sangster 1979, 12). Recent innovations in the design of bobbin trawls (fig. 33) have allowed ever rougher areas of seabed to be fished (FN, 4 Nov 1983, 5). Rock hopper ground gear is a simple but effective variant which involves setting large rubber discs (as much as 40cm diameter) on the groundrope and wiring them so that they do not rotate (fig. 34). Yet, as video clip 2 shows (see video tape), such equipment does not preclude the possibility of displacement of obstructions (appendix 2 section 2). In addition, after several years of attention from heavy bobbin trawls, very rough grounds north of Arbroath are now flat enough for ordinary non-bobbin trawls to be deployed.[13]

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[13] Lyndsey, pers.comm.

### 3.1.5 Nets

The trawl net has great potential for snagging and imposing considerable pulling strains on obstructions - a fact long recognised by fishermen (ISC 1908, q.1625, 57). The net also presses on the seabed. Aflalo (1904, 38) notes that '...the belly of the trawl bears the worst, and, although it is strengthened by pieces of old net known as 'rubbing pieces', it has to be renewed 3 or 4 times during an average years fishing."

Material passing into the net is likely to be displaced for a certain distance; modern trawlers may travel several miles before hauling. Material may be raised to the surface when the net is hauled or may fall out before that point. Once raised to the surface it may be discarded immediately, it may be discarded after a period or it may be taken ashore. Thus the distance over which material may be transported will vary greatly. Object size and morphology in relation to the mesh are likely to be significant in determining the outcome of contact with the net. However, it is important to note that different methods of deploying the same net may result in alterations to the effective mesh size - for example certain technical regulations concerning minimum mesh size can be circumvented by rigging the net so that the mesh size is artificially reduced.[14] Thus, the notional mesh size of a net cannot be regarded as an indication of the actual size of the aperture through which material might pass during a trawl.

The nature of the seabed in which the material is imbedded when contacted may also be significant. Evidence recorded in the minutes of the *Trawling Commission* of 1885 (RTC 1885) suggests that nets clogged by sediment will pick up smaller objects than otherwise possible due to effective reduction in mesh size. One fisherman stated that, in areas of soft seabed "... you would take up a man's ring in (the net) as the meshes fill up with mud. That is a fact" (RTC 1885 q.333, 9). Due to adhering sediment a small

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[14] Main, pers.comm.

object may be retained until the surrounding mud is removed; some vessels deliberately stream nets in mid-water to loosen mud after towing on a soft seabed. Similarly, a group of small objects may be bound together by sediment and thus transported when they would ordinarily pass quickly through the mesh. A sandy seabed will not adhere to objects in the same manner. Thus transport of objects may vary on the basis of the relationship between object size, shape, density , mesh size and character of the local sediment.

### 3.1.6 Anchor Seining

Figure 35 shows the basic principles of anchor seining. It can be regarded as a form of trawling although its potential to transport archaeological material might seem to be limited compared to otter or beam trawls.[15] Damage caused by this method is generally related to scraping and pulling strain (Davis 1958, 72) but may also derive from deployment of an anchor. Other forms of seining involve deployment of nets from the shore.

Thomson (1969, 79) makes it clear that snags occur regularly with this form of gear. If a snag cannot be cleared by simple hauling at the warp then a 'creeper', a spiked steel bar 1.5-2m long, may be used to snag the net and bring it to the surface. This process may cause further disturbance to a deposit.

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[15] Davis (1958, 64-76) and Strange (1981, 12-17) provide accounts of this method of fishing in both off-shore and estuarine variants. Noall (1977) describes the former seine net fishery based around the Cornish coast. Thomson (1969; 1981) covers the development of seining and its modern practice.

## 3.1.7 Shellfish Dredging

The basic principle behind dredging for surface or near-surface dwelling shellfish has changed little over the years. A bladed or toothed bar is dragged across the seabed by wind, hand or engine with the catch entering a bag. The gear is periodically raised to the surface for emptying.[16] Figure 36 shows a basic hand hauled dredge, figure 37 illustrates one mode of deployment.

Some form of dredging for shellfish is likely to have pre-dated trawling. The Rochester Fishery's Act of 1729, for example, notes that for "...time out of mind there hath been an oyster fishery in the river Medway in the county of Kent, and in the many creeks and branches thereof..."(Coombe 1979, 33). However, the precise origins of the method are not known. It was noted that early trawling activity was confined to relatively discrete areas of suitable seabed. This appears to have been equally true of some shellfish fisheries (Benham 1948, 93). Furthermore, whereas trawlers simply took from the sea, the shellfish fishermen sometimes cultivated areas of seabed. Collard states (1902, 56) that the 19th century oyster beds at Whitstable were as carefully prepared and maintained as if they were flower beds on shore (see fig. 38). However, the quantity of Roman pottery recovered from the seabed in dredges around Pan Sand and Pudding Pan Rock testifies to more speculative mode of activity outside of such areas (see section 4.2.2, 93-4).

Davies (1989, 135-60) describes the small size of areas dredged by sail and the level of skill required for such patterns of exploitation. Much physical labour was involved - not for nothing was hand hauling dredges known as 'drudging'. Motorisation and powered winches provided some remedy without altering the basic design of dredges employed in some southern oyster

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[16] Modern dredging for shellfish is described by Chapman (1977) and Strange (1981, 24-26). The transitional stages between hand and powered dredging are covered by Davis (1958, 79-84 ). The practice of hand dredging is described by, among others, Collard (1902); Coombe (1979, 33-48); Benham (1948, 73-95) and Davies (1989, 149-165).

fisheries. Latterly, it has facilitated the deployment of new, very robust, gear types, such as those used in the scallop fisheries of Scotland (see fig. 39).[17]

The past 15 years have seen a considerable increase in similar activity off England and Wales (Fowler 1989, 8; see fig. 40). A review of the scallop fishery in the southwest of England reveals a highly opportunistic method of operation. When exploitable stocks are discovered through speculative dredging, a period of intensive fishing often follows, until catches fall to an unprofitable level. The fleet then moves elsewhere to search for new stocks (FN, 11 Jan 1974, 9).

Figures 41-2 show the number of hours of fishing undertaken with scallop dredges in Scottish waters in recent years. The intensity of effort expended in some of the grid squares is noteworthy, especially when it is appreciated that activity would not be distributed evenly within the square. A map of the Eddystone grounds reveals that, even within a productive area, intensively exploited patches can be very discrete (FN, 12 Oct 1990, 8).

### 3.1.8 The Influence of Dredges

A bladed oyster dredge may uproot and displace material both by pushing it in front of itself and through the material entering the bag along with the intended catch. Collard (1902, 84) describes the range of material disturbed by hand dredges:

> "A basket dredged up in the north sea coated with spat: various jars, stag horns, flint pistols covered with marine growth, a battle axe , an ox head, various red amphorae, long tusks, and a leg bone 4 feet in length."

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[17] The origins, nature and extent of the fishery are described by Mason, (1981, 3-7; 1983) Mason and & McIntyre (1969, 3-8) and Mason & Drinkwater (1973, 40-44).

Although early dredges were hauled by hand the vessel from which they were deployed was usually under easy sail with the tide (see fig. 37), therefore a snag could result in considerable weight being brought to bear on an obstruction - and accounts are available which indicate that wrecks were impacted in this way (*ibid.*, 25-6). Motorisation and powered winches increased the pulling power available. However, a significant feature of early powered dredges was their movement across the sea bed. Rather than exhibiting a smooth pull they tended to, "...dig into the sea bottom and cause...the towing warp to tighten and jerk the dredge off the bottom...The dredge thus proceeds in a series of shallow leaps between short spells of effective fishing." (Mason & McIntyre 1969, 5). The potential for this form of gear to push material ahead of it for long distances may therefore be relatively limited. The force applied would be neither smooth nor consistent.

Modern oyster fishermen questioned about the likelihood of material being pushed ahead of dredges seemed to believe that such phenomena would be rare. They pointed out that the bladed dredges are usually on the seabed for a very short time, often no more than a minute. This is largely to reduce the amount of non-target material that enters the bag which can chip and damage the catch. Short tows also keep the dredges and bags relatively free of mud. The catch is sorted as soon as the dredge is brought aboard. In the Solent area, for example, two dredges are worked so that shooting and retrieval is a constant process. Non-target species and rubbish are usually jettisoned straight away. Thus transport will occur as material is raised and thrown back some distance away from its original position. An estimate of the average distance travelled by a boat between the dredge hitting the bottom and the material being returned to the water is 150m but this will vary with tide and other conditions.[18]

The potential for damage to, and uprooting of, material is clear but even a modern bladed oyster dredge may be significantly less

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[18] White, pers.comm.

destructive than a scallop dredge. Fished in multiple arrays, recent designs have included spring-loaded teeth (as in fig. 39) to reduce damage to the gear when deployed on rough ground. Current designs are successful in disturbing 84% or more of available shellfish (Chapman & Kinnear 1977, 8).

Video clip 3 demonstrates the power and destructive potential of this gear. The manner in which smaller obstructions are transported for considerable distances within the dredge structure itself is worthy of particular note (appendix 2 section 3). Observation (*ibid.*, 7-8) indicates that a non-spring loaded dredge tends to push a wave of debris in front of itself. This significantly reduces the fishing efficiency of the gear but may increase the displacement of material. Nature conservation interests regard the scallop dredge as highly undesirable and relatively inefficient (Fowler 1989, 8-9). Fishermen believe it offers a high return for effort expended and it is likely to maintain its popularity as long as stocks hold. Management policies are hampered by a fundamental lack of knowledge relating to critical stages in the scallops life-cycle such as spawning and hatching.[19]

## 3.1.9 'Prop-wash' and Suction Fisheries

Some post-motorisation shellfish gathering techniques defy convenient categorisation. These include the process of using prop-wash to excavate for shell fish in estuaries. The technique involves the deployment of a very heavy anchor and chain from the stern of a sturdy vessel. The wash from the propeller is then used to disturb the seabed and cockles within it. The vessel is moved round and the chain shortened progressively so that a mound of sediment and shellfish is pushed into one central heap. When the tide has fallen sufficiently, the boat dries out and the

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[19] Scallop fisheries in Britain are currently managed nationally by a minimum landing size policy (MLS) (10cm shell length in channel fisheries, 11cm elsewhere in the UK and France). A closed season has been in force in the whole of the Irish Sea during June - October since 1986. Large scallopers (18m+) are not allowed to fish closer than three miles from the shore on south coast grounds (Main & Tarvit, pers.comm.).

pile is raked over by hand to retrieve the catch (FN, 30 Aug 1974, 4; 8).

Inter-tidal zones such as the Wash in Norfolk have seen increased effort directed towards suction or hydraulic dredging. The essentials of this technique are described by Siddle (1988) and Johnson (1988).[20] Figure 43 illustrates the gear employed; a suction head leading to a form of riddle or sieve on the surface where the catch is sorted and unwanted material returned to the water. Such equipment is now regularly used in the Wash cockle fishery, to the distress of the prop-wash fishermen[21] and nature conservation interests.[22]

Cockles live near to the sediment surface and so relatively shallow digging is required for their collection. Suction dredging may increase the area of seabed disturbed compared to the prop-wash method. However, it is not necessarily true that the sediment is disturbed to a greater, or even the same, depth. The prop-wash method is less controlled in terms of depth of disturbance and would appear to penetrate more deeply than the hydraulic dredge which can be adjusted relatively accurately.

Recent proposals to start a razorclam fishery employing hydraulic equipment might cause concern. Figure 44 shows the level of recent suction dredging activity in Scottish waters. Video clip 5 shows hydraulic dredging for razor clams (appendix 2 section 5). The clams are found up to 40cm below the sediment surface and a razor clam fishery would involve extensive deployment of such gear in the sub-littoral zone.[23]

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[20] The equipment has been available in various forms since the mid 1960's (Kerr 1968).

[21] *The Guardian*, 18 Nov 1988, 3.

[22] Reports have shown that salt marshes on the fringes of areas exploited in this way are choked by sediment. (Perkins 1988, 4). This can lead to widespread erosion as the vegetation binding the sediment is depleted. Clare, pers.comm.

[23] Main, pers.comm.

Damage inflicted by hydraulic gear may result from penetration and physical abrasion - the sled is of robust construction and may damage any structure it contacts. Towing speeds reach 2-3 knots (Johnson 1988, 11). Material may also be displaced and abraded through being raised to the surface and discarded.

### 3.1.10 Man-powered gear.

A wide variety of pushed gear has been deployed over the years and is still utilised in some areas, necessarily in shallow inter-tidal and estuarine environments (Davis 1958, 145-153). The fact that the gear has to be man-handled limits its weight and design and helps to determine its influence on material on the seabed.

Two fishermen involved in push netting on Hastings beach around the wreck of the East Indiaman *Amsterdam* (Gawronski 1990) were interviewed in 1990. Figure 45 shows the general nature of the gear employed. Their comments suggest that archaeological material can be disturbed and displaced through the scraping action of man-powered gear. It is also likely that this gear will tend to have a greater effect on smaller and lighter objects. The impact to archaeological deposits resulting from the use of such gear is likely to fall into the categories of transport and alteration. In both cases the impacts will be restricted in scale. Removal may result from archaeological material entering the net.[24]

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[24] Methods which are not strictly man-powered, such as horse drawn trawls have also been used in inter-tidal and estuarine zones (RTC 1885, q.11,609, 311, q.11,796, 325).

### 3.1.11 Penetration into the Seabed

A general review of evidence relating to the penetration of fishing gear, including heavy offshore variants, suggests that disturbance is generally limited to the top 30cm of the seabed (Lous 1977, 5; ICES 1973, 3; ICES 1988, 21). Guidelines covering the burial requirements of pipelines in the North Sea formulated by the Dutch Department of Public Works consider fishing gear to be responsible for penetrations of 10-30cm. The 2m burial depth requirement for oil and gas pipeline in the shallow North Sea is based on the need to protect installations against the dragging anchors of very large vessels rather than fishing activity.[25]

Experiments have suggested that depth of disturbance to the seabed caused by fishing gear may have been overestimated in the past (West 1987, 631; Kenchington 1991, 13). Penetration of heavy tickler chains is rarely deeper than 5cm even on soft ground (ICES 1988, 20-21; Bridger 1972, table 1). Trawl nets are generally thought to cause disturbance to the surface layer of sediment only (ICES 1988, 20). The International Council for the Exploration of the Seas committee on gear behaviour concluded that trawl doors, however, will scrape an oblique furrow of 0-5cm depth on hard ground and 8-15 cm on soft ground (ICES 1988, 17 & 20).[26] When boards which have fallen onto their backs are dragged along the seabed as the tow restarts, deeper (50cm+) and protracted penetration can result.[27] Video clip 1 demonstrates the relatively light track left by the heads of a beam trawl in normal operation. However, penetrations of over 40cm have resulted from gear tipping forward due to contacting an obstruction or through being poor deployment.

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[25] Main, pers.comm.

[26] Trawl doors can be deliberately rigged to increase or decrease their 'grip' on the ground.

[27] Main, pers.comm.

Toothed dredges tend not to penetrate beyond 10cm and such disturbance is more usually confined to 5-6cm from the surface.[28] Hydraulic (suction) dredges cause deeper disturbance than other gears and trenches of an average depth of 20-30cm are common (ICES 1973, 3; Medcof & Caddy 1971, 2). The dredge shown in video clip 5 is designed for the razor clam fishery and will penetrate to over 1m below the surface. However the variant used in estuarine fisheries in the UK tend to be set to penetrate less than 5cm (Siddle 1988, 14).

In describing the spatial extent of the impact of fishing gear in coastal areas it is probably true to say that the surface and top 5-10cm of the seabed are most heavily impacted on a regular basis.

### 3.1.12 Changes Resulting from the Use of Mobile Gear

While there is clearly a need to be aware of the mechanical properties of specific gear types, some common elements can be detected in the nature of changes to a deposit resulting directly from the influence of mobile fishing gear. Alteration and transport may occur with removal a possibility when material enters a net. However it is also evident that many variables will influence the magnitude, precise nature and extent of these changes. The factors influencing transport and removal of material are likely to be particularly complex.

Damage caused to up-standing structure may be particularly severe, but certain types of mobile gear may cause relatively little damage if the obstruction contacted is appropriately shaped. In video clip 2 the trawl is seen passing over large, smooth obstacles but a smaller, angular object is uprooted and pushed ahead of the ground gear (appendix 2, section 2, lines 101-8). Morphology and density may be more significant than size.

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[28] Main, pers.comm.

Changes to deposits resulting indirectly from the influence of mobile gear may also include alteration, transport and removal. Abrasion and reduction in cohesion may result in accelerated degradation of material by other agencies. This may also result from the uprooting of previously buried material. Reduction in the size of individual elements of a deposit may increase the likelihood of transport by natural processes. The potential for heavy arrays of tickler chains and certain dredge designs to destabilise the surface of the seabed and thus induce local erosion must also be considered. Such erosion may expose previously protected material. Similarly, damage to organisms which tend to bind the surface of the seabed may also result in erosive action.

## 3.2 Static Gear

The considerable antiquity of set nets and baited traps (including hooks) has been established by reference to iconography and archaeological finds. The use of such gear appears to substantially pre-date mobile gears although a form of beach seining is described in a number of ancient sources.[29] The range of gear falling into this category is too great to allow a concise summary of developments. Suffice to say, the deployment of such gear can often be characterised by the exploitation of niches (such as beaches, rocky outcrops, wrecks). This does not necessarily imply small scale effort - major fisheries have been sustained by static gears.

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[29] Radcliffe (1921) reviews classical and ancient texts containing references to various forms of fishing. Archaeological material and iconographic evidence is also presented. Bass & Van Doorninck (1982, 306-10) provide a brief discussion of classical sources. Archaeological evidence for fishing technology in European prehistory is highlighted by Coles & Lawson (1987) and Coles (1984). The 1988 volume edited by Aston, *Medieval Fish, Fisheries and Fishponds in England*, includes a review of archaeological evidence of fishing equipment (*ibid.*, 137-186) and a concise, if highly selective, bibliography of source material on early sea fisheries.

### 3.2.1 Lobster Potting

The practice of lobster potting (fig. 46) is described in some detail by Stewart (1971) and is summarised by Strange (1981, 23-24). A commonly used technique is to set pots across, or even within, a wreck as such sites provide abundant habitats for lobsters.[30] Pots frequently become stuck on hauling and, if the structure is wooden, substantial damage may result.[31] A fishing boat under 10m long can be equipped with a winch capable of lifting 2-3 tons dead-weight.[32] Such damage has been noted and indeed observed occurring on a historic wreck site.[33] Mr. Froome, a Guernsey lobster potter, stated that fishermen are often unaware of the nature of the wreck they are setting on and that any object dragged across a wreck is likely to cause damage. He suggested that anchors pose more of a threat to wrecks than lobster pots.

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[31] A Dover lobster fisherman's description of this technique was accompanied by a request for the author to dive on a wreck to release his pots which he could not haul.

[32] Froome, pers.comm.

[33] Skanes, pers.comm.

### 3.2.2 Wreck Netting

Fleets of 3 to 5 nets are deliberately set across wrecks.[34] Weighted on the foot rope and buoyed on the head rope they form a curtain falling to the seabed. Strong polypropylene nets are favoured which can be pulled away from the frequent snags which characterise this method:

"During hauling it invariably happens that the centre net comes fast on the wreck. This can normally be freed by inching the vessel alternately ahead and astern, while at the same time pulling the headline over the block" (FN, 7 Aug 1975, 8; 9).

Fishing effort employing this technique is largely directed at substantial steel wrecks but any seabed obstruction can be targeted. Upstanding structures will suffer heavily from pulling strains.[35]

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[34] A general account is offered by O'Driscoll (FN, 8 Aug 1975, 8-9). See also Strange (1981, 30-31) and Davis (1958, 48-53) for descriptions of related gear.

[35] The gill nets of wreck fishers out of Peterhead last for no more than 3 or 4 trips, often less (Tarvit, pers.comm.).

### 3.2.3 Longlining

Longlining involves the setting of static lines equipped with large numbers of baited hooks (fig. 47).[36] Small lines (sma'lins) are used closer to shore and target smaller fish (such as haddock and flounder) as opposed to the larger cod, ling and halibut which are caught on lines set in deeper water. Archaeological material has been recovered on hooked lines (Brodie 1989, 34-37) but episodes of disturbance are likely to be relatively minor;

"When the men are setting lines for halibut, hooks occasionally get caught in the wreck of the ship, and small pieces of wood, sometimes with treenails in them are brought to the surface." (*Book of Whalsay*, 2-3. Museum of Shetland)

In normal use however, this gear is likely to have limited potential for influencing cultural material. Anchors used to hold the lines in position have the potential to cause damage as does the method employed for recovery of lost gear; a spiked bar known as a 'grade' or 'murderer' is dragged to snag the line.[37] Maintaining a slight tension on the line during hauling can help to reduce the chance of snags. Some fishermen prefer to haul a very slack line however, as they believe this reduces the chance of fish being forced off the hook (FN, 26 Apr 1991, 6).

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[36] See Davis (1958, 140-144) and March (1970, 16-17; 21-26). Benham (1979) describes the history and technical development of longlining in deeper waters off Iceland and the Dogger Bank. The latter volume includes a review of primary and secondary sources relating both to longlining and other gear types.

[37] Prescott, pers.comm.

### 3.2.4 Changes Resulting from the Use of Static Gear

Alteration and transport may occur but, with the possible exception of wreck netting, the magnitude of changes is likely to be very much less than those derived from the influence of mobile gear. Removal can occur under exceptional circumstances.

## 3.3 The Effect of Fishing Activity

The forgoing discussion indicates that various types of fishing gear and practice can cause a reduction in the range, quality and cohesion of material within archaeological deposits. The effect of fishing gear related impact is therefore negative - in some cases to an extreme degree. Strategies for mitigation of such impact should be developed. This will be discussed further in chapter 5. However, other, potentially more positive aspects of fishing activity must also be acknowledged.

Charts of snags (where nets have encountered obstructions) on fishing grounds have been used as the basis for archaeological survey projects (Redknap & Fleming 1985, 315; fig. 48). Indeed, a number of wrecks currently designated under the Protection of Wrecks Act 1973[38] were discovered through investigation of reported snags (see, Lavery 1988, vii). In addition, Westerdhal (1980, 312) demonstrates the value of recording and researching the significance of place-names used by the fishing community, such as Brick Reef and Coin Shoal.

Previously unknown material can be recovered for display and study through being raised in fishing nets, but such material is material separated from its archaeological context. Similarly, the discovery of a new site by this mechanism must be weighed against the potential damage done to that site; not only by the impact of fishing gear but also by the activities of the divers the fisherman may choose to inform or ask to retrieve his equipment. Despite this, it is important to maintain a balanced perspective. Three things are evident; it is not in the fisherman's interest to contact an obstruction on the seabed; it is, however, in his interest to fish as close to it as possible; and accidental contacts have occurred sufficiently frequently for the deployment of fishing gear to have been modified to limit the damage caused to the gear and boat by such snags.

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[38] See appendix 3, lines 1-76.

A sudden abundance of unmarked wrecks after the two World Wars wreaked havoc with the fishing industry (ROSF 1921-23, 135-6). Benham (1948, 82) relates, "...the Blackwater's broad bosom is (so cluttered with) victims of torpedo, bomb or mine...that the fishermen will not risk their nets and only one smack works." It is also known, however, that fish tend to congregate around wrecks and other obstructions on the seabed (ROSF 1919-1923, vii). Thus, although fishermen risk expensive damage, they will fish as close as possible to areas where fish congregate. Mr. Sheader, top trawler man in Hartlepool in 1969, claimed his success was due to the meticulous charting of wreck locations some of which, "...have been passed down to me by old fishermen, some have been located on the echo sounder and the remainder I have found myself through bitter experience and lost gear." (FN, 19 Sep 1969, 9). Some skippers risk deliberately trawling over a wreck when their echo-sounder indicates that sediment has built up around it.[39]

The risk attending a snag is reflected in the manner in which towed gear is deployed. Figure 49 illustrates a typical towing arrangement for a late 19th century beam trawl. The trawl warp is lead forward via a weaker piece of rope known as a 'stopper'. In the event of a snag this weaker rope would part allowing the vessel to swing round putting her bow into the weather thus avoiding being pooped by a following sea. Early ground-gear was also modified so that it would part readily (March 1970, 86). Dredges were deployed so that they could be jettisoned easily in the event of a snag (Benham 1948, 91). The advent of steam power did little to remove the necessity for such arrangements (RTC 1884-5 Appendix A.I, 354). Despite these precautions, loss of life did occur (March 1970, 172). Even modern beam trawlers can suffer severe stability problems due to a snag (de Boer 1975, 4). Quick release mechanisms on trawl warps have been introduced to alleviate the problem (FN, 29 Nov 1991, 3).

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[39] Durbridge, pers.comm.

Modern position fixing equipment allows fishermen to trawl ever closer to known obstructions. It is not unknown for fishermen utilising modern sonar gear to trawl with one otterboard either side of an oil pipeline.[40] Yet human error, faults in even the best equipment and unknown obstructions, perhaps exposed by sediment movement, mean that accidental contacts still occur. It should not be doubted that fishermen will "..do everything they possibly can to prevent accidents that will lose them time and money."(ISC 1908, q.771, 28).[41] Yet, during investigations related to the safety of submarine cables, a trawler owner was quizzed on how snags were resolved "...in what way - by simple brute force I should think." (ISC 1908, q.172, 8); a remark which offered little comfort to the telegraph companies faced with the bill for cable repair. Other remedies were available but not always utilised, as Graham (1943, 62-4) reveals:

> " The trawl had caught on something down on the bottom of the sea, perhaps a wreck. A patient skipper might have hove with the winch just enough to harness the ship's buoyancy, thus tugging at the fastened trawl as the ship lifted with each wave. The third hand had seen that done often, and once after they had waited 8 hours...there was no damage to the trawl...But Dick wasn't the patient sort of skipper...so when the trawl came fast he went full astern, and when that did no good he jumped down to the winch throttle himself...He hove up until she bowed to it, lifting with each wave but always finishing a little lower; there was a squeaking and a creaking from the joints in the ship's woodwork...Then suddenly the ship leapt as the trawl broke away from the obstruction...That was a good one they said."

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[40] Cartwright, pers.comm.

[41] At the Great Fisheries Exhibition of 1883-4, one expert opined that to "...insure fishing gear fully, or indeed to insure it at all under every circumstance, is a utopian dream." (de Caux 1884, 136).

The last word, however, goes to Mr. Price, a trawlerman:

"Putting down a lead will not tell you what obstructions there are in a given 5 or 10 miles, but trawl there with a trawl and you will jolly soon find out." (ISC 1908, q.1028, 38)

# 4 Fishing Activity as a Formation Process

The last decade has seen considerable attention focused on the influence of agricultural ploughing on archaeological material. Broad similarities appear to exist between this process and the influence of some forms of mobile fishing gear (*c.f.*, McNamara 1991, 14). Both involve a mechanical impact with potential for modification of surface distributions; in both cases the usefulness of the material within such a zone for inference and therefore the necessity to afford it any protection from further disturbance might appear limited (*c.f.*, Dunnell 1990, 592). Both processes operate in conjunction with other environmental and cultural processes; both processes may disturb deposits but can also lead to the discovery of new sites.

The comparison should not be over-stressed. Ploughing generally creates regular furrows (Nicholson 1980, 2-4) and often occurs in a pattern dictated by field boundaries. While some fishing activity is similarly bi-directional and closely confined (Thomson 1969, 83), other patterns of activity can be opportunistic. However, an examination of the broad issues addressed in plough-zone archaeology and consideration of the techniques employed might point to productive avenues of inquiry.

Boismier (1991, 17) drawing on the work of Lewarch and O'Brien (1981) highlights 5 factors which must be considered in analysis of archaeological material from the plough-zone; vertical displacement; horizontal displacement; changes in class frequencies after ploughing; changes in the condition and preservation of artefact assemblages; destruction or alteration of features. With regards to vertical displacement, research has centred on determining what proportion of artefacts within the ploughzone are visible on the surface at any one time and therefore available for collection or study.[1] While some fishing gear has the ability to uproot material on or near the surface, this problem domain seems less immediately relevant than others which can be seen to be of considerable shared interest. The scale of plough-related attrition has been demonstrated (Drewett 1980, 73; Yorston *et al.*, 1990, 67). Flowing from this is a recognition that the process cannot be regarded as an entirely contemporary phenomenon. Parallel developments in terms of deployment of heavier, mechanised gear in both fishing and agriculture lends a wider than intended relevance to Bonney's comment (1980, 41) that '...what we are witnessing today is a stage, perhaps the worst so far, in a very lengthy destructive process."

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[1] Objects larger than 4cm tend to appear on the surface with greater frequency than those smaller, this has been termed the 'size effect'. Experiments indicate that less than 10% of the ploughsoil assemblage is visible on the surface at any time and that due to the above noted effect smaller artefacts are underrepresented (Baker 1978).

# 4.1 Ecofacts, Sediments and Intrusive Material

In section 2.4.2 the characteristics of deposits which might allow the influence of specific formation processes to be identified were discussed. These included the presence of intrusive material. Net weights have been found on submerged sites. A linear distribution of net weights across a site might be suggestive of gear lost in use. A more discrete pattern might indicate a net in storage that was lost with the vessel (Bass & Van Doorninck 1982, 93-4; 300-1; 306-310). Laures (1985, 82) and Ruegg (1986) describe direct artefactual evidence of snagged gear - line or net recovery rings. These were passed down a line or net to exert a downward pressure on the snagged gear and so release it. The presence of modern netting on structure, however, must be used with caution to infer specific formation processes as considerable quantities of discarded net are to be found drifting in the sea. The presence of heavier elements of gear (trawl boards or beams) may be more reliable as indicators of recent or past impact.

Evidence of prehistoric and medieval ploughing has survived etched into chalk (Bowen 1980, 7, plate 4) and as extant ridge and furrow systems (Pryor & French 1985, 53). Are similar diagnostic features imposed on the seabed by fishing activity and, if so, how long will they last? Distinctive marks left by tickler chains have been described (Margetts & Bridgewater 1971, 3; Bridger 1970, fig. 4, 10) and trawl marks in close proximity to wrecks have been recorded by side scan sonar (see fig. 50 and section 4.4, 132). The longevity of tracks made by hydraulic dredges may occasionally be measured in months (Medcof & Caddy 1971, 6). In soft sediments trawl marks have persisted sufficiently to allow differentiation between recent and eroded tracks (Industry Services and Native Fisheries 1993, 2-3). However, experiments have demonstrated that such marks may not survive beyond 5 hours in environments with even moderate tidal energy (de Groot 1972, 3; ICES 1973, 2).

Physical marks left on the seabed may be short-lived phenomena. However, certain types of intensive exploitation might be inferred successfully using biological and physical indicators. Coombe (1979, 43) and Benham (1948, 88) state that once regular dredging stops, oyster grounds rapidly become silted over with mud. This suggests both that the process of dredging may keep specific areas atypically free of sediment and that the natural regime reasserts itself quickly. There is growing awareness, however, that intensive fishing with heavy gear, such as scallop dredges, can create a distinctive, possibly non-transient sea bed type - namely a flat, relatively featureless topography.[2] Consensus is also developing concerning long terms changes in the benthic community caused by heavy fishing pressure. Fast-growing species dominate and general diversity is reduced (ICES 1988, 16). There is less agreement about the length of time required for the seabed to recover or whether recovery is in fact possible.[3] The highly opportunistic nature of some scallop fisheries has been discussed. The consequences of even a small number of hauls with such gear through an archaeological site are likely to be significant. However, the duration of effort may be insufficient to create the diagnostic topographies and biological communities described - the passage of the gear may not be detectable even a relatively short time after the event. This suggests that such indicators are more useful in the context of contemporary management initiatives rather than attempts to describe the history of a deposit.

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[2] Main, per.comm.

[3] A species by species breakdown of benthic organisms known to be affected by trawled gear is presented by de Groot (1984, 180-4). While conceding that negative affects can be detected he argues that the fishing industry's role as a major supplier of protein and the fact that such effects are, in theory at least, reversible, make them acceptable. He generally appears rather more sanguine about the affects of intensive trawling than others who have reviewed the situation (*e.g.* Fowler 1989).

## 4.2 Simple Properties of Artefacts

Workers concerned with post depositional processes have undertaken studies related to the isolation of diagnostic physical marks on artefacts (that is, marks utilised to infer processes rather than systemic function or behaviour).[4] Mallouf (1982, 87-94) examines a cache of chert blades and flakes disturbed by ploughing. By distinguishing between fortuitous and intentional retouching Mallouf demonstrates how inference can be refined; in this case assignment of functional attributes to lithic material from cultivated land. Research has also focused on the mechanical properties of ceramics when subjected to physical force.[5]

Relatively little work has been conducted in relation to material in submerged environments. Relevant data has become available through accidental impacts between dredgers and wooden ship structure (McCarthy 1979, 145; Redknap 1984, 21, figs. 10 & 12). In addition, experimental work has produced information concerning the effect of fishing gear on concrete covered oil pipe lines (de Groot 1977). This might be used to predict the nature of physical features mapped onto other materials. However, while it may be possible, in theory, to build up an index of the damage patterns inflicted on specific materials by specific gear types in a variety of impact situations, the number of potential variables involved is immense. Therefore, for the purposes of this study, attention will be focused on the features mapped onto ceramics by the action of a bladed oyster dredge. The bladed oyster dredge was selected for study because, compared to other gear types, it is relatively simple with fewer component parts and therefore fewer variables to consider. In addition, assemblages of ceramic

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[4] For example, Roper (1976); Brain (1981). Wildesen (1982, 55) provides a brief bibliography of such work, see also Schiffer (1987, 263-302).

[5] The impact strength of ceramics has been investigated by Bronitsky & Hamer (1986) and Mabry (*et al*,, 1988). Schiffer & Skibo (1989) offer a preliminary theory of ceramic abrasion which includes a review of much related research.

material known to have been in contact with such gear could be identified.

### 4.2.1 Method

This study explores the proposition that the influence of fishing activity utilising bladed oyster dredges can be detected through low-level regularities in the physical attributes imposed onto ceramic material. If such features are identified, they may be used to refine inference concerning the character of deposits underwater - particularly in areas where fishing activity is poorly documented, sporadic or suspected to have occurred in the past. However, the possibility of isolating and describing features uniquely linked to a single process is doubted. Rather, the value of such work is perceived to lie in the attempt to "...point out the more common attributes...in a form conducive to further analysis and to comparison with other assemblages" (Mallouf 1981, 97).

Examination of material during this study took the form of visual inspection followed by measurement, and, where appropriate, drawing and photography. Fracture planes were examined and fracture morphology was recorded where possible. The number of fracture planes on each sherd was counted. Erosion or staining of fractures was also recorded. Figure 51 shows the manner in which the degree of erosion was assessed for recording purposes. On occasion, erosion made it difficult to determine the exact number of fracture planes present.

Research has demonstrated the value of examining biological accretions as a guide to the history of archaeological material (Mortlock *n.d.*; MacLeod & Killingley 1982; Watson 1987, 54). Relevant details were noted along with other characteristics of the sherds examined. The results of this recording exercise are tabulated in appendix 6. Accession numbers are noted where available.

A record of the size of ceramic sherds was obtained by measuring the maximum dimensions; length (dimension A) and breadth (dimension B) to give two values per sherd (see fig. 52). These two dimensions were then plotted against each other to form a scatter diagram. Dimension A (always the greater value) was assigned to the X axis. The aim was to characterise the absolute dimensions of the sherd on the seabed regardless of its original orientation within a complete vessel.

Microscopic inspection techniques were not employed. Identification of macroscopic features is regarded as a necessary preliminary to justification of the increased resources required for microscopic examination. In addition, reference to the work of Skibo and Schiffer (1987) suggests that diagnostic traces may not survive at microscopic resolution on surface deposits given the abrasive character of many underwater environments.

### 4.2.2 The Material Studied

The study assemblage utilised consists of a number of distinct groups of material and is described below. The manner in which the nature of the assemblage affects the form of analysis that can be undertaken on the data collected is also discussed. The possible contribution of experimental work to the creation of assemblages in which variations in damage patterns could be ascribed more confidently to mechanical properties of the dredge rather than to variations in fabric, such as hardness or inclusions, is discussed in section 9.3.1 (284).

The purpose of this study is to consider physical, as opposed to spatial, characteristics of assemblages influenced by bladed oyster dredges. However, it is evident that much could be gained from detailed knowledge of the distribution of the material on the seabed. Unfortunately, as will be discussed in section 4.3, this form of data is generally difficult to obtain. Each assemblage is known to originate from an area influenced by oyster dredging. But the possibility remains that individual sherds derive from widely separated locations. This problem is particularly acute when attempting to account for apparently atypical sherds.

## Pudding Pan and Pan Sand Assemblage

This assemblage consists of Roman Samian ware (Johns 1971) retrieved by oyster fishermen in the area of Pan Sands and Pudding Pan Rock off the Kent coast (see fig. 38 and 53). It is currently stored at the British Museum. The assemblage has previously been studied by, among others, Watson (1987, 14-15). He notes that vessels purchased from collectors may have been attributed to the area on the basis of having been identified as Samian which exhibited marine growth. The collection has been formed over approximately 80 years but the basic design of the dredges used in local fisheries has changed little. A single company, Seasalter Shellfish Ltd. controls much of the Whitstable fishery which now mainly comprises farmed oysters.[6] The Pan Sands and Pudding Pan Rock oyster beds are free grounds, however, with access open to all. In 1993 only 4 or 5 oyster dredgers were known to be operating speculatively at these locations with most of the dredging effort occurring on the Kentish flats. The sample obtained from the British Museum can be linked directly to oyster dredging, but trawling activity in the area has increased in the past 10 years and may have influenced material remaining on the seabed.[7]

74 vessels or parts of vessels were inspected, all made of the same fine, high fired fabric. The assemblage consists almost entirely of complete or near-complete vessels. The relationship between this collection and the actual range of related material raised from the area is unknown but considerable selectivity is indicated. A number of individual fishermen have reported material over the

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[6] Collard (1902) describes the historic oyster fishery in the Whitstable area and the development of the Whitstable Oyster Fishery Company, precursor to present day commercial concerns. See also Whitstable Museum n.d. for an account of the Sesalter oyster fishery.

[7] Stroud, pers.comm.

years, including many fragments of vessels. Quantities of similar artefacts are known to rest in private hands. The collection is professionally curated but secondary damage resulting from handling may have occurred. Some vessels have been cleaned and this may have obscured features of interest.[8]

## Ryde Middle Assemblage

Ryde Middle is a relict Pleistocene gravel bank in the Solent off the Isle of Wight. Almost all of the material studied derived from a relatively small area on the eastern end of this feature (see fig. 54). The ceramic assemblage has been amassed as a result of efforts on the part of archaeologists within the Isle of Wight County Archaeological Service to obtain information from oyster fishermen on the potential location of archaeological material in the area.[9] Everything handed in to the archaeologists has been retained.

253 sherds were examined and conjoining pieces could be identified; one vessel is near-complete after restoration work. No complete vessels were examined as part of this assemblage. However, complete vessels ranging in date from early medieval to modern were viewed in fishermen's homes and on their boats during the course of this study. It is believed that such vessels are generally retained or sold rather than reported.[10] However, interviews with fishermen in the area indicate that the assemblage studied is likely to be broadly representative of material raised with the exception of this class of object. One fisherman said that he would retain Roman vessels but when questioned further was only able to identify Samian ware as specifically Roman. He stated that he would retain less complete Samian vessels as compared to vessels of other fabrics. It has

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[8] For example item no. 1908 7-27 10.

[9] Simpson, pers.comm. The material is held at the Archaeological Centre, Clatterford, Isle of wight, see section 10.1.

[10] Tomalin, pers.comm.

been suggested that most fishermen are not very interested in material raised in dredges but easily recognisable objects, such as complete vessels or distinctive faunal remains will be retained for a period at least.[11]

The material ranges from Roman to late post-medieval in date and is stored in sturdy boxes with some sherds individually packaged. Secondary damage from handling is believed to be minimal but damage to attached marine encrustations is frequent - as evidenced by many loose fragments of such material within the packaging. Material from nearby areas such as Yarmouth Roads, Bramble Bank and the Solent Seabed was also examined as a check on observations made on sherds from Ryde Middle (see fig. 54).

Oyster dredging in the Solent area, which developed as an intensive, motorised fishery during the 1950's, is regulated heavily in certain locations; for example, the rights to the Beaulieu River beds are in private hands. Activity on other beds is licensed by the Southern Sea Fisheries Committee who set dates for fishing according to the state of stocks and the market. In most areas 6 weeks take *per annum* is allowed. Much of the Solent seabed is included in these licensed areas including Ryde Middle. There are, however, public fisheries such as Langstone Harbour and Southampton Water where oyster fishing generally occurs between November and April. Fishermen can form co-operatives and seek exclusive rights to certain areas; oyster beds at Calshot and Stanswood Bay are exploited under this system and are actively maintained by the co-operatives in order to promote oyster growth.[12] There are however, many fishermen who are not licensed and areas close inshore are exploited in a deliberate attempt to avoid regulation.[13]

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[11] White, pers.comm.

[12] Whitely, pers.comm.

[13] White, pers.comm.

## Southampton Water Assemblage

In 1992, 80 sherds of pottery, collected over the previous year, were delivered to Poole Museum Services by Mr. Wright, a fisherman. The material derives from an area around the Chilling oyster fishery in Southampton Water (figs. 54 & 55). The shelf on either side of the channel is the area most frequently worked and the usual working depth is 10m. The area which yielded the bulk of the pottery studied lies on the eastern side of the channel and is marked as point A on figure 55. It was not possible to identify the individual items which derived from this area.

The pottery has been examined by Mr. Thompson and Mr. Brown of Southampton Archaeological Unit. The following is based on their comments. The assemblage is multi-period. One group dates from the 18th century while an assemblage of late Medieval material, mainly Normandy Stoneware and some Spanish tin-glazed material, can also be isolated. Mr. Thompson, who has contacts in the local fishing and boating community, considers it surprising that there is not any modern material related to the heavy ferry and yachting traffic in the area. He feels this indicates an element of selection on the part of the fisherman. However, staff at Poole Museum believe that Mr. Wright is unlikely to have disposed of any pottery.[14] The pottery was kept in storage by Mr. Wright before delivery to the museum but there is no reason to assume that particular care was taken to avoid secondary damage.

A small amount of clam fishing, utilising toothed dredges, is prosecuted in Southampton Water, but not in the area of the oyster beds. Although some illicit activity with such equipment in the area cannot be ruled out, the material under consideration is unlikely to have been influenced by this process.[15]

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[14] Williams, pers.comm.

[15] Whitely, pers.comm.

## Discussion

Due to the nature of the sample, it is the influence of the *process* of dredging, initial impact, raising to the surface, sorting *etc.*, rather than the single event of the oyster dredge's impact on a ceramic sherd, that is being studied. This is appropriate, as it is this entire process, including return of material to the seabed, that will have influenced assemblages observed in the field.

Selectivity on the part of the fishermen imposes certain limitations on the analysis of this material. The potential absence of whole or nearly complete vessels has been noted, but the possibility that very small sherds were not reported because they were not recognised as ceramic, or were believed to be of no interest, should also be considered. In addition, vessels may have been broken before they arrived on the seabed - there is no reason to assume that, in each case, the first dredge contact was with a complete vessel.[16] Therefore, comparison of sherd size between and within assemblages is restricted to visual inspection of plotted dimensions and comparison of dimension value range.[17]

Problems caused by selectivity should not be overstated. The assemblages from Ryde Middle and Southampton water are atypical in as much as they have been retained and reported by the fishermen rather than deposited back into the water. Selectivity with respect to more complete vessels would, in most cases, operate whatever the ultimate destination of the rest of the material (reported to archaeologists or dumped back into the water). Therefore the selectivity influencing the study assemblages may also be present in assemblages encountered underwater. Thus, it does not invalidate observations based on

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[16] Tomalin (1993, 96) argues that assemblages from shoals, such as the Ryde Middle Bank, will provide information concerning cargos jettisoned from craft which became grounded or were overwhelmed.

[17] Orton, pers.comm.

this material. A more pertinent consideration in this context may be whether or not certain classes of material are under represented due to not having been raised in dredges at all rather than because they were raised and retained by fishermen.

Much care is required in analysing the data presented here, not least because other agencies, such as dragging anchors, might also have contributed to any patterning or damage observed. Despite this, the assemblages utilised offer the opportunity for useful comment. Further, it is considered essential to extract as much information as possible from assemblages such as these, which can be studied economically and without further disturbance of material on the seabed, before resources are directed toward collecting similar information by other means.

## Control Assemblages

Two control assemblages were also examined. The first derives from the excavation of the *Trinidad Valencera* (Martin, 1979a) and is made up of olive jars (Martin 1979b, 279-284). The fabric is generally coarse earthenware, with numerous gritty inclusions, colours range from light terracotta to grey (*ibid.*, 281). The material was recovered systematically, minimising opportunity for major secondary damage. Minor damage may have resulted from subsequent storage and handling. The number of processes which could have contributed to the observed damage patterns is considerable but bladed oyster dredging can be excluded.

The second control assemblage, held at the Museum of Shetland, consists of 123 ceramic and glass items recovered in toothed scallop dredges in the waters around the Shetland Islands. Scalloping began on a commercial basis in the Shetland area in 1968 and powered dredges have been used in the fishery from the outset (FN, 7 Feb 1969, 1). Most of the material studied was deposited in the museum in the past 5 years.

The collection contains a high proportion of complete or nearly complete vessels. The pottery largely consists of Bellarmine jar fragments. This stoneware fabric is harder than that of the olive jars in the *Trinidad Valancera* assemblage with fewer inclusions. The museum curator believes that the assemblage contains material that fishermen thought would be of interest rather than a representative sample of objects raised. All material handed in is kept and is stored in conventional archive packaging - significantly reducing the possibility of secondary damage. This study was the first occasion on which much of the material had been handled since being accessioned.

The above material was examined primarily to determine whether breakage patterns or marks on sherds ascribed to the action of oyster dredges might also be found in assemblages influenced by other processes. Due to gross differences in environment between Southampton Water and the Solent and the locations of the control assemblages, biological accretions on the latter were not studied. Size attributes are also not tabulated for the control assemblages The high degree of selectivity within the Shetland assemblage and characteristics of the fabric of the *Trinidad Valencera* assemblage (see 4.2.7 below) significantly reduce the usefulness of such an exercise.

## 4.2.3 Observations

Observations made on the assemblages will now be discussed. Where available, accession numbers of objects will be cited.

### Pudding Pan and Pan Sands Assemblage

No common morphology of fracture could be isolated although certain vessels exhibited various striations for which no ready explanation can be found.[18] In addition, a number of vessels exhibited pitting or scarring which did not appear to conform to the morphology of features caused by salt leaching out of the fabric.[19] The high percentage of intact vessels within the assemblage indicates a significant level of selectivity and therefore no attempt was made to measure sherd size although vessel diameters were recorded.

Some regularities could be observed. Damage to footrings was frequent (figs. 56-57); *circa* 72% of vessels examined exhibited this feature. Observations made during this study are summarised in table 1 appendix 6.

### Ryde Middle Assemblage

Sherds were measured as described above and the results are presented in figure 58 and table 2 appendix 6. It is possible to discern some common elements.

The condition of the edges of sherds can be described by reference to the freshness and morphology of the fracture plane; the nature of marine growth; and combinations of the two. A number of sherds exhibited a similar morphology of fracture. This can best

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[18] For example, vessels 1920 11-23, 10; 1920 11-23, 32; 1901 1733.

[19] A number of vessels are suffering from pitting caused by salt, for example, 1920 11-23 24 and 1920 11-23 21.

be described as distinctly angular (fig. 59). A notable feature of the assemblage as a whole is that individual sherds exhibited different physical features on different edges. One edge may be characterised by a fresh clean break, another by a break which is lightly eroded and another by a break which is heavily eroded and encrusted by marine growth.

Various types of marine growth were noted. An unidentified species of *Bryozoa* (Ryland 1976) was present as was the tube building worm *Pomatoceros triqueter* (Linnaeus) (Fish & Fish 1989, 175). Three species of barnacle were also identified *Balanus crenatus* (Bruguiere) (Fish & Fish 1989, 293), *Balanus improvisus* (Darwin) (Fish & Fish 1989, 294) and *Elminius modestus* (Darwin) (Fish & Fish 1989, 292). The past location of barnacle growth was also evidenced by calcareous scars left by specimens which had completed their life-cycle and become detached. However, some had not reached their full potential size before this occurred.[20] Examination of the various surfaces, as opposed to edges, of sherds revealed examples of differentiation between specific areas in terms of marine growth.

## Southampton Water Assemblage

Sherd sizes were measured and are shown in figure 60. Table 3 appendix 6 summarises observations on the condition of the sherds. As was noted for the Solent assemblage, edges of individual sherds exhibited a variety of physical features. The angular fracture morphology noted above in the Solent assemblage was also noted on sherds from Southampton Water. The same types of marine growth as were noted for the Ryde Middle assemblage were present. As before, examination of marine growth on the surfaces of sherds revealed examples of dissimilar encrustation between surfaces.

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[20] Mortlock, pers.comm.

### 4.2.4 Size Attributes

This section considers size attributes. The nature of the study material means that, in this instance, this characteristic is addressed in the context of an assemblage potentially exposed to prolonged dredging activity as opposed to isolated or occasional episodes.

The selectivity which has influenced the availability of material for study is exemplified by the Pudding Pan assemblage which consists almost entirely of whole vessels. Some are of considerable size; one vessel was of 28.5cm diameter.[21] This indicates that contact between a bladed dredge and a ceramic vessel does not inevitably result in breakage.

The control assemblage from the Shetland Museum also exhibited a high proportion of complete and near complete vessels (see figs. 61-2). Intact glass vessels (19th-20th century and therefore relatively hard) were particularly well represented (figs. 63-4). Video clip 3 might lead one to expect dredge impact to almost invariably result in breakage. If vessels can be contacted and raised to the surface with no breakage or clear physical features having been mapped onto them, it seems possible that transport along the seabed could occur with a similar lack of visible damage. However, size characteristics of the study assemblage will be considered in light of the proposition that, overall, such contact is likely to result in breakage and that breakage through recurrent contacts will result in gradual reduction in the size of individual sherds available for study creating a homogenised size range.

Figure 58 and 60 show the plotted dimensions of sherds examined from Ryde Middle and Southampton Water respectively. Both diagrams indicate clustering of dimensions and visual comparison of the two distributions indicates some similarity in the clustering. Potential similarities in the range of values within the

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[21] Vessel BMTC Unnumbered C15.

two distributions can be explored further by consideration of figure 65b-c. The X and Y value ranges are represented by box and whisker diagrams which present median values, the inter-quartile range and maximum / minimum values adjusted to allow for outliers (Fletcher & Lock 1991, 48-49; see fig. 65a). The median and modal values with standard deviation and range for each group are shown below:

| | | Mean | Mode | Std. Deviation | Range |
|---|---|---|---|---|---|
| Rye Middle | X | 12.01 | 9.2 | 4.52 | 38.7 |
| | Y | 8.01 | 8.2 | 3.2 | 18.1 |
| Southampton Water | X | 10.1 | 7.9 | 3.1 | 14.3 |
| | Y | 6.6 | 4.7 | 2.4 | 12.2 |

As can be seen from figure 58 the high range value for the Ryde Middle X dimension is influenced by a single large sherd. Figures 65b and c and comparison of the respective standard deviations indicates that, while similarities are evident, the Ryde Middle assemblage does indeed appear to exhibit a greater overall range of values. The Ryde assemblage also appears to exhibit a greater degree of assymetry in the distribution of X values - possibly indicating a predominance of values in the lower quartiles. A similar trend is apparent but is not as marked in the Southampton Water assemblage. The coefficient of variation (standard deviation divided by mean) is also higher for both dimensions in the Ryde Middle assemblage - although for both assemblages the coefficient does not indicate a very wide spread of values:

| | | |
|---|---|---|
| Ryde Middle | X | 0.3763 |
| | Y | 0.3995 |
| Southampton Water | X | 0.3069 |
| | Y | 0.3636 |

Prediction of gradual homogenisation of size range through prolonged exposure to dredging activity is not refuted by these findings. Indeed, distributions skewed toward the lower quartiles might support such a suggestion.

The proportion of sherds within the assemblages exhibiting a fresh break is shown below:

| | |
|---|---|
| Ryde Middle | 35% |
| Bramble Bank | 17% |
| Solent | 20.5% |
| Southampton Water | 17.5% |

This feature cannot be associated unequivocally with dredge impact as opposed to secondary damage. Yet, it might be used to support the suggestion that the process of oyster dredging tends to involve breakage and thus gradual reduction in size of individual sherds.

The contention that, while exposed to this process, sherd size will reduce until a point is reached at which the sherd effectively becomes too small to be regularly broken and size therefore stabilises, can be considered by plotting the incidence of fresh breaks against size. Figure 66 presents the Ryde Middle and Southampton Water assemblages plotted in this manner. As can be seen, fresh breaks appear at both extremes of the value range although the general distribution tends away from the smallest sherds. There are, however, many factors which could contribute to determining the size of individual sherds. Figure 67 shows the plotted dimensions of sherds from Ryde Middle, and Southampton Water with the addition of material from Bramble Bank, Yarmouth Roads and the oyster beds on the Solent Seabed; general trends in distribution noted above are reflected. Figure 68 shows the dimension value range for this composite assemblage.

Figure 69 shows the assemblage with Roman material highlighted. The results do not suggest that age and sherd size are necessarily connected. That is, older sherds are not necessarily smaller. This might tend to reinforce a suggestion that it is the length of time for which a piece of ceramic has been exposed to a specific process, *i.e.* dredging, not the absolute age of the sherd itself that influences size; although absolute age may well be significant in other respects.

Several factors will influence this form of analysis. Plotting a distribution based on age relies on a date having been ascribed to a sherd. The proportion of sherds which could not be dated reliably is shown below:

| | |
|---|---|
| Ryde Middle | 13.4% |
| Southampton Water | 5% |

Smaller sherds may be the most difficult to date overall due to lack of diagnostic features. The most complete and therefore easiest to date vessels may be more frequently selected for retention by fishermen.

The potential influence of fabric and form on sherd size can also be investigated. Figures 70 and 71 show the composite assemblage described above with specific fabrics highlighted; namely amphora and tile (*tegula*). The results of this exercise tend to suggest that there may be a closer relationship between fabric / form and size than age and size For example, in figure 70 two distributions can be discerned. The lower is largely comprised of rim sherds; the upper is characterised by body sherds.

### 4.2.5 Fractures

The following section considers the proposition that the action of a bladed oyster dredge can impose a diagnostic damage pattern onto ceramic which can be recognised at a later date. In contrast to the foregoing analysis, such features may be useful when examining material influenced by single episodes or restricted periods of dredging as opposed to prolonged activity.

Watson (1987, 55) considers visible damage patterns on material from Pudding Pan and Pan Sand. From observed features he infers a deposit that is gradually eroding at least partly through the actions of man.[22] However, a point not discussed by Watson is the probable occurrence and significance of multiple impacts to footrings. The nature of the damage to the footrings of the vessels is not related to general erosion although some damaged areas have been subsequently eroded (see table 1 appendix 6). As can be seen from figures 56, 57 and 72, the shape of the footrings may render such vessels particularly vulnerable to this form of damage from a dredge; especially if Watson's contention that some of the vessels are likely to have been exposed on the seabed with the base upward in the first instance, is accepted.

If the damage to footrings is related to contact with oyster dredges, then it is also the case that some patterns of damage are unlikely to have been caused by a single contact. On some examples only a small portion of the radius of the footring is missing (fig. 57). On other examples a large proportion of the footring has been broken off, leaving multiple fracture planes (fig. 56). Some footring damage is fresh and uneroded while other

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[22] Recovered material was viewed and measured with the intention of isolating regularities in the vessels to investigate production and transport links and to consider the nature of the deposit. Watson suggests a coherent cargo rather than scattered site (1987, 31-2). Variations in marine growth are used to suggest that material has moved between, or is recovered from, two different environments. The physical features observed on vessels are briefly considered in relation to the fishing gear potentially involved in site formation. The effect of patterns of fishing activity on the formation of theories concerning the location of the source of recovered material is also discussed (*ibid.*, 53-7).

examples are both eroded and encrusted with marine growth. Certain vessels exhibit both eroded and uneroded footring damage. This indicates that some vessels have been contacted more than once (and possibly moved more than once) before finally having been raised to the surface and retained. They may have been raised to the surface on previous occasions but thrown back. Other vessels may have been contacted and moved on a number of occasions which still remain on the seabed. Thus some regularity in the type of damage (nature and location) can be used to refine inference concerning the value of locational information associated with the vessel.

The Ryde Middle and Southampton Water assemblages did exhibit some common features in the general nature of physical damage exhibited. The occurrence of fresh breaks has already been highlighted as has the frequent presence of multiple fracture planes on single sherds. The latter, in combination with variations in the apparent condition of different edges on the same sherd, could be used to infer multiple impacts and thus, potentially, multiple relocation events. This is discussed further below. However, common features in terms of morphology of fracture were harder to discern. As already noted, one type of fracture which may be worthy of note can best be described as distinctly angular (see fig. 59). The difficulties introduced by the necessarily subjective judgement involved in ascribing a specific fracture to this morphological category are fully recognised.

It has been suggested that such an angular breakage pattern is generally associated with high fired material, *e.g.* stone ware. The clay is essentially vitrified, as such, it shatters rather than crumbles.[23] Examination of tables 2 and 3 in appendix 6 does not suggest a clear link between this fracture type and a particular fabric. Similar angular breaks were identified within the scallop

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[23] Thompson, pers.comm. Stoneware ceramic sherds from a range of terrestrial contexts held by the Southampton Archaeological Unit, were viewed which exhibited this form of fracture. This included a number of sherds from ploughsoil.

dredge control assemblage (fig. 73) and also tentatively within the *Trinidad Valencera* assemblage (fig. 74).

Overall, it did not prove possible to describe recurrent surface marks or impact scars on sherds - indeed the glass vessels within the scallop dredge assemblage were noteworthy for an almost total absence of discernible damage patterns (figs. 63-64). Features were recorded within the *Trinidad Valencera* assemblage which appear to relate to the manufacturing process (see fig. 75). However, when slightly abraded or eroded, the potential for confusing such attributes with those associated with a variety of mechanisms is evident.

### 4.2.6 Marine Encrustation

A variety of types of marine growth were noted on sherds from Southampton Water and Ryde Middle. Variations in the nature of marine growth might indicate changes in environment or orientation within the seabed. However, consideration of the factors which might influence the nature of marine growth, allied to recognition of the limitations of the sample available for study, set limits on the appropriate use of such data in this context.

Physical characteristics of the archaeological material itself, such as shape and extent of surfaces, might influence settlement and colonisation. Therefore, density of growth alone is no clear indicator of length of exposure. Surface features such as texture, colour and composition of glazes and colour coats might also be significant. Further, such factors do not remain constant. As the surface of a sherd erodes, the colour and composition of a glaze may alter and therefore its influence on settlement may also change. This said, it was not possible to associate a specific surface or glaze with the complete absence of any of the animals noted as present within the Southampton Water and Ryde Middle assemblages.

Micro-environments, as opposed to coarse environmental characteristics of a general, area are also highly significant in determining the speed and nature of encrustation. Small variations in sherd orientation may alter settlement patterns through changes in water flow and availability of light.

Barnacles require contact with running water. Calcareous scars on many of the sherds indicate where barnacles have died and become detached. This evidence can be used to infer that the sherd has been exposed sufficiently long for the animal to complete a life cycle. Some barnacles had not reached their full potential size before being lost or falling off. This may indicate re-orientation or disturbance within the expected life-cycle. Further, barnacles are attracted by the calcareous scars and so previous settlement may promote subsequent colonisation. The animals is hermaphroditic and so tend to grow in dense colonies, so dense in fact that the size and shape of individuals can be influenced. This may in turn affect estimates of the duration of colonisation. Equally, presence of other animals may inhibit barnacle settlement.[24]

*Bryozoa* (a filter feeder - gelatinous when alive) also require contact with free flowing water. While believed to be more tolerant of muddy shade than barnacles, the animal will not flourish when buried within sediment. While some *Bryozoa* growth over barnacles was noted this is only likely to occur if the barnacles are dead. Worms such as *Pomatoceros* are thought to require some time to develop and some species will survive on the underside of sherds in contact with the sediment.

Inter and intraspecies competition for space; lack of knowledge about the influence of physical characteristics of archaeological material on settlement; and the wide range of environmental factors, singly and in combination, which may be important in determining the nature of observable colonisation, introduces considerable complexity when making inferences about the

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[24] Mortlock, pers.comm.

history of the material. Sherds appear to require detailed study on an individual basis and such study must be informed by detailed knowledge concerning localised environmental factors and the orientation of the sherd *in situ*. The assemblages under consideration will not bear this form of analysis. In addition, the frequent appearance of detached marine growth in the packaging of the material studied precludes any purely quantitative approach, reliant on counts of individual animals. Yet, while refined methodology may be inappropriate, simple analysis of biological characteristics of sherds can still prompt useful observations.

A review of tables 2 and 3 in appendix 6 shows that, in combination with erosion, staining and morphology, biological accretion can be used to infer multiple impact events. A sherd with a freshly broken edge may also exhibit an edge that has light erosion and light marine growth while a third edge is both heavily eroded and densely encrusted. While, for the reasons stated previously, little can be said about the precise chronology or the time lapse between events, multiple events of breakage can be postulated on the basis of this aggregate information.

This simple inspection of biological accretions can be extended to permit consideration of the orientation of sherds within the seabed and, indeed, of whether a sherd shows evidence of multiple orientations - perhaps associated with periodic disturbance or transport. As above, this involves making comparisons between different parts of individual sherds. When edges are considered, the area of interest is quite easily defined. When general orientation is being investigated, the basis on which comparisons can be drawn is less clear. While, intuitively, it would seem reasonable to consider the two flat surfaces of a sherd as distinct entities, this can pose problems. The significance of slight variations in orientation and local environment has been noted. The full range of orientations a sherd can occupy should be considered. In practical terms, this is not possible and, given the predominance of body sherds in the assemblages, comparison between flat surfaces is less arbitrary than it may at first appear. However, handles and other complex shapes are less amenable to this form of general characterisation.

Recognition of the variables introduced by habitat preference and competition for space prompt adoption of a simple presence / absence approach when listing the types of accretion on the surfaces of a sherd. When determining whether surfaces do show signs of differentiation therefore, density of colonisation was not considered. Figures 77 and 78 show a single sherd which exhibits markedly different encrustation on two surface. Figure 76 illustrates the degree of variation between individual sherds that may be found within a single assemblage (Southampton Water in this instance).

The material recorded was examined and where clear differentiation was observed this was noted. The proportion of sherds which exhibited such differentiation is shown below:

| | |
|---|---|
| Ryde Middle | 9.4% |
| Southampton Water | 25% |

This data might be used to infer that the majority of sherds examined have occupied multiple orientations in surface or near surface environments since deposition. It might also indicate that sherds within the Southampton Water assemblage may have suffered less disturbance than the Ryde Middle material; a greater proportion showing clear differentiation between surfaces However, problems will always attend comparisons drawn between assemblages from different locations due to the potential influence of minor variations in environment. The lack of more specific spatial data associated with individual sherds hampers extension of these observations to inform assessment of find spots as potential indicators of the location of sub-surface or primary deposits.

A link between encrustation and post depositional history can be explored further by considering the sherds which exhibited no accretion or accretion on one surface only. Sherds with no accretion may have been recently exposed. Those with accretion on only one surface may have suffered fewer episodes of disturbance than those exhibiting the same, or similar, accretion on both surfaces. If this attribute suggests greater stability then the sherds should also be larger through having been impacted and exposed to potential risk of breakage less often. Figure 79 shows a plot of dimension against accretion utilising the Ryde Middle and Southampton Water material. Differences in marine growth between surfaces within this assemblage are not confined to the largest examples. However, some support is given to this proposition by the fact that the complete or near-complete vessels dredged from the Solent area and viewed during this study were characterised by minimal marine encrustation (see fig. 80 and 81). This introduces the possibility of discrimination between different elements of single or multiple assemblages within a dredged area. Conventional typological dating provides a ready means of achieving this end in certain situations but, where multiple deposits of a similar period or type are suspected, considering biological accretions in this manner might be of value.

Certain variables must be acknowledged which also have relevance to previous comments. Variation in accretion may be the result of a hostile environment rather than recent exposure after burial. In addition, other, more subtle, indicators of burial such as adherence of sediment may not persist until the object is recorded; indeed such evidence may have been removed in order to facilitate closer examination of the sherds. This also applies to other types of biological accretion which have not survived to be observed in this study - the animals considered here are all evidenced by hard, calcareous traces.

### 4.2.7 Discussion

Some of the above observations might support the view that the prolonged influence of oyster dredging can produce a surface assemblage with distinctive characteristics. Other observations hint at the potential complexity of the material under consideration. The assemblages studied consisted of a range of fabrics. If fabric and form influence the structure of the size range, the nature of clustering of values observed here may not be precisely mirrored in an assemblage consisting largely, or entirely, of a single fabric. The *Trinidad Valancera* assemblage comprised storage vessels of a specific fabric and therefore a comparison of size attributes was not considered relevant for reasons given above. It may be erroneous to expect an assemblage of amphora sherds to exhibit the same size characteristics as a distribution of stoneware. In addition, as already noted, since the original condition of the ceramics when deposited on the seabed cannot be known, the true significance of observed size attributes must be uncertain to a degree.

The method selected for representing the size of sherds must also be assessed critically. Although the relative size of sherds is presented in a manner amenable to simple visual analysis, this method cannot account in detail for some variables, *e.g.* shape. A sherd with angular projections may be more likely to be broken than a sherd with smooth contours. However, such variation will not be apparent from inspection of the scatter diagrams produced for this study..

Observations concerning biological accretions, as an adjunct to recording physical features, can contribute to the general characterisation of an assemblage. However, because the nature of marine growth is highly dependent on local environment, it was not considered appropriate to consider biological aspects of the control assemblages from Shetland and the *Trinidad Valancera*. For the same reason, data presented here as part of the characterisation of surface assemblages influenced by bladed dredging should be used with care elsewhere.

## 4.2.8 Yarmouth Roads Assemblage

During systematic visual searches in Yarmouth Roads (see fig. 54), ceramic material from an area influenced by oyster dredges was collected by divers. The resulting assemblage offers the opportunity to assess the degree to which material contacted by a dredge and raised to the surface exhibits different features to material remaining on the seabed in a dredged area. 42 sherds were examined.

Material located by divers may have been raised to the surface in a dredge before and replaced with concomitant secondary damage. It is also possible that any physical features observed are the result of other agencies, for example dragging anchors. However, during searches, numerous observations of potential dredge tracks on the seabed were made and the area is known to be worked regularly.[25] In addition, observations were made linking material observed on the seabed with potential dredge related disturbance. For example, barnacles were observed to be on the underside of a stone lying on bare clay.[26]

Material raised during these searches was recorded as previously described. The results are shown in table 4 appendix 6. Figure 82 shows a combined plot of sherd dimensions for the diver collected sample and the Ryde Middle and Solent Water assemblages. Figure 83 provides a comparison of ranges of dimension values. The respective mean, median, range and standard deviations are shown below.

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[25] See dive logs YR044-17/07/84; YR065-12/8/85; YR034-23/08/85. Dive log YR054-28/7/85 notes the presence of a broken dredge frame on the seabed. The survey archive is held at the Archaeological Centre, Isle of Wight, see section 10.1.

[26] See dive log YR86-050-12/06/86. Also note YR054-28/07/85 which describes an amphora sherd which '...has probably been turned over very recently, most likely within the last year.' Dive log YR069-23/08/85 mentions '...clear indications of dredging, smashed modern pot and broken ironstone.'

| | | Mean | Mode | Std. Deviation | Range |
|---|---|---|---|---|---|
| Rye Middle | X | 12.01 | 9.2 | 4.52 | 38.7 |
| | Y | 8.01 | 8.2 | 3.2 | 18.1 |
| Southampton Water | X | 10.1 | 7.9 | 3.1 | 14.3 |
| | Y | 6.6 | 4.7 | 2.4 | 12.2 |
| Yarmouth Roads | X | 13.7 | 10.1 | 5.7 | 26.5 |
| | Y | 8.8 | 5.5 | 4.02 | 15 |

Similarities between the diver collected sample and other assemblages studied can be highlighted; for example, the presence of multiple fracture planes with a number of different characteristics present on the same sherd and the occurrence of angular breaks.

The diver collected sample exhibits a slightly different range in dimension values. Figures 82 and 83 and the table above suggests that the overall range of the diver collected sample is slightly less than for the Ryde Middle assemblage. However, the values are more widely distributed within the range - as indicated by the comparatively larger box in figure 83 and the higher coefficient of variation:

| | | |
|---|---|---|
| Ryde Middle | X | 0.3763 |
| | Y | 0.3995 |
| Southampton Water | X | 0.3069 |
| | Y | 0.3636 |
| Yarmouth Roads | X | 0.4160 |
| | Y | 0.4568 |

It would also seem that the diver collected sample contains larger sherds than the other assemblages studied; the range value for the X dimension is influenced by a single large sherd but this is identified as an outlier for the purposes of the distribution analysis. The median value is higher as are the minimum and maximum value on the box and whisker diagram. However, as was noted for the Ryde Middle distribution, some asymmetry, with a bias towards the lower quartiles, is evident (fig. 83). This asymmetry has been a consistent feature of the assemblages studied.

Of the assemblages studied, the Yarmouth Roads group contained the lowest proportion of fresh breaks :

| | |
|---|---|
| Ryde Middle | 35% |
| Bramble Bank | 17% |
| Solent | 20.5% |
| Southampton Water | 17.5% |
| Yarmouth Roads | 3% |

This observation might support the suggestion that recovery in an oyster dredge is associated with breakage and therefore reduction in size. Yet the observed difference in dimension ranges between the assemblages can be explained in a number of ways. It may indicate that smaller sherds pass more easily into the dredge net and so are more frequently raised to the surface. However, evidence already presented indicates that complete vessels of some size are not infrequently transported in this manner. The material raised by divers may represent sherds which have been impacted less frequently by dredges. Alternatively, divers may simply have been more successful in observing larger sherds on the seabed and therefore the method of collection structured the size range of the material located and therefore available for study.

Despite these qualifications, there seems no pressing reason to suggest that material raised to the surface in a dredge cannot be used to describe the likely characteristics of similar material remaining on the seabed in dredged areas. In addition, individual items within the diver collected assemblage also allow specific points raised in the preceding sections to be considered further. Features noted on item 5021, the base of an amphora, permit the likely effects of a dredge impact to be described (figs. 84a & b). That damage noted on this sherd was caused by a dredge cannot be proved conclusively, however, marks associated with the passage of a dredge were noted in the immediate area. Notes made by the finder, consideration of marine encrustation and discoloration of fabric allow the likely orientation of the object within the seabed to be illustrated (fig. 86). *In situ* breakage is suggested by the fact that the pieces remained in intimate association though no longer joined. While the area of fracture which would have been exposed, according to the reconstruction proposed in figure 86, did show some erosion (fig. 85), edges of fractures which would have been buried were not eroded for most of their length. The most likely point of recent impact is shown (point A fig. 84a). Of particular interest is the angular morphology of the fracture.

This example illustrates a number of points; that reduction in size and coherence may result from dredge impact and that angular fractures may be associated with events of this kind. Only limited progress has been made towards identifying regularities intimately associated with dredging. Yet the value of considering a combination of physical and biological attributes, as opposed to depending on the isolation of a single diagnostic feature, has again been demonstrated by this example. Furthermore, find spots of material raised from Yarmouth Roads have been recorded. Therefore, future work on this assemblage might include more detailed consideration of biological accretions in relation to physical attributes.

### 4.2.9 Conclusions

Specific methodological issues raised by this study are discussed in section 4.4 along with the possible role of experimentation in further research. Conclusions arising from the study of size attributes, breakage patterns and biological accretions have already been drawn but certain general observations can also be made.

Information presented here indicates that vessels can survive an impact mostly or wholly intact. Therefore, the presence of complete or near complete vessels in a surface assemblage cannot be used to infer the absence of biases and changes which might be associated with dredging activity.

Within the assemblages studied, it has not proved possible to link a specific, readily identifiable type of damage to the action of bladed oyster dredges in a manner which excludes other causal agencies. However, potential general characteristics of ceramic material in contexts influenced by bladed oyster dredging have been highlighted which might allow inference to be refined. When studying plough damaged implements Mallouf (1982, 81) observed that the high quality of the chert, "...aids greatly in determination of breakage characteristics...whereas among cherts of poorer quality such attributes do not tend to be as clear-cut or well preserved." Further work should include careful consideration of the effect of form and fabric in determining such characteristics.

The nature of the sediment surrounding the material of interest may also be significant when considering or predicting damage patterns. The following observation was made by a diver[27] involved in the visual search for pottery in Yarmouth Roads:

"The coarse sand in which much of the small cobbles are embedded seems to be the ideal matrix for pot sherds! They would stay clean (*i.*e. little growth) but would probably be pulled out by a dredge without much damage."

As these comments indicate, the substrate will influence both encrustation and the likely results of dredge impact. A firmer substrate with higher clay content might not release part buried sherds so readily. Therefore the pulling strain imposed by the dredge might be more likely to result in fracture or damage due to higher mechanical stress.

Ultimately, however, survival of specific damage patterns, as opposed to general physical characteristics, may depend on the post impact history of the material and the time lapse between impact and observation. A ceramic container moved out of context by a dredge may well bear marks diagnostic of that

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[27] Dive log YR057-09/08/85

episode. However, even if such marks could be recognised in the first instance, erosion by water borne abrasives *etc.* may alter or obscure them. A clear conceptual division must therefore be maintained between prediction of the actual existence of diagnostic features and the probability or otherwise of their subsequent recognition in the field.

The potential of the study of marine growth has been indicated but its realisation in this study has been unsophisticated. In the analysis of damage patterns, biological accretions may be useful as an aid to categorisation through subdivision. As indicated by the example discussed in section 4.2.8, the nature of encrustation might allow the researcher to distinguish between marks created by an impact on an object lying partly or wholly on the surface and marks created by an impact which prised an object out of the sediment as well as raising it to the surface. It is evident, however, that more sophisticated analysis of biological accretions, particularly any investigation seeking to elucidate temporal problems, will require more rigorously collected samples. Equally, the properties inherent in archaeological material which influence the speed, density and nature of settlement must be better known before such analyses, with concomitant demands on resources, can be justified.

## 4.3 Complex Properties of Artefacts

In section 4.2.2 (92) the desirability of detailed knowledge concerning the distribution of material influenced by fishing gear was contrasted with the difficulty of obtaining such data. However, a suggestion that oyster dredges are likely to have had a significant influence on surface distributions is generally supported by fishermen active in the Solent area. Dr. Tomalin, county Archaeologist for the Isle of Wight, reports a view expressed by some fishermen that, when intensive oyster fisheries commenced in the 1950's pottery was, in some places, recovered more frequently than oysters. Now it is recovered less frequently in regularly fished areas. This is ascribed to the action of the dredges which have dispersed the material. Indeed, Dr. Tomalin has, while aboard a fishing boat, witnessed the recovery of the same object twice in one day. Mr. White, a fisherman working out of Lymington, claims to have dredged up four conjoining pieces of the same pot over the course of three days fishing. He and his sons also report a reduction in the density of pottery recovered in recent years as compared to the 1950's.

A reduction in the rate of recovery does not necessarily equate to actual absence of ceramics. Remaining sherds may be less susceptible to being raised in dredges through being an inappropriate size or shape. Similarly, while surface material may have been very substantially influenced, there is no reason to assume that sub-surface assemblages have been affected to the same extent. Localised erosion and deposition of sediment will likewise serve to bury or make available new material on the seabed. Long term oyster dredging may well impose certain characteristics on surface assemblages, dispersed distribution, absence or poor representation of certain size classes, but it does not, in itself, necessarily render an area barren of archaeological interest. Further, dredging in the Solent is generally prosecuted in depths of less than 17m due to difficulties experienced in shooting and hauling dredges in deeper water. 10m is considered a comfortable working depth. This means that even if certain areas have been heavily influenced there are other, easily definable, zones, possibly contiguous with exploited areas, which have been largely protected from related disturbance.

### 4.3.1 The Birch Point Explosive Dump

Most distributions of archaeological material available for study have a past history which may be inferred, but rarely demonstrated with confidence. This is particularly problematic when attempting to describe the nature of changes to spatial properties of a deposit derived from the influence of fishing activity. A controversy concerning the dumping of explosives at sea, and their subsequent recovery in fishing nets, is the unlikely source of data on a fishing gear impacted deposit whose pre-impact history and distribution is known in some detail.[28] This case study will be used to consider the proposition that sufficient regularity can be observed in the influence of trawled gear on spatial relationships to allow the refinement of interpretations of observed seabed distributions of archaeological material.

Three factors make this case study particularly valuable. The first is the confidence with which the pre-impact distribution can be described.

In May 1990, fishermen in the Firth of Clyde reported that they had trawled up explosives and detonators in their nets. They claimed to have picked up the material at distances ranging from 2-18 miles outside of the limits of an official explosives dumping site at Birch Point.[29] Disposal of explosive waste had been undertaken at Birch Point since 1953 (and ceased in 1989). The

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[28] I am very grateful to Mr. Saward of The Marine Laboratory Aberdeen, who led the survey of the explosives dump, for making unpublished data relevant to this study available to me.

[29] The Department of Agriculture and Fisheries Scotland (DAFS) report on the dump (ICI 1990, 1-12) contains a summary of the site's development and that information is not repeated here beyond what is necessary to establish the usefulness of the survey data.

area in which dumping was allowed was reduced from a 2 nautical mile radius around the point 53 37'N, 004 59'W to a 0.5 radius in 1964. Annual licenses were renewed without objections from local fishermen between 1974 and 1989. In 1984 the dumping radius was reduced to 0.25 nautical miles and the method of dumping changed to ensure that the material fell within this zone. The area was clearly marked as restricted on Admiralty charts and its existence was well known by the local fishing community (ICI 1990, 1-2.). Video surveys carried out in 1981, 1985 and 1988 indicated that visible material did not lie outside of the 0.5 mile radius and that there was a major concentration of appropriately packaged material in the 0.25 miles radius area.[30]

Following increasing numbers of claims from fishermen that they had trawled up explosive waste from outside of the restricted area and amid growing concern in the fishing press, the Department of Agriculture and Fisheries, Scotland (DAFS) undertook echo sounding surveys of the area (FN, 18 May 1990, 2). These were augmented by towed video surveys of the dump site and sample trawls. Significant differences between the distribution described by this survey and those described by previous surveys were noted.

The second important feature of this case study is the ability to demonstrate that it was indeed fishing gear that was responsible for disturbance of the deposit.

The dump was deliberately sited to take advantage of very weak currents near the seabed. After the 1990 survey DAFS confirmed (ICI 1990, 19-20) that disturbance of material was caused almost exclusively by trawling and not environmental factors. Indeed, survey work was interrupted by fishing vessels towing across the path of the survey vessel and directly across the dump site.

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[30] Saward, pers.comm.

The third feature of the deposit which can be highlighted is the likelihood that only one basic gear design was involved in the disturbance. This greatly reduces the number of variables involved in subsequent analysis.

Prior to the 1950's the fishing effort in the area was mainly ring netting for herring with some seining and long line activity. The 1950's saw otterboard trawling develop in the fishery for *Nephrops norvegicus* (L.), the Norwegian lobster (Main & Sangster 1985). Trawling was illegal in the Firth of Clyde until 1963 although a report of 1961 indicated that it did occur.[31] The seasonal *Nephrops* fishery developed into year round effort in 1968. The area was opened to all trawling in 1985 but the dump remained a restricted area.

To the best knowledge of the fishermen and the DAFS researchers only *Nephrops* trawls were utilised at the dump site.[32] Further, these were of regular mesh size (7cm) and all employed similar, light ground gear.[33] The dump area is known to support a large population of *Nephrops*, a valuable commercial catch, which may have made a tempting target despite the obvious safety problems.

Figure 87 shows the alleged distribution of material based on reports by fishermen. It does not show the exact distribution of material as observed on the seabed by DAFS scientists. This information is not yet available although the nature of the findings were outlined to the author. The figure shows only one type of material, blocks of emulsion explosive waste of regular size (*circa* 30cm by 20cm by 15cm). Other material was also

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[31] Tarvit, pers.comm.

[32] Saward, pers.comm.

[33] Main & Sangster (1985, 2-5) provide a detailed description of this gear which features, along with a fine meshed net, very soft ground gear consisting of a hemp rope with lead weights which holds the ground very closely. Relatively heavy trawl doors (0.5 tons each) which remain firmly in contact with the seabed are employed which create a dust cloud designed to herd the burrow-dwelling catch inward toward the net mouth.

recovered from the dump, namely single or bundled detonators and fragments of hessian sacking.

Thus a known distribution can be shown to have been impacted by fishing gear of known specific design. An indication of post-impact distribution showing one class of regularly sized material is also available.

Further regularities can be established. Fishing activity in the area is not random. The dump site lies at the bottom of the Arran trench. The trench runs roughly north-west to south-east. Tows which follow the trench are more convenient for the fishermen because depth remains relatively constant. Tows across the trench are problematic because frequent changes in the setting of the towing warps would be required to keep the trawl on the bottom. Thus the local bathymetry and known hazards have a significant influence on trawling patterns (see fig. 88).

The difference between the 1990 distribution derived from fishermen's reports and those revealed by surveys in and prior to 1988 are clear. Previously noted, dense concentrations of material could not be detected within the 0.25 or 0.5 mile radius dump areas (ICI 1990, 15). A high rate of damage to hessian sacking used for packaging and subsequent release of material onto the seabed was also indicated (*ibid.*, 20-21).

Two main distributions of material can be seen in figure 87, A and B. The official limits of the dump site are also shown. Distribution A was alleged to contain the majority of the dumped waste. The survey by DAFS revealed that this distribution actually conformed more closely to the official outer limit of the dump than was alleged. The DAFS researchers consider this to be largely an artefact of inaccurate dumping.

Distribution B was alleged to contain less material. As can be seen, this distribution is extended in the general direction of the trawling activity in the area. There were also a number of outlying find spots. The reported distribution shown in figure 87 generally conforms to the distribution noted during seabed survey work.[34] The DAFS scientists consider this distribution to have resulted from trawler induced transport.

It can be stated with some confidence that some material from the dump has been displaced by several miles. This confirms that dispersal of material is a likely result of such impact and allows an appreciation of the potential scale of changes to spatial attributes. However, consideration of the mechanisms involved in the transport of material, indicate that even when basic gear design can be treated as a constant, a number of variables prevent a simple analysis of the resulting distribution.

The relationship between physical properties of the material on the seabed and the specific design of fishing gear in use, will be significant in determining the nature and magnitude of transport. As noted in section 3.1.5, the nature of local sediments may serve to temporarily alter the characteristics of material and so affect this relationship. The distribution noted above related to one type of regularly shaped material. An archaeological deposit may contain a variety of material types exhibiting a range of shapes and densities. Therefore, it may be more likely that diagnostic distributions of material sharing certain characteristics will occur, rather than recognisable distributions of archaeological material *per se*. The situation is further complicated when more than one design of gear is in use in an area. Experimental trawls with a range of commercial gear were conducted in the Birch Point area by DAFS. Vessels of 10m, 25m and 60m length were employed, each equipped with commercial otter trawl gear of a type appropriate for the vessel's size. It was found that a 25m vessel equipped with prawn trawling gear similar to that used by local boats was the most effective at retrieving material from the seabed.[35] In an area where such gear is deployed, a higher percentage of appropriately sized objects may be transported by being raised to the surface and subsequently dumped in a new

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[34] Saward, pers.comm.

[35] Saward, pers.comm.

location; the transport mechanism which is possibly hardest to identify subsequently and which may create the most extreme distributions. Similar material in areas where heavier ground gear and coarser meshes are deployed, may be more frequently transported by being pushed ahead of the gear rather than entering the net and being raised to the surface. This may tend to create a less widely dispersed distribution. Such suggestions must be tentative given the number of potential variables involved but they do reinforce the necessity of considering gear types individually rather than assuming a uniform influence on material.

One transport event might change significant physical properties of the object so that it becomes less, or indeed more, prone to subsequent transport by the same or different agencies. When the explosive waste was securely packaged in hessian sacking it possessed very different physical and hydrodynamic characteristics as compared to those exhibited by loose blocks of explosive on the seabed.

This aspect of trawler impact can be explored by consideration of other types of explosive waste, such as detonator tubes, which were also dumped at Birch Point. The detonators were originally packed in sacks but subsequent to trawl impact were found loose and in small bundles. Data concerning the location of detonators indicates that displacement was substantially less pronounced than for the emulsion blocks.[36] It might be possible to explain this by reference to differences in physical characteristics between the two. In certain situations then, can some types of material, perhaps defined by size and density, be regarded as better indicators of deposit boundaries because they are likely to have been moved less far? Equally, if trawling in the area of interest is bi-directional and conforms to a regular pattern, will the distribution of such material establish a form of relative equilibrium, displacement in one direction being balanced by

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[36] Saward, pers.comm.

subsequent displacement in the other? Research undertaken elsewhere may shed some light on this question.

The relationship between object size and extent of horizontal movement and the influence of bi-directional transport have been investigated in plough-zone archaeology.[37] Boismier (1991, 17-18) states that horizontal displacement is largely related to object size, equipment type, direction of ploughing and slope. In general artefacts larger than 4cm are moved the furthest with smaller objects influenced to a lesser degree. With bi-directional ploughing, a mean horizontal displacement over time of roughly 5m may be expected. Dunnell (1990, 593) argues that if bi-directional transport did not produce equilibrium, then material would be evenly spread within fields. He states that this is evidently not the case, even after centuries of tillage. Other workers have not tended to support this rather sanguine view (Odell & Cowan 1987, 468; Cowan & Odell 1990, 599; Yorston 1990, 597). Yorston (*et al.*, 1990, 75) does not predict spatial atrophy, but does refute the notion that material in the ploughzone is in a state of gentle and quantifiable oscillation, asserting:

"Not only does the distribution spread out, it continues to spread out indefinitely so long as the disturbing influence is present."

Odell and Cowan (1987, 477) conclude that ploughing creates a basically random distribution of objects with potentially spurious clustering. Observations made on plough-impacted material cannot be transposed directly onto problem domains relating to fishing gear, but the general point that bi-directionality does not necessarily lead to any form of equilibrium, is significant. However, some potential constants which could aid interpretation

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[37] Hayfield (1987, 11) allows a degree of oscillation but affirms that pottery will not travel far from where it was introduced. Roper, who experimented with refitting conjoinable flakes displaced by ploughing, suggests (1976, 374) that in 20 -30 years artefacts may move 20cm - 10m. Ammerman (1985, 38) found a mean lateral displacement of 1.18m to 1.74m over 2 years and 6 ploughing episodes - although some tiles in the experiment moved as much as 5m.

have been highlighted and are mirrored in observations made at Birch Point, namely a link between dominant plough direction and lateral displacement (*ibid.*, 469).

The influence of cultural or behavioural, as opposed to mechanical, elements of tillage have been highlighted as both pervasive and problematic in relation to objective analysis. During the Hvar Valley survey in Yugoslavia, it became clear that a large amount of material was located, not in the top soil, but in clearance cairns and on field boundary walls (Gaffney *et al.*, 1991, 66-77). Indeed, certain artefact classes were only available in these secondary deposits.[38]

The distribution of material at Birch Point was also heavily influenced by non-mechanical factors. It is not possible to establish whether the material shown in figure 87 was displaced from the dump and raised or had been displaced previously and raised during a subsequent trawl. Once on the surface it may be jettisoned immediately or retained for a period and then dumped. The material would then be available for further transport by subsequent trawls. The DAFS scientists noted that at no time did fishermen return to the dumping area to re-dump trawled up explosive waste as was requested by the Coastguard. Rather debris was often jettisoned where it was hauled up.[39] Further variation is introduced by the fact that catches from the area are landed at a variety of locations depending on price and weather. Therefore, it is not possible to assume that such jettisoning of material will occur along a specific route nor that individual trawls will begin and end in the same place.

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[38] All of the quern stone material in the sample was found in the clearance cairns as was 97% of the tile population by weight. In addition, 30% or more of the clearance cairn assemblage of amphora was made up of larger and more diagnostic elements such as bases, handles and rims (Gaffney *et al.*, 1991, 74-77).

[39] Saward, pers.comm.

## 4.3.2 Rye Bay

The need to consider behaviour related to fishing practice when attempting to analyse the surface distribution of material is further emphasised by activity in Rye Bay Sussex.

In certain areas, conventions exist whereby material snagged in nets is subsequently dumped at a location away from frequently used grounds. Mr. Wight, stated that fishermen in the Solent area use the Hurst Narrows in this way. He noted that anchors are particularly likely to be moved as their shape makes them especially prone to becoming snagged. Mr. Ruck, a fisherman in Rye Bay, revealed that material recovered in that area is dumped around the fairway buoy outside of Rye Harbour. Since trawling is not conducted close to the buoy, it is argued that this practice prevents such material from damaging gear in the future. The archaeological result, however, is a multi-period assemblage of material formed through a process not necessarily reconstructable by examination of the evidence on the seabed. The practice is technically illegal, therefore knowledge of such agreements may be largely restricted to local fishermen.

Mr. Blight, a trawlerman and salvage diver, provided further information about the pattern of trawling in Rye Bay (fig. 89). The most heavily fished area is known as 'The Hole'. Trawls are usually conducted towing with and against the tide as indicated - very rarely across the tidal stream and only speculatively in locations outside of the main area. Beam trawls (*circa* 4m long) are used as well as otter trawls. Trawling in Rye Bay on 23rd November 1983, in his boat *Alethea Anne,* Mr. Ruck snagged and raised a medieval steering oar, 6.73m long and weighing nearly 1.5 tons (see fig. 90). The oar is now on display at the Hastings Shipwreck Heritage Centre. Mr. Ruck's Decca trace of the tow during which the snag occurred was made available (fig. 91). As can be seen, the tow took place outside of the most heavily fished area and was not straight but planned to avoid known wrecks.[40]

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[40] Ruck, pers.comm.

Mr. Blight stated that Mr. Ruck was not the first fisherman to raise this object. He himself had raised it and thrown it back into the water. He mentioned at least one other fisherman who believed that he had snagged the object but not raised it to the surface. Figure 89 shows the approximate points at which Mr Blight (point A) and Mr Ruck (point B) snagged the oar. As can be seen, the two find spots are separated by a considerable distance. More significantly, the direction of movement from one location to the other is across the prevailing direction of tows. Mr. Blight stated that it is likely to have moved as a result of being snagged by a fisherman and deliberately taken outside of the normal trawling areas to avoid further inconvenience.

Information provided by Rye Bay fishermen allowed the significance of the steering oar find-spot to be re-assessed. The nature of the material on the seabed around the fairway buoy can also be assessed through oral testimony. In areas where trawling or other practices have declined or stopped, such local knowledge, vital for the interpretation of surface finds, may already have disappeared.[41] This is well illustrated by the careful cultivation of shellfish beds, noted in section 3.1.7. Collard (1902, 77) indicates that pottery was used as a 'hold fast' for spat (young oysters) and that any pottery found or dredged up would be carefully 'shaded' back into the water. There are also records of large quantities of tile and pottery having been deliberately prepared on shore (coated with lime) and then placed on the oyster beds to improve the area for the spat (*ibid.*, 52).[42] This raises the possibility of relatively discrete distributions of ceramics in coastal waters which are the product of a process quite distinct from any that relates to their original function. This example was recorded, but it is possible that similar

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[41] That this practice is not new or restricted to Rye Bay is suggested by Jenkins description (1920, 194) of the range and quantity of material that could be trawled up around the 'deposit buoy'.

[42] Davies (1989, 137) records a similar practice in the Falmouth area.

practices occurred earlier in the history of oyster cultivation without a written record surviving.

The general nature of the influence of trawling on spatial relationships has been illustrated but distributions of material resulting from trawler impact are complex. Broad parameters have been established within which regularities in changes to spatial relationships may be sought, for example topography, prevailing directions of tow, the characteristics of gear deployed and local practices, none of which need be constant through time. Considerable doubt has been cast on the likelihood that an unequivocally diagnostic distribution can be recognised in a range of situations. Analysis of deposits will require detailed study on a case by case basis.

## 4.4 Implications for Inference and Methodology

One of the most important observations that can be made on the basis of this study is the need for clear problem orientation when considering methodology. There is a need to differentiate between attempts at characterisation of a surface distribution and study aimed at the detailed reconstruction of the history of individual items within that assemblage. For the purposes of survey work and deposit assessment, the former line of enquiry may be more productive. In addition, the level of resource required to achieve the latter goal could be prohibitive.

Intensive fishing activity will have significant implications for survey at a number of levels. Regional or area survey may attempt to determine the nature and general distribution of the archaeological resource. If groups of material are located, then survey work may be directed at defining the limits of specific concentrations in order to allow them to be described as sites. Once the boundaries of such sites have been established to the investigator's satisfaction, further work may be directed at describing the location of surface material in detail.

At the regional level, the survey technique employed should be chosen with past and current fishing activity in mind. Side-scan sonar is a widely used survey instrument with great potential in terms of locating archaeological deposits[43] It operates through emission of signals which are reflected off of features on the seabed. The height and, to a certain extent, the density of an obstruction can be determined from the sonar trace. This equipment may require careful deployment in an area where the relief of deposits is likely to have been substantially reduced by intensive fishing activity. Mr. Wilson, a Rye Bay fisherman,

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[43] Green (1990b, 49-51) describes the equipment in general terms, Klien (1985) provides a comprehensive technical account. Theoret (1980) and Redknap & Fleming (1985) describe survey projects which have employed side-scan sonar.

stated that on a site known as the *Hop Pole Barge*, traces from echo sounders used indicate an obstruction standing 2m above the seabed. Now fishermen trawl over the spot with no damage to their gear. No significant changes in the seabed have been noted in the area. It is assumed that the site has been flattened and dispersed as a result of intensive beam trawling.

Dispersal of surface material by fishing activity may also influence the apparent number of events which are detected in a survey. Magnetometers, which detect magnetic anomalies, are frequently used in area survey.[44] During survey work and while processing data it may be necessary to decide on the magnitude of anomaly that will be regarded as a significant event for the purposes of the project in hand (see Garrison *et al.*, 1989, ii-129-133). Fishing activity may reduce concentrations of material and therefore the magnitude of resultant readings which may fall below the specified threshold. An underestimation of the number of deposits present may result if the project design is not refined accordingly. Equally, certain types of deposit or isolated find could be over-represented, for example cannon. Dispersal of material may also lead to an overestimation of the number of separate archaeological events in an area - particularly if a system of visual survey or transect sampling is employed.

The Birch Point case study raises doubts concerning the possibility of establishing the true limits of a distribution in certain areas. Several wrecks of similar type containing similar material may lie in close proximity in heavily trawled zones such as the Thames Estuary. Could separate, dispersed assemblages be distinguished? The desirability of achieving an accurate description of the actual distribution of material from a single site is not doubted. The practicality of achieving it economically is open to question. Survey techniques of the type employed at Birch Point could be utilised if sufficient resources were available.

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[44] Clausen & Arnold (1976); Arnold (1981); Green (1990b, 44-7).

Would the result justify the expenditure short of the discovery of conjoining fragments of a single artefact?[45]

In section 3.1.1 (60) it was emphasised that sailing trawlers were restricted in the direction in which they could tow - usually progress would be made with the tidal stream. If sailing trawlers were the only vessels ever to have operated in an area, it may be possible to relate linear distributions to the direction of prevailing current. But a distribution created by sailing trawlers may have been affected subsequently by less restricted, powered trawling. Additionally, since sailing trawlers towed with prevailing tidal streams, analysis of a distribution purely in terms of fishing activity may ignore the potential of the current regime as an agent of artefact movement in its own right. Overall, although the general trend in direction of displacement might well be identified, the various mechanisms involved in transport are not necessarily reconstructable to the point where the original location of an item can be estimated with any confidence.

The difficulty of establishing the boundary of an extended distribution may result in close attention to apparent dense concentrations of material on the seabed.[46] The significance of observed intradeposit spatial patterning of surface material may then be considered. Emphasis has been placed on the critical nature of the relationship between physical characteristics of archaeological material and those of the specific type of gear deployed. It has been suggested that the shape of an object may

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[45] Conjoining pieces of an artefact from HMS *Invincible* (Lavery 1988) have been found in locations separated by several miles. Trawling is suspected as an agency of transport (Mack, pers.comm.).

[46] The question of delineating sites from surface scatters is given considerable attention in various papers in a volume edited by Schofield (1991) *Interpreting Artefact Scatters*. A consensus appears to exist in terms of the naiveté of assuming a necessary connection between changes in surface artefact density and location of sites; the number of non-cultural processes which can alter surface densities and distributions is well illustrated. A discussion of the term 'site' (*ibid.*, 3-4) reveals the varieties of meaning attached to the phrase. A basic conclusion drawn appears to be that the rigid application of density based definitions may result in a systematic exclusion from analysis of significant components of the archaeological record.

be highly influential in determining the influence of fishing gear. For example a rounded object may allow certain types of gear to pass harmlessly while an angular obstruction will be uprooted or transported. Certain classes of material may be grossly under represented in such assemblages due to their susceptibility to damage and transport. Whereas it may be tempting to anticipate a clearly detectable swathe of damage through a deposit caused by the passage of, for example, a trawl, the disturbance may in fact be highly selective on the basis of morphology. In addition, disturbance by fishing gear may alter the orientation of an object and therefore its apparent shape - making subsequent recognition of its previous susceptibility to disturbance difficult.

The question of the nature of the relationship between surface material and sub-surface features is highly pertinent when considering deposit assessment. Certain types of fishing gear have an intense effect on surface and near surface material. Few will affect material that is substantially buried; although an event which causes a part-buried structural member to be uprooted will cause deeper disturbance. This has implications for the practice of non-intrusive assessment. The visible evidence may suggest a highly disturbed deposit, while in fact significant elements may have largely escaped severe depredation. Thus, awareness of past and present fishing activity could modify an assessment of the nature of a surviving deposit in significant respects. If surface elements are highly disturbed, non-intrusive methods may not result in an adequate characterisation of the deposit. Intrusive investigation, with concomitant expenditure and damage to the deposit itself, may be required. In some respects this further disturbance may be considered as a secondary impact of fishing gear.

In section 3.1.12 the possibility that the action of certain types of fishing gear tends to reduce the size and cohesion of archaeological material was noted. Reduction in the size of bones due to breakage during plough impact can result in sufficient loss of diagnostic detail for certain species to become analytically invisible within plough-zone samples (Lyman & O'Brien 1987, 495). Similarly, differences in friability between types of pottery has been demonstrated to cause significant bias - certain types of fabrics being represented by quantities of small fragments offering little potential for analysis of form, type or date (Gaffney *et al.*, 1991, 66). Some fishing gear (for example scallop dredges) may produce a similar result. Indeed, analysis of material in terms of date in section 4.2.4. was compromised by the presence of a number of non-diagnostic sherds. Recognition of such an effect would certainly be a material consideration in determining the suitability of surface material for deposit characterisation.

# 5 Fishing Activity: Management Options

In chapters 3 and 4 it was suggested that a comprehensive view of commercial fishing as a formation process required knowledge of the mechanical properties of individual types of gear to be complemented by appreciation of aspects of fishing practice. Progress towards effective mitigation of the impact of fishing gear will also depend on consideration of both mechanical and cultural or behavioural factors. In addition, the design and implementation of appropriate measures cannot be divorced from appreciation of the social and cultural circumstances of the people who will be affected. This chapter will commence with a review of the fishing industry; its present condition, economic strength and political influence will be considered. This will allow subsequent proposals directed at restricting the potentially harmful influence of fishing gear to be assessed in a more informed manner. Legal aspects of fishery regulation are reviewed in appendix 5.

## 5.1 The Fishing Industry

Raw figures relating to the number of men and boats active at any one time do not provide a ready means of gauging the state of the fishing industry. The fleet at Cambletown, in the Clyde area, has been reduced by 50% since 1981. Elsewhere in the region, numbers of vessels have fallen by 30%. However, landings in October 1991 were worth £305,400 as compared to £142,010 for the same period 10 years ago (FN, 29 Nov 1991, 48). 1990 was widely reported as a disastrous year in terms of weight of catch, but the actual revenue from the fisheries was higher than in

1989. Market forces created demand and therefore higher prices for smaller catches.[1]

Pervasive replacement and modernisation of ageing boats has resulted in greatly increased efficiency in some sectors (FN, 11 Oct 1991, 12). In other areas the advancing age of vessels poses a threat to continued activity - economic uncertainty inhibiting new investment (FN, April 15 1994, 8-9). This has led to a realisation that, for management purposes, numerical estimates of vessels involved in a fishery are meaningless unless accompanied by measures of catching power. This is emphasised by the fact that, although a 40% reduction in the Welsh and English fishing industry has been reported since the mid-1970s, the industry itself accepts that reduction in catching capacity is still required (Banks 1994, 54). Furthermore, available data does not reveal a single, clear trend in terms of expansion or contraction - figures available for Scottish waters suggest that, overall, recent years may have seen an actual increase in vessels operating in inshore areas (see fig. 92). Widely reported fluctuations in the fortunes of the fleet operating in the North Sea and distant waters cannot be used to characterise the condition of the niche exploiting near-shore fisheries - the main focus of interest here. It may be most appropriate to consider the coastal fleet as a distinct part of a larger industry facing substantial difficulties but attempting to adapt to new circumstances.[2]

A concise statement describing the condition of the industry is difficult to provide; arriving at a simple assessment of the political influence and lobbying power of the fishing community is equally problematic. Some fishermen feel that they do not have as much political influence as, for example, the farming lobby, in the UK or in Europe. Whereas there are 'gentleman farmers' there are no 'gentleman fishermen', that is, there are no fishermen with titles and ready access to the legislative and

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[1] Lyndsey, pers.comm.

[2] A historical perspective is provided by the *Report of the Departmental Committee on Inshore Fisheries* of 1914 (CIF 1914).

political process.[3] The fact that certain farmers receive direct subsidies from Europe while fishermen do not has been highlighted as a particular grievance (FN, Apr 15 1994, 2). Unlike the Faroese or Norwegian fishing communities, fishermen in the UK do not represent a significant percentage of the total electorate.[4] While fishing communities in Scotland are believed to have been influential in the fortunes of the Scottish Nationalist Party,[5] with a large Government majority in the House of Commons, their influence may not be great. If a situation arises where the Government majority is marginal, however, the localised political influence of the kind exerted by fishing communities in some coastal constituencies will become more significant. Therefore their lobbying power will vary with the prevailing political climate.

The problems associated with such variable degrees of influence can be illustrated. Sport fishing interests in Scotland claimed that commercial drift net fisheries off the north-east coast were reducing stocks and therefore harming their businesses. In 1991 the Government restricted the commercial fisheries with the stated objective of eventual total closure (FN, 25 Oct 1991, 1-2). This decision was widely interpreted within the fishing industry as politically inspired; the fishing communities affected were in seats held by the opposition while the likely beneficiaries of the decision were perceived as potential supporters of the Government. The decision also appears to have been announced during the run-up to a by-election in a constituency (Kincardine) with strong angling interests (*ibid.*, 10; FN, 8 Nov 1991, 7).

The episode described above can be contrasted with the debate surrounding the passage of the Protection of Wrecks Act 1973

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[3] Cartwright, pers.comm.

[4] In 1993, two weeks before elections in Norway, anti European Community sentiment derived from mistrust of EC fishery policy was perceived as being a significant factor in rallying support for opposition candidates (*The Independent*, 31 Aug 1993, 3).

[5] Lyndsey, pers.comm.

(POW 1973).[6] In this instance, fishing interests can be seen to have influenced presentation of the legislation in a manner which may have profound implications if a prosecution is ever brought against a fisherman. During the third reading Mr. Sproat, Government MP representing Aberdeen South, explored the potential effects of the Bill on fishing activity at some length. A topic, he confided, that is "...of considerable interest to my constituents."[7] He sought reassurance that commercial fishing would not be unduly affected, and indeed would be given precedence where potential conflicts of interest arose. Whilst acknowledging that fishing could not be permitted around dangerous wrecks he sought confirmation of a different interpretation of the restriction on fishing activity around wrecks designated on account of archaeological or historical value:[8]

"It is my intention that there should be no bar on fishing from the surface unless it were deliberately intended to obstruct a licensed salvor."

Mr. Sproat appears to have received the assurances he sought with Mr. Onslow stating that only collection of shellfish by diving should be restricted under the Act and that this could be licensed if required.[9] Reference to these debates does not, therefore provide strong support for the use of the POW as a mechanism to protect deposits from commercial fishing activity. The fact that such activity is likely to damage an archaeological deposit does not appear to have been a material consideration.[10]

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[6] See appendix 3.

[7] *Hansard*, Official Report, 4 May 1973 (HC 855, 1668).

[8] *Hansard*, Official Report, 4 May 1973 (HC 855, 1696).

[9] *Hansard*, Official Report, 4 May 1973 (HC 855, 1705-6).

[10] In North America fishing interests can also be shown to have influenced heritage legislation, and in specific circumstances, traditional fishing rights may take precedence over archaeological heritage management. The Abandoned Shipwrecks Act 1987 outlines State duties as regards certain historic shipwrecks. It affirms that management of such wrecks should involve partnerships with fishing interests (ASA 1990, 50122; Section 5 (2)). This reflects the strength of representations made by fishing interests during public consultation (Waldbauer, pers.comm.). In certain locations around the

The industry has taken steps to provide itself with a more consistent ability to influence policy. The Scottish Fishing Federation's (SFA) claim that it represents a truly democratic expression of 'grass-root' opinion within the fishing industry does not appear to be seriously questioned although some disquiet at the lack of substantial progress in negotiations with Government is evident (FN, 29 Nov 1991, 17). The SFA currently maintains an office in Brussels to facilitate lobbying of the European parliament (FN, 6 Dec 1991, 3).

When considering lobbying power, however, it is appropriate to question the degree to which it is appropriate to refer to a single industry at all. There has been considerable conflict between fishermen operating mobile and static gear.[11] Despite many voluntary local agreements (FN, 11 Jan 1991, 4), significant losses of static gear are still attributed to the actions of trawlers (FN, 9 Nov 1990, 3). Modern beam trawling, is particularly unpopular with other fishermen (FN, 6 Sep 1991, 24). Recent calls for total bans on inshore beaming echo debate surrounding a previous attempt to ban beam trawling within the 12 mile limit (FN, Feb 15, 1974, 1). This measure found favour with large sectors of the inshore industry which felt that beaming was ruining their grounds.[12] Yet the planned restriction was eventually dropped (FN, May 31 1974, 1). This appears to have been partly due intense lobbying of local MP's at a time near to a

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Great Lakes in North America, *e.g.* Thunder Bay Michigan, Native American fishing rights are recognised under treaty with the US Government. While not currently exercised, a formal review procedure in the year 2000 is likely to see such rights taken up. Fishing can then be prosecuted without hindrance on and around wrecks managed through State or Federal legislation. The likelihood that tangle nets will be extensively employed has particularly severe implications for recreational use of such sites (Halsey, pers.comm.).

[11] The Trawling Commission of 1885 was charged with investigating the "...complaints that have been made by Line and Drift Net Fishermen of injuries sustained by them in their calling owing to the use of the trawl net and beam trawl, in the territorial waters of the United Kingdom." (RTC 1885, title page.)

[12] FN, 18 Mar 1974, 5; FN, 29 Mar 1974, 5.

general election (*ibid.*, Editorial) and the adoption of a quota based system rather than restrictions on specific gear.

The 'closed' character of many fishing communities may also be worthy of comment in this context. Historically, the hardship and specialised skills associated with fishing (Fenton 1992, 142 & 149-50) may have done much to discourage marriages to people outside of the community. A fisherman not supported by a wife *au fait* with the practical aspects of her role was considered to be at a severe disadvantage (Thompson *et al.,* 1983, 234). But perhaps this very closeness has also allowed the industry to prevail against uncertainty. In his account of coastal fisheries Marshall (1987, 188) comments, "...although the communities will usually look for new methods, they are sometimes reluctant to change and are nearly always difficult to penetrate. Strangers were outsiders; we never saw any women fishing or any black fishermen."

Although localised, the fishing industry remains a major economic factor in a number of areas.[13] Such areas are often characterised by a dearth of alternative employment opportunities. In addition, many fishermen regard the fact that they earn their living from the sea as giving them a distinct character among competing coastal interests, many of which they regard as essentially leisure oriented.[14] Local authorities have not always shown sympathy to fishermen (Peak 1985, 84-110) but the extent to which a working fishing community may be perceived as a tourist attraction should not be underestimated. Mr. Adam, Euro MP, commenting on the proposed closure of the salmon drift net fishery, described above, stated that the government had ignored the contribution of the fishermen to the

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[13] At the Rural Forum Conference 1991, held in Anstruther, east Fife, the continued existence of active smaller fishing communities outside of major centres was linked with the more general debate about the survival of rural communities (FN, 8 Nov 1991, 31). The great significance of an apparently small industry to the wider rural economy was underlined (Prescott, pers.comm.).

[14] Squire, pers.comm.

local economy "...not only in providing a health food, but also in adding to the attractiveness of Northumberland for tourists" (FN, 25 Oct 1991, 10).[15]

Fishermen may suffer from suspicion borne of unfamiliarity. Equally unhelpful is a misplaced romanticism on the part of those ignorant of the true nature of their lives. Those perceived as picturesque may not be regarded as having urgent problems related to their work. Neither situation is helpful in providing fishermen with a political voice that is heard beyond the bounds of, often localised, minority group lobbying.

The European Community fisheries policy,[16] with its reliance on Total Allowable Catches and quotas, comes under regular fire in the fishing press and appears to be held in low regard by the fishing community. Fisheries ministers in the UK and recent closures of grounds have caused considerable resentment and feature heavily in critical articles and editorials.[17] Changes in the way that catches have to be reported as part of the administration of the quota system appear to be equally galling to the industry.[18] Furthermore, conservation bodies are expressing increasingly vocal concern about the damage done to the seabed by fishing gear .[19] At the Third International North Sea Conference, held in March 1990, it was suggested that the impact of fishing gear should be investigated and dealt with in the same way as pollution of the more conventional variety (Ijlstra 1990, 225). Confrontational tactics employed by Greenpeace activists demonstrating against boats equipping with drift nets in Newlyn

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[15] The distinct contribution made by fishing communities has also been recognised in conservation-related management plans (North Yorkshire and Cleveland Heritage Coast Steering Group, 1992, section 12; Countryside Commission 1992, 3).

[16] FN, 14 Dec 1990, 14-15 & 7; FN, 18 Jan 1991, 20; See appendix 5 lines 10-33.

[17] FN, 30 Nov 1990, 26-7; FN, 14 Dec 1990, 12.

[18] FN, 31 Mar 1990, 3, FN 17 Aug 1990, 24.

[19] 'The Shame of our Seabed', *Green Magazine,* Oct 1990.

prompted *Fishing News* (29 Jul 1990, Editorial) to call for contributions to a fighting fund to combat conservationist propaganda.[20] The *Daily Telegraph* (19 Mar 1990, 16) carried an article titled "How trawlers are raking the North Sea to death". However, national reportage of the tragic loss of three fishing vessels in accidents during 1991 illustrates something of the dual role of villain and victim occupied by fishermen in the media (*e.g. The Independent*, 5 Oct 1991, 8).

The above is only a sketch of some of the major difficulties confronting fishermen. Added to the above must be a widely accepted fall in fish stocks (Banks 1994, 53; Harrison 1994, 49-50), marine pollution, rising fuel prices[21] and increasing competition from foreign vessels - a problem which will be returned to below (see section 5.6.1, 185). While the residual strength of many communities on a social level is evident, many young people are being attracted away from a life in the fishing boats. The industry is, therefore, beset by social as well as economic problems.[22] A recent editorial in *Fishing News*, spoke of "...fishermen throughout the country who have their backs to the wall and their communities at risk" (FN, 18 Jan 1991, Editorial). Similar assessments of the state of the industry and phrases such as, 'raw deal' are occurring with increasing regularity in the fishing press. No analysis of the socio-economic factors which have combined to create the current situation is offered. The essential fact is that the fishing industry perceives itself as an industry under intense pressure (see fig. 148).

In recognition of the above points, it is considered axiomatic that an ideal management strategy will result in effective conservation of the integrity of the archaeological resource without major

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[20] A subsequent Greenpeace campaign 'Fish For Tomorrow' which focused on matters of shared concern such as discards, industrial fishing and more consistent regulation, appears to have enjoyed considerable support from sectors of the fishing industry (FN, 23 Aug 1991, 28).

[21] FN, 26 Aug 1983, 1; FN 18 Jan 1991, 1.

[22] Tarvit, pers.comm.

interference with the legitimate business of other sea users. It is also emphasised, in the context of what follows, that the concept of the site as a unit of interest, with the attendant implications of defined, discrete boundaries, is a particularly limiting one (see section 4.4, 134). Many known sites are in fact very imperfectly known as regards the true distribution of related material. Similarly, the impact of fishing activity is likely to be equally severe on archaeological events, such as anchorages or submerged landscapes which defy convenient delineation. The use of alternative terms, however, tends to introduce awkward verbosity. The word 'site' is therefore used for convenience to refer to a known concentration of material without any implication that all the material relates to one event or that the actual limits of the distribution have been unequivocally established.

## 5.2 Modification of Fishing Gear

In section 3.1.12 it was concluded that many types of fishing gear in current use have the potential to decrease the range, quality and coherence of archaeological material on the seabed. If fishing gear could be rendered harmless to archaeological material then the stated ideal of achieving archaeological conservation without major interference with fishing activity may be attainable. However, the fishing community has, in the past, been wary of externally proposed changes in gear design perceived to emanate from people with little knowledge of, and no sympathy for, the business of fishing. The prevailing attitude seems to have been that the gear in use was finely tuned and that small changes could create significant problems (ISC 1908, q.1805, 63.). Goodman and Lawton (1959, 372) indicate that, if modifications are to be made at all, they must be seen to improve catches. This point is emphasised by Foster (1976, 3) in his description of the requirements put forward by fishermen during the developmental stages of a new trawl design.[23]

Examples can be found of successful imposition of conservation related modifications. The late 1970's saw the development of intensive shrimp fisheries result in a high rate of mortality among sea turtles on the southeastern coast of the United States (Watson & Seidel 1980, 1). The problem was highly visible and emotive as dead turtles were found on holidays beaches. Various strategies for reducing mortality were explored. Enforced modification of fishing gear by the addition of a Turtle Exclusion Device near the codend of trawls was chosen (Seidel 1979; see fig. 93). It was acknowledged that some reduction in catch would result (Watson & Seidel 1980, 6-7). Similar technology has now been applied to channel clearance dredgers (Workman 1989, 31-33). These measures met with considerable resistance from

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[23] A reduction in the weight of catch does not necessarily equate to a lower value - a smaller, more selective catch may be worth more.

fishermen which included blockades of navigation channels which had to be broken up by the US Coastguard.[24]

Fisheries regulations have provoked not dissimilar protests in the UK (see section 5.6.1, 185-6) and elsewhere in Europe (FN, 8 Nov 1991, 1). The factors which may encourage such storms to be weathered by administrators rather than avoided are diverse and likely to be case specific. Damage to wreck sites is not an issue of immediate concern to the general public - the attrition is invisible to non-divers.

The ideal solution, therefore, is a modification which prevents damage to archaeological material and demonstrably improves catching power to the extent that it will be adopted voluntarily.

### 5.2.1 Potential Modifications

An examination of available information does not suggest that appropriate modifications are available. Minor modifications to elements of beam trawls have been implemented. These include rounded beam heads (RTC 1885, 443) and the adoption of fender bars and double bridle arrangements to reduce impacts on pipelines (de Groot 1977, 4; de Bruin 1979; see fig. 94). However, the overall design, weight and average towing speed of beam gear make it unlikely that such modifications will significantly reduce damage to archaeological remains.

Modifications to otter boards intended to reduce damage to telegraph cables have been proposed. An otterboard with rollers on the bottom was patented but never used widely (ISC 1908, q.1665, 56;62). Tripping ropes to allow clearance of fouled boards were suggested and the General Post Office carried out some experimental design work (ROSF 1924, 74; ROSF 1925, 58). The Western Union Telegraph Company suggested that trawlers do away with boards altogether and utilise pair trawling

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[24] Giesecke & Finegold, pers.comm.

techniques.[25] The same company also stated that oval otter boards were less likely to snag and impact obstructions (*ibid.*, 374 & fig. 1, 373). Despite this activity, no widely adopted modification to boards resulted.

In section 3.1.3 variation in the performance of different boards in contact with obstructions was discussed (see fig. 31-2). The Rectangular Vee board may be most appropriate for use in archaeologically sensitive areas. Unfortunately these boards have a poor spreading action (holding the mouth of the net open). They are preferred for specialised applications, such as prawn trawling.[26] The use of drogues to provide the required spreading action rather than solid boards provides a radical alternative. Such a rig is thought to be less robust than a conventional arrangement but no more difficult to deploy.[27] However, many fishing operations require the trawl doors to create sand clouds to herd the target species towards the net, a feature not offered by this variant.

Following a realisation that anchor seining (see section 5.5.1) was linked to disturbances of cables, some attempt was made to modify the gear deployed (ROSF 1929, 66). A rise in the popularity of non-anchor seining and mid-water fishing has perhaps done more to reduce impact related to this method than any changes to the equipment.[28]

Section 3.1.4 and video clip 2 highlight the fact that bobbin-based ground gear permits tows over rough ground but that the potential for modified trawls to pass harmlessly over archaeological material should not be over-emphasised. Additionally, the gear's relatively poor efficiency in catching flat-fish on finer ground would make it unpopular as a generally

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[25] The method involves using two vessels to tow and spread the net (Goodman & Lawton 1959, 373).

[26] Main, pers.comm.

[27] Galbraith, pers.comm.

[28] Prescott, pers.comm.

applied modification.[29] Modifications to beam trawl ground gear have been suggested (de Groot & Appleton, 1971). These include replacement of chains with electronic ticklers made of stainless steel (Stewart 1976, 21; Stewart 1978). However, no commercially viable system has resulted which provides advantages in the context of archaeological heritage management.

The main factor affecting pressure derived from the trawl net on the seabed has been identified as speed of tow (ICES 1988, 21); increased speed increases the amount of lift generated by the gear and so reduces downward pressure on the sediment and any material on it.[30] Since gear performance is greatly enhanced at optimum towing speeds fishermen are unlikely to fail in this respect deliberately. However, careful selection[31] and rigging of nets can greatly reduce the contact between the net and seabed or obstructions (Foster 1976, 3-12; Corrigall & Watson 1977; West 1987, 630).

Recent conservation oriented proposals include a requirement for panels of square (as opposed to diamond) mesh in and around the codend (Robert 1986, 15). This, unlike diamond mesh, does not distort under tow and therefore facilitates the escape of juvenile fish (FN, 6 Apr 1989, 20-23; See fig. 95). A more open mesh may also allow more mud *etc.* through, reducing net drag and damage to the seabed.[32] However, the optimum placement of a square mesh panel for the purposes of reducing drag may not be the same as that required for facilitating the escape of juvenile fish.

Developments in auto-trawling may be of some interest. Sensors linked to winches automatically reduce tension in the event of a

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[29] Galbraith & Main, pers.comm.

[30] Video clip 1, appendix 2; notice the light tracks left by a modern, heavy beam trawl in normal operation.

[31] In trials the "Lossie J" trawl cleared boulders 2m high (Galbraith, pers.comm.).

[32] Galbraith & Main, pers.comm.

snag and thus, coincidentally, reduce the force of impact and subsequent pulling strain exerted on an obstruction, (FN, 30 Mar 1990, 11; FN, 23 Nov 1990, 8-9). Previously unfishable grounds have been exploited thanks to this technology which also incorporates forward looking sensors which can detect shoals and obstructions (FN, 20 Sep 1991, 14). This system, which can be fitted to vessels of all sizes, may well assist in reducing damage to prominent features. However, more ephemeral and low relief deposits may not register sufficiently on the sensors to be afforded protection.

Although concern exists relating to the impact of scallop dredging gear on the potential longevity of the fishery itself, modifications developed to date focus on reducing damage to the gear rather than the seabed or catch. Spring-loaded toothed bars allow impact on solid obstructions to be absorbed and so cut down maintenance time (Chapman & Kinnear 1977, 1). Recent attempts to limit the impact of scallop dredging have concentrated on reducing the total width of the array of dredges towed; this option was chosen over restrictions on towing time and engine power as being the easiest to police (FN, 8 Nov 1991, 7). The weight and action of the gear make it unlikely that significant modifications will emerge.

### 5.2.2 Voluntary Change in Effort

Some willingness to experiment voluntarily with alternative methods of fish capture can be detected, for example, automated longlining. As noted in section 3.2.3 this gear has little impact on archaeological material. The number of fishing vessels taking up this method has increased significantly in Scotland and to a lesser extent in southern waters (*Scottish Fishing Weekly*, 9 Nov 1990, 6). What reasons can be found to account for this?

Longlining, in comparison to trawling, is highly selective. Fewer immature fish are caught and specific non-quota species, such as dogfish, can be targeted (Johnstone & Mackie 1985, 12-13; FN, 20

Sep 1991, 22). Reliable automatic line-baiters and reels have removed much of the drudgery associated with traditional lining (*Scottish Fishing Weekly*, 9 Nov 1990, 8-9) and new materials for lines and hooks have increased efficiency. Such gear can be fitted to a wide range of vessels and in some variants can be dismantled quickly and easily for temporary or seasonal shifts to other types of fishing.[33] Moreover, comparison between catches from a trawler and an automated liner reveal a larger saleable catch for the latter for a third of the fuel required by the trawler (FN, 19 Apr 1991, 14). The quality and therefore the value of catch is also improved, fish are not crushed in the codend of a trawl but handled individually. Some specific food markets require unbruised fish, so a niche can be exploited. Efforts are being made to develop techniques to allow the fishery to diversify to allow year-round activity (FN, 18 Jan 1991, 6).

While environmental concerns may prompt official bodies to promote its adoption (*Scottish Fishing Weekly*, 9 Nov 1991, 9) the appeal of this method to fishermen seems rooted in self interest. Support for any particular modification or restriction may also result from it being perceived as the lesser of two evils. Square mesh panels[34] are being promoted by some fishermen at a time when disenchantment is growing very rapidly with existing conservation methods (NFFO 1993).[35] There is no intention to suggest that concern for stock conservation within the industry is not genuine. But enthusiasm for changes to gear may be confined to modifications that will benefit the fishermen directly (FN, 6 Apr 1990, 6). It is unlikely to encompass issues such as conservation of archaeological resources.

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[33] Johnstone, pers.comm.

[34] For example FN, 6 Apr 1990, 11; FN, 9 Nov 1990 2; FN, 11 Jan 1991, 12. However, subsequent developments and controversy over the optimum placement of such panels (FN, 1 Feb 1991, 8-9; FN, 6 Sep 1991, 2) has lead to temporary suspension of their official adoption; this emphasises the difficulty of introducing technical modifications.

[35] FN 18 Jan 1991, 1; FN 18 May 1990, Editorial; FN 12 Feb 1993, 1

Proposals involving changes to gear are complicated by the question of who will pay for appropriate modifications should they be identified. In addition, technical regulations are notoriously difficult to enforce once imposed. Tacit acceptance of this by authorities appears to have inhibited the application of promising modifications in the past.[36] Indeed, European Commission auditors reported in 1993 that expenditure directed at developing and implementing technical regulation was not providing value for money.[37]

Attendant difficulties appear to negate the value of any modifications unless they make a very significant contribution to archaeological conservation. However, commercially viable methods of fishing can be adopted, not involving mobile gear, which appear to have limited impact on archaeological deposits and have the added bonus of serving nature and stock conservation interests.

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[36] Gear technicians at the Marine Laboratories in Aberdeen designed a highly selective net (Main & Sangster 1986; see fig. 96). Despite support from DAFS and considerable publicity, the fishing community failed to adopt it on a voluntary basis - due to uncertainty about catch levels and individual unwillingness to be the 'first to take a risk'. Fishery authorities refused to make it mandatory because they claimed it would be too difficult to police (Main, principal designer of the separator panel trawl, pers.comm.). However, renewed interest has been expressed in the trawl as an 'industry led' alternative to other, less possible conservation regulations (FN, 15 Apr 1994, 24).

[37] Lockwood, pers.comm.

# 5.3 Physical Protection of Deposits

If fishing gear cannot be modified, can archaeological material be given physical protection from impact so that fishing can continue in close proximity to, or even over, the deposit? This review will outline the major elements of potential options. Technical information will be restricted to points relevant to an assessment of the viability of specific strategies as part of an archaeological heritage management programme. The degree of protection afforded by individual methods is a primary concern but cost will be influential in determining whether or not a specific technique will actually be applied. Expense may be incurred in site preparation, implementation and on-going maintenance and monitoring. In section 2.2 (32) it was emphasised that, ideally, the full range of material and spatial relationships within a deposit should be conserved and potential changes to the deposit deriving from the protective strategy itself should be identified. Finally, ease of future access should be also considered.

## 5.3.1 Protective Structures

Within the oil industry considerable attention has been focused on rigid structures which offer both protection against fishing gear and 'overtrawlability' (Heal & Naughton 1991, 30-31). However field tests have shown that designs which were deemed overtrawlable in tank tests have snagged gear in practice (Ingram 1991, 35). Further, while the design of protective structures is advanced they are intended to afford protection to discrete locations on the seabed and not material dispersed over a wide area. Figure 97 shows a typical design (non-overtrawlable) featuring open sides to allow easy access for maintenance. The table below indicates design parameters relevant to offshore gear.

| Type of Fishing | Effective Mass tonnes | Impact Velocity knots | Snag Load tonnes |
|---|---|---|---|
| Otter Trawl (Door Impact) | 2.05 | up to 7 | 60 |
| Beam Trawl (Impact on Corner) | 5.36 | up to 7 | 100 |
| Seine Trawling | | | 8 |

(Heal & Naughton 1991, 31)

Even allowing for the development of smaller and lighter variants for inshore use, cost is likely to be an obstacle to widespread application of this technology to archaeological problems. Indeed, installation and removal costs of such structures, which can weigh from 18 to 800 tonnes, regularly exceed the cost of design and construction (Daeschler 1993, 48).

Viable options for protecting more dispersed sites may include the placement of concrete matting over the deposit. This would provide a high level of overtrawlability for low relief deposits but would be of limited used where substantial structural remains exist on the seabed. Sea Mark Systems, Aberdeen, have produced a range of jointed concrete units which can be adapted to a very wide range of shapes and situations (see fig. 98). The cost of such material is (1991) £50 per m$^2$. In shallow water (up to 30m) a vessel suited to installing the units would cost £30 -50,000 per day. 40-50m$^2$ can be laid on pipeline in an hour by experienced technicians. Installation requiring more delicate placement or involving non-standard units would be considerably slower.[38]

Protection of isolated features through use of rigid structures is clearly possible at a cost. However, little data concerning the compression of sediment and thus archaeological deposits beneath such structures is available.[39] Compression can be reduced by

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[38] Duncan & Gibson, pers.comm.

[39] Reid, pers.comm.

preparatory sandbagging but this will add to the cost. Other problems include potential for scour around rigid structures on the seabed and lack of ready access to the deposit at a later date. Lighter, flexible protective mats may provide an option with wider potential application. The Scottish Hydro-Electric Board is currently researching light-weight protective matting for power lines but precise details are sparse due to commercial concerns. [40]

### 5.3.2 Burial

Burial under gravel is widely used in the oil industry to protect low relief installations from trawling. It has the advantage of relative simplicity but the disadvantage of continuing maintenance costs and restricted post-burial access. Gravel up to 6cm diameter is sufficiently dense to withstand excessive redistribution by current and swell but small enough to pass through the mesh of most gear deployed.[41] An initial covering of over 1.5m thickness is believed to be required. A less thick covering may be adequate for inshore sites as the gear threatening them would be lighter.[42] Burial is also used by the cable-laying industry but the technology is highly specialised and not appropriate to this discussion.

The cost of covering an area 30m by 60m with medium sand-gravel to a depth of 1m in a water depth of 20m-30m was estimated at £20-50,000 (1992).[43] This does not include the cost of essential pre-burial preparation such as sandbagging of prominent structural features *etc.* Costs will vary with the distance the vessel has to travel to and from the site. Use of non-local craft (specialist vessels may not be available in the

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[40] Main, pers.comm.

[41] Tarvit, pers.comm.

[42] Stewart, pers.comm.

[43] Smith, pers.comm.

immediate area) will increase cost significantly. The availability of a local source of aggregate is also highly desirable. Gravel won from an area where certain shellfish parasites are rife may introduce the disease to the area around the dump site. This would have disastrous consequences for the local fishing industry and public relations. The need to win and wash non-local material would increase costs substantially. Operations on sites shallower than 20-30m may not be significantly cheaper. Operations on deeper sites, involving the use of remotely operated vehicles to monitor gravel placement, are likely to be considerably more expensive .[44]

Subsequent monitoring and redistribution of dispersed gravel has significant cost implications and there is potential for scour around the edges of gravel-dump areas. Burial may also alter conditions within the deposit. Possible enhancement of anaerobic potential might be regarded as a positive factor but sediment compression should be assessed.

Burial can also be achieved through deployment of artificial sea-grass - originally conceived to combat scour. The fact that dense algal growth can alter current flow and lead to localised lowering of energy levels and thus increased sediment deposition is well known (Fonseca & Fisher 1986; Virnstein & Curran 1986; Eckman *et al.,* 1989). Artificial sea grass mats have been used to good effect in the oil industry. The mats are claimed to cost 20-30% of conventional scour control methods and the system has been thoroughly field tested in terms of its ability to withstand damage caused by the passage of a trawl.

Sediment depth can be increased by up to 60cm very rapidly. Unit cost (1991) is in the region of £100 per 5m$^2$. Each unit can be installed in approximately 20 minutes without the need for specialised support vessels; the mat can be delivered to the seabed rolled-up and is then deployed by divers.[45] Seabed Scour

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[44] Pointer, pers.comm.

[45] Gibson & Duncan, pers.comm.

Control Systems Ltd. manufacture a range of mats which have been installed in a variety of locations since 1987. Sand bank depth of 1.25m has been achieved in 31-45 days. The technique has been welcomed by the fishing industry as a method of protecting installations which causes little or no inconvenience to trawling activity. The National Federation of Fishermen's Organisations commented '...your company has a product that would satisfy our environmental demands where offshore structures are involved.' [46]

The mats must be fixed to the seabed by anchored lines which are fired into the sediment and penetrate to a depth of 1m. Alternative methods of fixing the mats in place may have to be developed for use on archaeological deposits. In addition, it is very difficult to extract the mats once they have been in place for some time. Concern has also been expressed over diver entanglement in the artificial fronds which raises questions concerning the suitability of this method for accessible dive sites.

Trials undertaken by the Dutch Department of Public Works And Trade in the Wadden Sea[47] have emphasised that the usefulness of such mats is highly dependent on local environment. The fronds tend to lose buoyancy when colonised by organisms such as mussels and stop functioning as sediment traps. Careful orientation in relation to prevailing current is required and effectiveness is reduced when deployed on a slope as opposed to flat seabed. As with gravel burial, coverage with artificial mats might enhance anaerobic conditions locally. While quantitative data is not available, sediment compression beneath established mats is believed to be negligible.[48]

Artificial sea-grass has been employed, experimentally, to assist in wreck conservation as a means of combating scour rather than

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[46] Letter to SSCS Marketing Manager from Mr. D.Shilling, NFFO, 31 May 1988.

[47] Maarleveld, pers.comm.

[48] Frith, pers.comm.

fishing activity. At the site of the *William J. Salthouse,* Southern Australia, a number of mats, weighted by railway track, were installed in 1990 (Elliget & Breidahl 1991, 28-29). Partial coverage of an area *circa* 30m by 15m cost approximately $100,000 (Aus).[49] The seagrass appears to have stabilised the sand bank around the site but localised scour still occurs.[50] In Florida (Skowronek 1987, 317) efforts to measure the effectiveness of stabilising a site through installation of artificial seagrass have been hampered by deliberate and persistent disturbance by vandals.

The use of sandbags may appear to provide a relatively cheap and convenient burial strategy. However, covered areas must be regularly monitored. During the excavation of a vessel in St. Peters Port, Guernsey (Rule 1990, 49), 16 tons of sandbags were used to cover an area 6m by 6m in *circa* 5m of water. The sandbags had to be replaced a number of times during the winter due to the effect of storms.

In Holland sandbagging has been employed (1991) to protect the site of 17th century East Indiaman from erosion and vandalism.[51] The structure was packed and levelled by sandbagging. Its was then covered by a layer of 1.5mm mesh heavy, nylon gauze to act as a sediment trap. Further sandbags were placed on top of this. An area of 45m by 50m was covered. It is acknowledged that this probably does not cover all the material related to the site. 5000 sandbags were used although it is estimated that half the number would have sufficed. The cost of the operation was over £10,000 (1991). The hire of a suitable work platform contributed significantly to the cost and the work was commercially contracted. Some slight scour at the edges of the protected area has been noted but sediment levels appear to have stabilised over the site.[52]

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[49] Henderson, pers.comm.

[50] Strachan, pers.comm

[51] Located 5 miles off-shore from the Frisian Islands (Burgzand Noord).

[52] Maarleveld, pers.comm.

Sandbagging has been shown to be effective in mitigating bladed oyster dredge impact.[53] However, the nature of the action of toothed scallop dredges is problematic. This gear type, with its powerful digging action would seem ideally suited to redistributing sandbags and gravel. As with other strategies discussed, data concerning chemical and physical changes to a deposit resulting from application of sandbags is not readily available.

### 5.3.3 Buoyage and Charting of Obstructions

Proposals to use buoyage to protect features on the seabed have met with mixed reactions. The Admiralty has, in the past, stated that extensive buoyage of wrecks would create a danger to navigation.[54] Cost and inconvenience to other sea users were also the Government's main grounds for refusal of requests for widespread buoyage of hazards resulting from shipping losses in the First World War (ROSF 1919-23, 135). More recently, the use of buoyage to avoid accidental impact has been suggested in relation to North Sea complexes.[55] While fishermen support buoyage of certain obstructions, the maintenance and placement of substantial buoys has been a cause of considerable friction with the oil industry.[56] Buoys deployed in the North Sea are generally very much more substantial than those that might be employed to mark the site of a protected wreck, but many of the same problems relating to semi-submerged, non-illuminated or drifting

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[53] Personal observation suggest that sandbagging on the site of the Studland Bay wreck was successful in deflecting the impact of powered oyster dredges. Disturbance to the surrounding seabed and upstanding features was significant. The sandbag covering did require rearrangement after the dredge impact (see appendix 3, section 4).

[54] For example, ISC 1908, q.814, 30; q.931, 34; q.1901-3, 66.

[55] Tarvit, pers.comm.

[56] For example, minutes of a meeting held on 28 March 1979, Murray Archive, see section 10.1.

buoys may be encountered. In addition, experience does not suggest that the presence of a single buoy on a site will deter fishermen.[57] Installing a protective ring of buoyage would increase cost and nuisance. Equally, given the known propensity for fish to gather round obstructions, advertising the location of such a concentration may serve to encourage speculative trawling with concomitant damage. Advertising the location of a site to vandalistically inclined divers may also have its drawbacks.

Provision of information in the form of charts and lists of obstructions has been a priority for both oil and submarine cable companies in attempts to establish working relationships with the fishing industry. Government fishery agencies collate information to be distributed directly to fishermen and related interest groups (McDiarmid 1977, 2-5). Every 2 weeks the White Fish Authority chart service provides lists of new obstructions to be published in Fishing journals.[58] Ensuring that new and existing archaeological sites appeared on such charts would seem to be both prudent and easily achievable. Yet delineating precise boundaries for deposits is problematic and the disadvantages of disclosure highlighted above would also apply.[59]

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[57] See appendix 3, section 4, lines 176-181.

[58] Tarvit, pers.comm. In addition the Sea Fish Industry Authority (SFIA) publish a series of *Kingfisher* charts which show seabed obstructions. The SFIA have latterly developed a new series of 'awareness' charts which show details of specific hazards, such as complexes of well heads and debris fields. These are available free of charge (Knox, pers.comm.).

[59] Guidelines accompanying the US Abandoned Shipwrecks Act 1987 note that the Act requires that adequate notice should be given to fishermen concerning the location and nature of historic wrecks in an area in order to encourage avoidance (ASA 1990, section 6(b)). This is allied to encouragement to State and Federal authorities to conduct the appropriate survey and inventory work to facilitate characterisation of the resource (*ibid.*, 50129-30).

## Discussion

No single method of providing physical protection to archaeological material on the seabed can be identified which is not attended by problems of either a financial or practical nature. These problems increase when the deposit of concern is dispersed or high-relief. A lack of data concerning potential effects of specific protective strategies on deposits is also apparent. However, established methods and technical expertise is available which could be utilised to protect discrete areas. The fact that cost may limit such protection to relatively few sites (and possibly to a few features within such sites) has significant implications for a management programme involving this strategy. These are discussed further below (see sections 5.6, 178 & 9.4.1, 288).

## 5.4 Closed Areas

An alternative to modification of gear and physical protection of sites is to seek to prevent the occurrence of impact through exclusion of fishing activity. This involves a significant departure from the stated ideal of co-existence and avoidance of substantial interference with the legitimate business of other sea-users. In addition, a review of attempts to police fishery related legislation indicates that even the existence of statutory restrictions is no guarantee of actual protection for an area.[60] The fishing community's own view of the problem is worthy of note. In the 1920's the Jury of the oyster fishery in the Medway refused to undertake the '...impossible task of policing the activities of other fishermen.' (Coombe 1979, 36).

The Protection of Wrecks Act 1973 (POW)(DOT 1986; Firth 1993, 69-70) provides for the protection of charted areas of seabed around specific points and is applied to wreck sites of archaeological, historic or artistic importance.[61] At least 4 protected sites are known to have been disturbed by fishing gear in the recent past. If vigorously policed, such exclusion zones may be effective. However, the scale of effort required to police fishing activity generally indicates something of the resource problem facing archaeological heritage managers wishing to safeguard a number of sites through intensive monitoring.[62] Despite this,

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[60] In the early years of this century inshore waters began to receive protection from depredation by steam trawling but transgressions were frequent (Jenkins 1920, 171; Peak 1985, 64). In the 1970's British beamers were allowed to fish within the 3 mile limit while foreign (French and Spanish) had to stay on the 6 mile limit but were apparently notorious for not doing so (*ibid.*, 117). A review of activity in Scottish Inshore waters reveals a similar situation. The Herring Fishery (Scotland) Act of 1889 provided extensive powers of closure of territorial and extra territorial waters (Jenkins 1920, 164-5). Unfortunately this restriction was ignored by foreign vessels and Scottish vessels registered to foreign ports.

[61] See appendix 3, lines 1-95.

[62] This is highlighted by the establishment of the remodelled Scottish Fisheries Protection Agency. Launched in 1991 with a £10.3 million first year budget and a staff of 250, the agency operates 4 off-shore patrol vessels, 2 fast patrol vessels for in-shore work and two aircraft (FN, 19 Apr 1991, 2).

measures taken to protect the remains of the barque *Zanoni* in Southern Australia, demonstrate that individual sites can be afforded some measure of protection.[63]

The wreck of the *Zanoni,* lies in 18m of water and, in places, stands 8m proud of the seabed. The superstructure is of wood and iron. The site has been extensively sandbagged to reduce the effects of any impact by trawled gear. Regular monitoring work is conducted which has included the mooring of inflatables overnight to observe activity.[64] Significantly, the conservation effort does not rely on legislation alone. After discussion with the fishing community, a 30m long derelict barge was sunk nearby to act as an alternative attraction to fish and fishermen.

## 5.4.1 Implementation of Closed Areas

The experience of nature conservation agencies regarding attempts to restrict fishing activity in specific areas offers valuable insights relating to three fundamental questions; why do fishermen object to closed areas; why might they support their creation in certain circumstances; and how might that support be engaged?

The Statutory Marine Reserve at Lundy (1986) was created under the terms of the Wildlife and Countryside Act 1981 (see figs. 99-100).[65] The Act does not allow the creation of any bylaws that

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Statements at ministerial level acknowledge that even annual expenditure of £50,000,000 on fisheries protection in the UK is not achieving effective enforcement of quotas and other regulations (*The Guardian,* 9 Jul 1993, 4).

[63] I am grateful to the State Archaeologist for South Australia, Mr. Jeffrey and Mr. Harvey of the Victoria Archaeological Survey for providing information on this project.

[64] Draper, pers.comm

[65] Information presented here resulted from interviews with Mr. Gomm, the Nature Conservancy Council official who co-ordinated the Lundy project and with Mr. Gash who undertook the co-ordination of the negotiations surrounding the Skomer reserve. I am very grateful to Mr. Gomm for making the original proposals and later consultative documents and working papers available to me.

interfere with the exercise of any function of the Sea Fisheries Committees (SFC) or other local authorities.[66] In practice, the consent of any interest group involved, or potentially affected, is required before a reserve can be created (Kayes 1987, 48). Thus the local Sea Fisheries Committees had to be persuaded to pass bylaws to restrict commercial fishing in the proposed reserve.[67] A conservation officer was posted on the island for 6 months to liaise with fishermen as negotiations for the creation of the reserve continued. The SFC proved intransigent and the minimal concessions that were won are believed to have resulted from pressure exerted on the SFC by its parent Government department.[68] Mobile fishing was effectively only banned in areas where that method had not been prosecuted regularly anyway due to rough ground.

Throughout the process, fishermen proved unwilling to surrender access to areas of seabed, even if the areas concerned were not exploited at the time. They argued that changes in circumstances may make it desirable to exploit such areas in the future. Despite this, individual fishermen, via the fishing press, have suggested the creation of artificial reefs and closed areas (FN, 11 Jan 1991, 12). Fishermen's organisations have also proposed extensive closed areas (NFFO 1993). The motivation for such suggestions generally derives from the widely acknowledged need to re-stock grounds which have been heavily exploited. SFC support for the creation of a statutory reserve at Skomer (Gash 1990; see fig. 99) is believed to have been partly due to anticipation of the reserve acting as a nursery.[69]

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[66] For a description of Sea Fisheries Committees see appendix 5, lines 43-75.

[67] A review of the pressures and interest group lobbying which resulted in the weakness of the Wildlife and Countryside Act of 1981 (WCA) is provided by Gibson (1989, 702-703). He suggests that major resulted from concessions to industrial fishermen and describes the Government's amendments to the WCA 1981 as characterised throughout by compromise and qualification. Problems caused by a lack of political will are also highlighted by Gubbay (1990, 7).

[68] Gomm, pers.comm.; Kayes (1987, 50).

[69] Gash, pers.comm.

Spillover is the term used to describe enhancement of local fisheries by emigration of adults and large juveniles from a closed area. It may appear that closed areas created for archaeological purposes can be promoted as catalysts for such regeneration, but the concept must be examined critically. There is good evidence that spillover does occur although comprehensive data is lacking (Rowley 1992, 26). Species abundance has certainly been shown to increase dramatically within protected areas. At the Leigh Reserve in New Zealand the rock lobster population has increased by a factor of 8 and the upward trend still appears to be continuing after 15 years of protection.[70]

Outside such reserves, however, the magnitude of a possible increase in local catches is impossible to predict. What does seem clear is that, as a function of non-larval movement of species, spillover will probably not significantly increase catches other than very near the boundaries of the closed area. This has implications for policing. If fishermen are to gain advantage from the closed area, an essential prerequisite in this context, they must fish very close to the limits of the protected zone. This promotes intensification of impact on a restricted area of seabed. It also increases the chance of accidental infringement through genuine navigational error. The size, shape and location of such reserves must also be determined with full regard to the preferred habitat and behaviour of the target species. It may be very difficult to reconcile these parameters with boundaries based on archaeological priorities.

Recent success in achieving some degree of control over fishing activity seems to have resulted from involvement of the fishing community rather than external imposition of restrictions. In December 1992 part of the Wash, in Norfolk, was designated as a National Nature Reserve. Substantial progress has also been made in developing a management plan for the area through an English Nature estuary management initiative (English Nature

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[70] Laffoley, pers.comm.

1993d). The reserve includes inter-tidal and sub-tidal areas. In addition, a non-disturbance area and a closed season for cockle dredging have been established with the agreement of the fishing community (but implemented through SFC bylaws).[71]

This is in stark contrast to previous, fierce opposition to similar proposals (FN, 7 Aug 1990, 24 ). It is believed that progress was made because fishing interests were given a major role in drawing up discussion documents relating to their activities.[72] No attempt was made by English Nature to impose direct restrictions, rather a consensus was sought and dialogue has been maintained.[73] The appointment of a national fisheries liaison officer in 1993 emphasises the perceived value of good communication with the industry.[74] The area covered by the reserve is leased from the Crown Estate by English Nature and a number of co-lessees including the Eastern Sea Fisheries Committee. The terms of the lease require the creation of a board composed of various interest groups to consider any management proposals. It cannot be doubted that substantial compromises are involved in achieving such success, but a working relationship with the fishing community is clearly possible.

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[71] Amos, pers.comm.

[72] An emphasis on liaison, and regulation of activity on a voluntary basis where possible, is evident in the guidance supplied by English Nature to officers concerned with drawing up management plans (English Nature 1993b, 44-55; 1993d, 15).

[73] Laffoley, pers.comm.

74 The job specification was designed to attract someone from within the industry (a former MAFF employee was selected) and the post was graded and advertised in such a way as to ensure that working fishermen could apply for it (Laffoley, pers.comm.).

## 5.5 Working with the Fishing Industry

The following section will consider whether successful strategies for protecting specific areas of seabed while co-existing with the fishing industry have evolved outside of nature conservation activities. The offshore oil industry and submarine cable industries have been chosen for study. Activity related to offshore gas and aggregate extraction could have served equally well as examples. Oil installations are automatically provided with 500m exclusion zones under the Mineral Workings and Offshore Installations Act, 1981. Submarine cables also enjoy protection under law (see below).[75] Yet an examination of relations with the fishing industry does not indicate that legal remedies are sufficient when seeking a cure to the problem of fishing related interference with the seabed in designated areas.

### 5.5.1 Submarine Cable Companies

The first telegraph cable was laid across the channel in 1850. Within 24 hours it had been broken, reportedly by a beam trawler from Boulogne sur Mer (de Bruin 1979, 1). Thus the battle lines were drawn at an early stage in the relationship between submarine cable operators and the fishing industry.[76]

A series of international meetings and enquiries sought to address this potential conflict of interest. The *International Convention for the Protection of Submarine Telegraph Cables* was signed in 1884 (ICP 1884-5). A system of compensation, payable by the owner, for fishermen who sacrificed snagged gear rather than risk damage to a cable was formalised (*ibid.*, article VII, 8). Penalties for damage caused to cable wilfully, or through culpable

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[75] Legislation relevant to aspects of the case studies presented here is briefly reviewed in appendix 4.

[76] Early cable technology and cable laying operations are described by Garrat (1950).

negligence, were established; these persist today in modified form. Cable owners also pressed for restrictions on trawling activity.[77] While the Government were willing to support inspection of gear, on the basis that poorly maintained gear posed a greater threat to cables, formal enquiries stressed the role of communication and education in resolving any problems (RBA 1914).[78]

"What is required, above all things, is a friendly understanding between the two interests; and the committee are convinced that a great deal can be done by co-operation and efforts at mutual accommodation." (RISC 1908, X).

However, some indication of the pragmatic considerations behind official promotion of harmony and dialogue can be found in this refusal to restrict trawling activity:

"They (the committee members) consider that it would be an unjustifiable interference with a business that represents a capital of several millions, gives employment to a body of hardy and industrious men and supplies a substantial part of the food of the people; while its enforcement would involve police measures of a difficult and costly nature." (RISC 1908, X).

The compensation scheme, however, was not an immediate success. It was concluded that fishermen preferred to haul up and risk damage to gear and cable rather than suffer the delay and uncertainty of the compensation process (RISC 1908, q.64, 4).

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[77] *Report of the Interdepartmental Committee on Injuries to Submarine Cables with Evidence and Appendices* (ISC 1908, viii). The telegraph companies suggested; banning trawling in large areas around cables particularly to the west and southwest of Ireland; trawl gear should be altered to be less damaging; trawlers should be compelled to trawl in the same direction as the lie of the cables and not across it.

[78] *Report of the Board of Agriculture and Fisheries in Relation to the Complaints of Damage to Submarine Telegraph Cables by Trawlers.* (RBA 1914). The Board of Agriculture and *Fisheries Annual Report* for 1913 [Cd 7449] (34-39) provides a concise summary of this conference, the background to the problem and the resolutions passed along with supporting statistics. See Jenkins (1920, 214-221) for an account of education and the fisheries.

Between 1908 and 1912, 137 interruptions to cables were reported. Of these, 56 were attributed to trawl gear, with a further 26 suspected to be caused by fishing activity. The same period saw only 32 claims for compensation (PCL 1914, 7). The number of interruptions to telegraph cable attributed to trawler damage can be traced through the statistical records contained in the Ministry of Agriculture and Fisheries Annual Reports on the Sea Fisheries (ROSF).[79] Reports in the mid 1920's reveal a large increase in disturbances which cannot be linked to a similar increase in trawler activity[80] but, overall, little change can be detected in the situation in the following decades. Goodman and Lawton (1959, 373) state that, despite the compensation system being in place, regular instances of fouled cables being cut with axes and acetylene torches were suspected:

"Anonymity has given these fishermen freedom to flaunt the regulations with impunity and some of them are not loathe to do so wherever and whenever the cables of the repair ship are an obstacle to good fishing."

More recent (late 1970's) upsurges in the number of reported faults seem to relate to new, heavier beam gear cutting through the tops of sand waves which would previously have protected cables (de Bruin 1979, 1). Aitken (1977, 4) concludes:

"International laws and conventions are forgotten when the fisherman is 'on fish'. Publicity put out on cable protection is not heeded if the result of it is going to be no catch."

The compensation scheme for sacrificed gear continues to operate. As currently applied, the scheme is regarded by the cable industry as an important means of fostering a working relationship with fishermen. Yet its contribution to cable security is not thought to be great. Application for compensation is

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[79] Prior to 1918 the reports containing such information were distributed by the Board of Agriculture and Fisheries ([Cd 7449]).

[80] ROSF 1924, 74; 1925, 58-60; 1931

believed to be a last resort, turned to when all attempts to free the gear have failed.[81] Normal practice is to risk damage to the cable and also claim compensation. Those who administer the scheme feel that the desire to attempt to retrieve equipment and carry on fishing overrides any feeling of responsibility towards the cables on the seabed.[82]

Since the 19th century cable companies appear to have tried to reduce the chance of damage by using heavier cable and attempting to avoid popular grounds (ROSF 1924, 74). Current Telecom policy is to regard burial to 60cm depth, where possible, as the primary protective measure; this guards against dragging anchors as well as fishing gear. Routing will be radically altered to take advantage of suitable sediment and permit burial of as great a proportion of the cable's length as possible. In the recent past, Telecom have re-routed cables to avoid grounds where particularly damaging gears, such as scallop dredges, are deployed[83] and much effort is directed at publishing details of cable locations. The cables themselves have also become better armoured. Current designs can withstand pulling strains of around 60 tonnes.[84] Such developments seem to indicate acceptance of the high probability of eventual trawler impact - despite the fact that cables are protected under law through the conventions signed in 1884/5 (see above).

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[81] Tarvit, pers.comm.

[82] The annual bill for the compensation scheme is *circa* £100,000. Numbers of claims for compensation and the level of minor faults in an area rarely match. In the southern Noth Sea, robust gear capable of snagging a cable with no interference to continued fishing is deployed. Actual cable faults greatly exceed the number of claims submitted. In the Irish sea, where lighter gear is deployed and a considerable amount of charted, redundant cables exist, the number of claims far exceeds the number of faults experienced (Myall & Broadbridge, pers.comm.).

[83] Myall & Broadbridge, pers.comm.

[84] Bracksman, pers.comm.

## 5.5.2 The Oil Industry

A relatively recent conflict of interest has arisen since the onset of major exploitation of the North Sea oil fields and the concomitant construction of major installations on prime fishing grounds.[85] The legal questions arising from this conflict, and the socio-economic consequences for the fishing industry in Scotland, have been the subject of considerable discussion. However, consideration of available information relating to the actual practice of co-existence, as opposed to the principles involved, indicates that significant problems remain unresolved.

The fishing industry's complaints against the oil industry include damage to gear through snagging dumped debris; loss of access to fishing grounds; fear of pollution; and competition for manpower. The oil industry appears to regard commercial fishing as a potential risk to installation security. Miles and Geselbracht (1987, 163) state that as far as sea use is concerned:

"The most widespread and intensive conflicts relate to oil and gas activities but this is also the area where approaches to conflict resolution seem to be most highly developed. Participants seek to find ways to accommodate each other."

Comments made by leading figures in the fishing community do not, however, suggest a harmonious relationship between the industries (FN, 6 April 1990, 30). Rather, the economic strength of the offshore industry is perceived as sweeping fishing interests aside. A refusal by oil companies to make substantial concessions to fishing interests in the early years of North Sea exploration seems to have set the broad pattern for later developments - despite some recent, high profile attempts at liaison.[86]

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[85] From 1967 to 1976 the number of wells drilled rose from 7 to well over 300 (MacArthur 1976, 27). Detailed statistics on current and projected oil related developments off-shore can be found in the annual report to parliament by the Secretary Of State for Energy, *Development of the oil and gas resources of the UK.*

[86] FN, 6 Sep 1974, 5; FN, 4 Oct 1974, 7; FN, 18 May 1990, 2.

"In practice in the North Sea, the only matter in respect of which the interests of the fishing industry have been a restraining influence on the development of the offshore petroleum industry is in relation to the route of certain pipelines. Otherwise offshore petroleum development has gone unhindered."
(Churchill 1989, 69)

The conflict is perhaps best viewed through the perspective of the disruption caused to an established industry by a new, major industry with very specific requirements concerning seabed use. The Submarine Telegraph Act of 1885, extended by the Continental Shelf Act 1964, has been used to compensate fishermen who deliberately abandon snagged gear to avoid risking damage to sea-bed installations (Dyk 1974, 3). However, the industry was able to resist calls[87] for compensation for gear damaged by dumped debris until an oil drum, bearing a company logo, which had been deliberately punctured was recovered in a net off Peterhead in 1974.[88] Negotiations opened for the establishment of a fund to compensate fishermen for damaged, as opposed to sacrificed gear, with the United Kingdom Offshore Operators Association (UKOOA) (FN, 11 Dec 1974, 7). This became operational in July 1975.[89]

This system continues to operate today. The fund is, administered by a committee organised by the fishing industry (MacArthur 1976, 29) and certain rules apply when settling claims.[90] The table below shows the nature of payments made in

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[87] Increasingly strident complaints (FN, 31 May 1974, 5; FN, 12 Jul 1974, 2) culminated in the banner headline, 'Fishing And Oil: High Time For A Showdown,' (FN, 22 Nov 1974, 8-9).

[88] Tarvit, pers.comm.

[89] Minutes of Agreement between The Fishing Federations and The UKOOA, Murray Archive, see section 10.1.

[90] No claim can be made if the damage occurred within the 500m exclusion zone around oil installations. No payment results from damage caused by snagging a well-head as these are clearly marked on charts. Pipeline snags will be paid for, but the total cost of damage will rarely be paid in full as

1977-8.[91] Details of payments made in subsequent years have not been made available.

**Claims for compensation related to fishing gear damaged by oil-field debris 1 Jan 1977 - 31 May 1978**

| | Number | Gear | Hardship |
|---|---|---|---|
| Total claims reported | 151 | £96,791 | £61,685 |
| Referred to oil companies | 126 | £82,113 | £51,757 |
| Settled by oil companies | 58 | £24,147 | £3,105 |
| Not accepted | 42 | £36,564 | £15,852 |
| Under consideration | 26 | £18,626 | £12,036 |
| Cases referred directly to UKOOA fund | 25 | £14,678 | £9,928 |
| Settled from fund | 40 | £14,579 | £2,800 |
| Under consideration | 14 | £13,960 | £9,695 |
| Not accepted by committee | 1 | £40 | £70 |

The UKOOA did not appear to intended the fund to be used to compensate for consequential loss (that is, lost fishing time due to gear damage as well as the cost of the gear). However, the committee seem to have retained a degree of flexibility in this respect.[92] The scale of the debris problem is indicated by the fact that payments in excess of £100,000 a year are funded by the UKOOA.[93] However, the sums paid out are not believed to reflect the actual level of financial loss suffered. The commitment of the

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pipelines are also charted (Draft paper on the administration of The Compensation Fund, Murray Archive).

[91] FOOCG/78/5; Murray Archive.

[92] Draft paper on the administration of The Compensation Fund, Murray Archive.

[93] Tarvit, pers.comm.

industry to the scheme is widely questioned and a withdrawal of financial support is feared.[94]

Little progress has been made with regard to the question of compensating fishermen for loss of access to grounds.[95] The Fisheries and Off-shore Oil Consultative Group (FOOCG) was formed in July 1974 to "...exchange information on general matters concerning the fishing and oil industries and to keep under review developments with the object of fostering close relations between the two industries so that each may carry out its operations with minimum interference to the other."[96] It appears to have had some success in providing a forum for exchanges of views (MacArthur 1976, 28-9). Yet, even in the early years, a sense of frustration is apparent amongst the representatives of the fishing industry concerning lack of explicit recognition of, and compensation for, loss of access:

> "The (fishing) Federations said that they continued to feel strongly about this issue and unless some satisfactory arrangement was reached they might be forced to withdraw their co-operation." [97]

Significant problems attend delivery of such compensation. It is difficult to translate loss of territory into loss of catch. It is also difficult to evaluate loss of territory in monetary terms although estimates indicate that, at 1976 prices, the annual loss to the fishing industry may be up to £600,000 (Ulfstein 1987, 183). Furthermore, there may be a legal basis for not compensating fishermen due to the common property nature of fish under English law (Churchill 1987, 203). However, such a system has operated in Japan (Miles & Geselbracht 1987, 163).

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[94] FN, 15 Aug 1975, 7; Lyndsey & Tarvit, pers.comm.

[95] Specific instances of compensation for disturbance to fishing during survey work have been reported (FN, 29 Nov 1991, 50).

[96] FOOCG Draft Progress Report, 1975, Murray Archive.

[97] Item 30, Minutes of the 15th meeting of the FOOCG, 1979, Murray Archive.

Decisions concerning the removal of redundant oil installations have heightened anxiety about access to grounds. The toppling rather than removal of the Piper Alpha platform (with the resultant creation of a very extensive debris field) is regarded as a poor precedent (FN, 6 Apr 1990, 29). Article 5/5 of the 1958 Geneva Convention on the Continental Shelf states that all redundant installations should be completely removed to seabed level. The Law of the Sea Convention 1982 (LOSC), is less stringent. The UK is not a signatory to the latter and despite the lack of a ratified International Convention (DOE 1993b, 5.8.4) the Government appears to be adopting a *de facto* case by case policy on installation decommissioning (Ulfstein 1989, 192; Gubbay 1988, 103). The suggestion that not clearing debris to seabed level will provide habitats for fish in the form of artificial reefs, and so benefit the fishermen, is being actively promoted by the oil industry. This option avoids the significant cost of total clearance and comprehensive debris sweeps (FN, 1 Feb 1991, 10).[98]

## Discussion

The imbalance in economic strength alluded to above does appear to be influential in determining the character of oil industry - fishing industry relations. Yet this advantage, plus mandatory exclusion zones around oil installations, has not guaranteed the absence of fishing activity in proscribed areas. Although obliged to keep 500m clear, a skipper was in 1989 fined for fishing underneath the helipad of an oil Platform. The fine of £10,000 was easily met from the £29,000 garnered from the sale of the catch.[99] Multi-faceted, relatively costly, protective strategies which anticipate transgressions (including burial, rigid structures and publication of location of installations) continue to be developed (see section 5.3).

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[98] Picken (1994) reviews the environmental and legal issues associated with decommissioning offshores structures.

[99] Lyndsey, pers.comm.

Submarine cable companies also have recourse to the law - damage to a charted cable is an offence. However, liaison and compromise appears to be seen as the path of least resistance and is preferred while interference with cables remains at a low level; although this approach is tempered by a willingness to prosecute where possible and exemplary damages are presently being sought as a result of interference with a live cable.[100] It is acknowledged that a contrast with certain approaches adopted by the oil industry does partly result from the fact that the cable companies do not enjoy the same economic strength. But recognition of the fact that past, haphazard cable routing and decommissioning policy has resulted in large amounts of uncharted, redundant cable on the seafloor, making aggressive policing of live cables difficult, is also significant.[101] In general, for both the oil and cable industries, actual enforcement of exclusion zones at sea is intensely problematic. This may be related to the extended, linear form of some of the installations of interest. It also relates to the simple fact that monitoring activity on the open sea is very difficult. The support of the fishing industry does not seem to have been engaged to the point whereby exclusion zones are respected voluntarily although some progress on the part of the cable companies is evident. Whether such support will ever be forthcoming is open to question.

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[100] Mayall & Broadbridge, pers.comm..

[101] Broadbridge, pers.comm.

## 5.6 Protecting Archaeology: Principles and Implementation

The general conclusion that can be drawn from the foregoing discussion is that the stated ideal of conserving the integrity of archaeological deposits while avoiding significant disruption to fishing activity is unlikely to be achievable. In the following section, the major principles which might inform a strategy for protection of the integrity of the archaeological resource against fishing related depredation are outlined. In any given area, factors other than fishing activity may have to be considered and attempts to conserve archaeological material *in situ* are likely to involve a number of complementary initiatives.

The manner in which these principles might be implemented is also discussed in the light of present policy developments. However, the possibility of change in policy must be acknowledged and the framework outlined is not dependent on any specific mechanism. It is anticipated that several different strategies may be employed in order to secure introduction of the required measures.

- Protection Should be Sought for Defined Areas of Interest not Site-specific Locations.

It has been stated that the bulk of the archaeological resource of an area is currently likely to be unknown and unlocated although it may be suspected (see section 2.2, 32). If it is accepted that, due to cost, only a relatively small amount of the known material will receive physical protection, then over-reliance on this approach may be inappropriate.

Some form of selection policy will inevitably operate - between deposits and within deposits. What criteria will be used; degree of preservation; coherence of structure; historical association or perceived importance as an 'outstanding example' of its type? However selection is made, two things seem assured; there is a risk of the extraordinary being given preference over the common place; and the sample base from which the selection will be made will be far from representative of the whole resource - only known and located sites could be included. This conflicts with the fact that for future research, it will be desirable, even necessary, to have a number of comparable sites, similarly protected from depredation, available for investigation.

If these points are accepted, then seeking to regulate fishing activity in an area, so that damage is avoided, rather than concentrating on mitigating damage on specific sites, has significant advantages. Primarily, it allows effort and resources to be committed to a broad range of sites, known and unknown. This will not, of course, preclude the need for expenditure on protection against other processes. In addition, certain known sites beyond such areas may also require physical and legislative protection.

Areas should be selected primarily on the basis of archaeological potential. It is acknowledged that the choice of areas for management will itself be a source of bias in the sample preserved. The various factors which might contribute to assessment of the archaeological potential of an area are reviewed by Garrison (*et al.*, 1989, II-9 - II-126; see also RCHME 1992). The inclusion of archaeology within the territorial sea in heritage databases currently used for policy formulation and development control on land, will contribute to the identification and assessment of such areas in the future.[102]

Reference to recent proposals from Government agencies and pressure groups concerned with nature conservation might indicate the size of area considered appropriate as a unit of concern by others involved in managing sea and seabed use. Attempting to manage activity within naturally defined units, such as estuaries, would have practical advantages (see English Nature 1994a, 60 &74). Controlling activity within areas of open sea is likely to be more problematic (see NFFO 1993; see fig. 101). The current Government view suggests that the appropriate geographic unit for much coastal planning and management is the estuary or relatively short stretches of open coast (DOE 1993a, 3.5).

The difficulties associated with attempting to monitor fishing activity have been highlighted already. However, selection of appropriate boundaries for managed areas may reduce the problem. Such pragmatism must inform selection policy and provides further support for avoiding areas consisting largely of open sea.

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[102] In 1992 the warrants under which the Royal Commissions for England, Scotland and Wales, the national bodies of survey and record (Fraser 1993, 22-4), operate were modified to include a duty to include historic wreck in the records curated. In England, a desk top study which considered options for the creation of a national inventory (RCHME 1991) preceded this development and was followed by a one year pilot project centred on the Solent. In 1992 the Royal Commission on the Historical Monuments of England began a project aimed at extending the National Monuments Record to include archaeology with the territorial sea of England (RCHME 1993a, 48).

- ## The Use of Mobile Gear Should be Restricted

A blanket ban on all fishing, mobile and static, should not be attempted but restrictions on mobile gear are considered a minimum requirement; specifically beam trawls, suction dredges and scallop dredges. A total ban on mobile gear would have the added advantage of avoiding enforcement of technical regulations.

Zoning within protected areas might be considered. Substantial progress may result from informing the fishing community where they can fish rather than where they cannot.[103] An initial period of intensive survey might result in specific zones being re-opened to specific gear types. Although attractive in some respects, such a proposition complicates the policing of any protected area and for that reason alone may not be appropriate. Resources would be required for the initial survey and, once opened, areas may have to revert to higher levels of regulation on the basis of subsequent discoveries. In addition, permitting use of any form of mobile gear within a protected area may necessitate the commitment of resources to some form of physical protection of known sites to guard against accidental impact. The unknown sites would be unprotected. Developer funding of such protection (that is, the agency causing the damage pays for the mitigation) is not currently considered a viable option. Therefore, the need for such measures would significantly increase the cost of establishing closed areas.

Closed areas might be bounded by zones within which regulation is linked to an obligation to report rather than to gear restrictions. Fishermen operating within such zones could be obliged to report snags and material raised in their nets to a named authority. The boundaries of the closed area may require adjustment as a result of investigation prompted by such reports.

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[103] Use of zoning to indicate where specific activities are permitted is likely to figure prominently in future English Nature management initiatives (Laffoley, pers.comm.)

Fishermen, however, may well be unwilling to report material if the result is likely to be an extension of a closed area.

- Acceptable Alternatives to Mobile Gear Should be Promoted.

Seeking a total ban on fishing activity does not appear to be necessary in order to conserve the archaeological resource within protected areas. The prosecution of less damaging methods, primarily those utilising static gear, should be actively encouraged. Longlining (section 3.2.3) may be an acceptable compromise method which would also serve general nature and stock conservation interests. Lobster potting away from known concentrations of material may be acceptable but has the potential to cause damage by snagging structure. Experiments featuring the deployment of static traps to catch fin-fish have taken place. Relative success with this method has lead to suggestions that it might be used to allow fishing near to sensitive oil installations (FN, 12 Feb 1993, 8). If the technique is demonstrated to have commercial potential then it could be considered for use in archaeologically sensitive areas.

As noted in section 5.1 (141), restrictions on mobile gear may elicit support from static gear fishermen. Gibson (1975, 705) has pointed out that:

> "Paradoxically...local fishermen...are among the more enthusiastic supporters of measures that should reduce competition for the environment in which they operate."

Allowing certain kinds of fishing to continue in an area might gain support from those already prosecuting that fishery and those willing or able to convert. However, choice of gear for deployment in an area is based, among other factors, on the targeted catch and seabed conditions. All species targeted by a prohibited gear may not be targeted effectively by permissible alternatives.

Mid-water trawling could be considered in areas that have been surveyed for up-standing structure, but conservation bodies consider the risk of accidental contact with the seabed during pelagic trawling as too great for it to be permissible in protected zones.[104] Wreck netting should be restricted to artificial reefs established for the purpose or deliberately scuttled vessels.

- Restrictions Should be Promoted on the Basis of Advantages Accruing to the Fishing Industry.

Potential for re-stocking of contiguous grounds is likely to be the main-stay of such a campaign (although points raised in relation to spillover in section 5.4.1 (165) must be fully considered). The industry may also be able to use acceptance of closed areas as a means of avoiding other, even less popular conservation measures proposed by regulatory authorities.

### 5.6.1 Discussion

Analysis of legislation that might be used to implement such measure will not be offered. Indeed, in the context of current coastal zone management policy, legislative prescriptions are perhaps the least promising option. In addition, fishermen have a legitimate right to pursue their occupation. Any approach which is based solely on an assumed primacy of the need to protect archaeological material is highly unlikely to succeed. However, as a starting point, it is necessary to identify the best option for the archaeological resource, in terms of management regime and location of managed areas, *regardless of the requirements of other interest groups*. If the struggle to achieve a satisfactory regime is likely to be particularly arduous, then the conception of what archaeological heritage managers are struggling towards must be particularly clear. There should be no attempt to create managed

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[104] Gomm, pers.comm.

areas without a written policy statement setting out objectives which should reflect local circumstances and be made available for scrutiny by all interested parties.

In response to the recommendations of a select committee's investigation of coastal planning and protection (CPP 1992; GCPP 1992) the Government has released a number of discussion documents and has published the results of a major exercise designed to collate information about the management of activities on the coast (DOE 1993c). The present Government (Conservative) view tends firmly towards voluntary regulation through existing structures. Rather than imposing solutions it seeks to encourage local resolution of conflicts within the framework of national policy. The need to avoid expensive commitments to difficult policing activities is explicitly stated (DOE 1993a, 3.1). However, recent proposals stemming from Governmental and non Governmental organisations for Marine Consultation Areas (DOE 1992b; 1992c.) superseded by Sensitive Marine Areas (English Nature 1993a; 1993b); and Marine Protected Areas (Warren & Gubbay 1991; Firth & Ferrari 1991; 1992) demonstrate a developing consensus on the need to manage certain activities on an area, rather than site specific basis.[105] Indeed, the phrase Marine Protected Area is increasingly used to refer to the concept of large, multiple use protected areas with integrated management systems providing levels of protection varying throughout the area (Kellerhen & Kenchington 1991, 1).[106]

In section 5.4.1 the potential benefits of effective liaison were made apparent. However, it is certainly unlikely that liaison and

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[105] The intensity of current activity directed towards management of the coastal zone is indicated by the *Directory of Coastal Planning and Management Initiatives in England* (King & Bridge 1994). Abundant opportunities exist to insinuate archaeologcial concerns into local management plans, many of which incorporate some form of zoning.

[106] Kellerhen and Kenchington (1991, 3-7) review the development of Marine Protected Areas from an international perspective. In discussing the creation of such areas the utility of buffer zones is noted (ibid., 14) although practical problems associated with their implementation are also highlighted.

persuasion alone will suffice in attempts to establish desirable controls. Therefore, full use must be made of structures established for other purposes. The various proposals listed above are not offered as model or preferred systems. They simply serve to indicate that, while the regime outlined previously might seem utopian if considered in isolation, it may appear more viable when shown to coincide with the general requirements and aspirations of other interest groups. English Nature officials consider that it is necessary to come to agreement with fishermen concerning shared objectives.[107] It may be difficult for archaeological heritage managers to identify such shared objectives - hence a coincidence of interest with nature conservation bodies in terms of managed areas may also offer distinct presentational advantages. However, to be of substantial benefit to archaeological heritage management, areas must be closed on a long-term rather than a seasonal basis. In addition, less compromise may be possible in terms of the location of controlled areas due to the nature of the archaeological resource.

It has been suggested that early consultation over any proposal, whether implemented on a voluntary or statutory basis, is essential to avoid charges of archaeological heritage managers having pre-judged the situation.[108] Meetings at a local level (*c.f.*, English Nature 1993b, 52) are to be preferred to any attempt to communicate via established organisations - although the trade press (notably *Fishing News*) is believed to be an effective means of announcing meetings or canvassing opinion.[109] When considering selection of areas for management, it is unlikely that an area will be found which the fishing industry regards as being of no interest for current or future exploitation. Therefore, the precise boundaries of a protected area are likely to be the subject of considerable discussion. For example, during consultation in advance of establishment of the Kapiti Island reserve in New

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[107] Patterson, pers.comm.

[108] Amos, pers.comm

[109] Lockwood, pers.comm

Zealand (created under the Marine Reserves Act 1971) objections were made on the grounds of safety. During bad weather it is necessary to shoot and haul nets in the lee of the island, within the proposed reserve. This specific requirement was accommodated (Department of Conservation 1990, 10). It is also worth emphasising that, despite potential conflicts of interest:

"The Sea Fisheries Committees' long experience of sensitively enforcing complex bylaws on the shore and at sea should not be lightly disregarded." (CPP 1992, 304)

While substantial progress may result from achieving local compliance, the situation is complicated by an increase in the number of foreign, particularly Spanish, boats operating in UK waters using licenses purchased from British fishermen (FN Feb 12, 1993, 4). Such vessels are often not UK based thus the understanding and co-operation at a local level perceived to be necessary for successful liaison may not develop. Problems associated with such vessels are likely to increase when the various exclusions which currently bar foreign vessels from inshore waters are reviewed in 1995. Strong pressure is being brought to bear by Spanish operators to allow greater access to UK waters after 1996 as part of the Common Fisheries Policy (FN Apr 15 1994, 3).[110]

Events surrounding the passage of the Sea Fish (Conservation) Act in 1992 serve as a cautionary tale in the context of a study such as. The Act limits UK licensed vessels over 10m in length to a total number of days at sea equivalent to that vessel's substantiated record for 1991. A series of demonstrations were organised at the House of Parliament and elsewhere to protest at a measure regarded as a crude means of limiting fishing effort perceived to exceed restrictions implemented by other EC

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[110] The UK Government are presently arguing against this on the grounds that Spanish and other European vessels have no historic fishing rights in such areas (*The Independent*, 21 Dec 1993, 5).

states.[111] Further action, including blockades of harbours, culminated in a mass rally in Edinburgh during a major EC summit. However, the protest failed to gain front page treatment in any national paper and only received substantial coverage in *The Scotsman* (12 Dec 1992, 10) and *The Herald*, published in Glasgow (12 Dec 1992, 6). The timing of the protest may have been unfortunate as many other interest groups also made their presence felt at the summit and national papers have subsequently carried articles on the industry's plight (*e.g. The Independent,* 29 Dec 1992, 4). Yet this does little to dispel the view that the industry's woes are not major news if there are competing attractions.

Reportage in the Fishing press described an industry more unified in opposition to the Act than ever before (FN, 18 Dec, 12). An impression of solidarity is undermined by other reports detailing the complaints of fish processors who felt that blockades organised by the catching sector were harming their businesses.[112] Despite this, pressure co-ordinated by the National Federation of Fishing Organisations (NFFO) for a review was maintained.[113] Legal action in the UK High Court resulted in referral of the issue to the European Court and a ruling is not

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[111] FN, 15 Feb 1991, 1; FN, 8 Mar 1991, 1; FN, 8 Feb 1991, 1-5 & Editorial. A rally in Scotland was accompanied by overt calls for non-compliance and confident assertions that such regulations could not be made to work if the fishing industry chose not to co-operate (FN, 18 Dec 1992, 1 & 12-13).

[112] Fish processors at Peterhead had won a court injunction preventing a blockade but this was ignored by the fishermen (*The Scotsman*, 12 Dec 1992, 10).

[113] The NFFO considered that the measures were pushed through with very little consultation. Government (Conservative) constituencies were targeted in a campaign which involved attendance at constituency surgeries to ask questions concerning the proposals - particularly those constituencies represented by members of the cabinet. This and other activities were regarded as successful in raising public awareness but unsuccessful in that the Government pressed on with the bill. Only one Conservative MP is definitely known to have changed his voting intentions as a result of the campaign (Mr. Sebastian Coe). The NFFO handled their own public relations during the campaign, the Scottish Fishermen's Federation is believed to have spent over £40,00 on professional public relations advice (Banks, pers.comm).

expected until 1997; the measures cannot be implemented until a ruling has been received.[114]

This case cannot be presented as a clear example of resurgent lobbying power - the success of the court case brought by the NFFO is closely related to the complex relationship between national and European law. More parochial issues without supra-national implications may not be amenable to the same form of delaying tactics. Yet it does emphasise the manner in which the fishing industry has shown remarkable resilience in recent times. It is possible to suggest that the industry has a limited future in its present form and the size of the fleet looks set to fall. Fishermen are actively seeking centralised funding for decommissioning of vessels in areas where stocks will not support the current scale of effort. However, it is likely that the industry will continue to display the tenacity which has characterised it for so many years. It will exhibit the ability to adapt to new opportunities which has bedevilled previous attempts to design a comprehensive management regime. Accordingly, those proposing strategies for mitigating the impact of fishing activity would do well to bear in mind the following comments from a Government investigation of inshore fisheries:

"The industry is therefore not one of static conditions: in all its aspects it has been and still is subject to major practical changes and it is therefore dangerous to assume that any system of regulation or protection can be safely or usefully based on a stereotyped pattern that is related too closely to conditions of the present day or even of the recent past." (RSIF 1970, section VII, para 48).

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[114] *The Independent*, 3 Dec 1993, 6.

# 6 Marine Burrowing Activity

This chapter will consider the burrowing activity of selected members of the macro-benthos in relation to archaeological material on and within the seabed in UK coastal waters as previously defined (see preface). However, distance from shore is not the sole factor which determines the character of the faunal community in any location. Environmental characteristics such as the nature of sediments and availability of habitats and niches will also be significant (Hayward & Ryland 1990, 1). Therefore, phenomena described in this chapter may also occur at locations beyond the limits of coastal waters.

First, changes to an archaeological deposit likely to derive from burrowing activity will be described. An assessment of the effect of such activity and a judgement as to whether strategies for mitigation should be developed will be offered. Second, a case study will be presented which will consider the practical identification and study of burrowing as a formation process.

# 6.1 Terrestrial Burrowing Activity

Data from research relating to burrowing in deposits on land will be reviewed before the potential effects of equivalent process underwater are considered. Burrowing within terrestrial and marine contexts is not directly comparable. Clearly there are aspects of the nature of sediments underwater, their deposition and suspension, which are very different from the creation and erosion or deposition of soils and sediments on land. However, once these important and identifiable differences have been appreciated, evidence from terrestrial contexts can be seen to have some relevance to this discussion. Therefore observations derived from terrestrial research are presented as indications of possibilities rather than as phenomena which will necessarily be mirrored in detail underwater.

The fact that burrowing fauna, such as worms, are significant in the formation of the terrestrial archaeological record has long been recognised by land archaeologists. Atkinson (1957) drawing on observations made by Darwin (1881, 176) noted that, due to earth worm activity:

> "...Significant archaeological finds have been displaced downwards from the position in which they were originally deposited, and in some cases at least the amount of displacement may have been sufficient materially to alter the apparent stratigraphic relationships of the objects concerned." (Atkinson 1957, 222).

More recently workers have concentrated on analysis of the effect of these organisms and have amply demonstrated the potential significance of intensive burrowing. Stein (1983, 284) investigating an archaic midden at Carlston Annis suggests that the whole of the deposit could be reworked in the space of 51 years; worm activity may have been present for around 6000 years. In California it has been estimated that gophers bring 2.5 metric tonnes of sediment to the surface per *annum*, per square hectare (Erlandson 1984, 789). At Jasper Ridge midden site in Central California, calculations based on potential rodent densities and potential annual turnover of sediment show that, since its abandonment, the site could have been reworked more than twice over (Bocek 1986, 600). Wiksten (1989) and Wilkins (1989) review the influence of burrowing invertebrates and vertebrates on archaeological deposits.

Research has succeeded in isolating specific phenomena associated with burrowing activity which have implications for our understanding of the archaeological record. Worm activity has been shown to homogenise deposits affecting textural, chemical, mineralogical and stratigraphic properties of soils. Boundaries such as pit and burial cuts are blurred or removed altogether. The preservation of specific classes of evidence, such as seeds, has also been adversely effected (Stein 1983, 284). Intensive termite activity produces similar results. The preservation of bone is promoted by localised increases in the alkalinity of the soil (although attendant increased soil porosity can also have a detrimental effect). In addition termite nest building can produce 'pseudofacts' which closely resemble prehistoric hearth material and affect vertical distribution of artefacts. Concentrations of material are dispersed and formerly dispersed material is concentrated at the lowest level of burrowing activity, producing features which mimic archaeological horizons (McBrearty 1990, 111).[1]

Studies of larger burrowing fauna have also been successful in linking cause with effect. Erlandson (1984, 789) concludes that intensive burrowing by gophers leads to the homogenisation of cultural deposits and the blurring of discrete boundaries within such deposits. Investigation of a prehistoric campsite indicated that 30% of the bone and 27% of the shell material present was displaced. Average tunnel depths suggests that most systematic displacement occurs within 30cm of the surface (*ibid.*, 590).

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[1] Wood & Johnson (1978, fig. 9.4, 324) provide a spectacular example of false stratigraphy created by this process.

Bocek (1986, 592) notes that such burrowing appears to segregate soil constituents by size. It causes artificial concentrations of smaller material near the surface and larger material at depths of between 30 and 60cm. However, despite causing extensive stratigraphic disturbance, rodent activity has little effect on horizontal distribution. Johnson (1989) generally confirms the above observations and emphasises the need to consider the relationship between artefact size in recorded layers and the size of burrows created by burrowing fauna in the area to avoid mistaking the effects of bioturbation for culturally significant groupings.

The major conclusions drawn by the various workers who have investigated what has become known as 'faunalturbation' (Wood & Johnson 1978, 318) can be summarised in 4 main points; burial is caused by both the transference of soil to the surface and by the collapse of burrows causing subsidence; once buried, an object will continue to sink until it is either no longer influenced by such activity or a firmer substrate is reached which is not suitable for burrowing; the extent of such activity is primarily influenced by the suitability of the substrate for burrowing organisms (and thus the size of the burrowing population); the important role of other agencies (such as wind-borne material and hill-wash) must be recognised but the precise extent of the influence of such agencies may be difficult to separate from the biological influence on a deposit. Derived from such studies is a clear recognition that, despite some similarities, the intensive activity of smaller organisms, such as worms and termites, must be clearly distinguished from the behaviour and impact of larger burrowing fauna, such as rabbits and gophers. In summary, a developing corpus of research indicates that as a formation process and as a pervasive agent of disturbance to archaeological deposits, burrowing activity is highly significant.

## 6.2 Marine Burrowing Activity

The following discussion will consider the proposition that marine burrowing organisms can be identified which will have a similar influence on archaeological deposits as has been noted for terrestrial burrowing organisms. Archaeological material buried in muddy sediment is likely to be influenced to a greater extent than material buried to the same depth in a firmer substrate.

Substantial studies[2] have highlighted the range and number of species which burrow into the muddy seabed and the extent of their influence upon it. Such work indicates that in some environments, unmodified by man, the physical, and to a lesser extent chemical, characteristics of the upper sediment are primarily influenced by biological processes. No useful purpose would be served by an exhaustive listing of potentially significant species. Instead, the activity of selected organisms is described to indicate the *nature* of burrowing activity most likely to be relevant to this study. The aim is to consider changes to archaeological deposits underwater derived from burrowing activity, not the detailed description of such behaviour *per se*.

Knowledge of the preferred environment of each organism is clearly relevant to a consideration of its influence on the archaeological record. Such information is given in general terms in footnotes. Further details of species distribution ,where known, are available in the literature cited and are not repeated here. Actual distributions and depth ranges of some of the species discussed are not perfectly known. Published material is augmented by observations made in the field. Discussion will commence with organisms active in muddy sediments.

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[2] Atkinson & Nash (1985) provide a concise review of some of the better known burrowing species. Pye (1980), while offering a detailed study of the nature and extent of burrowing activity in one specific area (the west coast of Scotland) indicates the pervasive influence of such activity in some environments. McCall & Tevesz (1982) review biogenic modifications of sediments while Rhoads (1974) also considers organism -sediment relationships.

## 6.2.1 Tube Building Invertebrates

Among the invertebrates, some polychaetes, particularly those sedentary deposit feeders which construct vertically oriented tubes for habitation, are worthy of special note.[3] This is primarily due to the scale of sediment transfer from below the surface associated with their feeding behaviour.[4] Consider the polychaete *Pectinaria belgica* (Pallas). This invertebrate constructs an unusually large tapering tube up to 12cm long and annual turnover of sediment can be in the ranger of 6-8.6 kg, dry weight per $m^2$; such an area would be likely to contain less than thirty inhabited tubes. Clearly the scale of such sediment transfer should not be underestimated (Rhoads 1974, 267).

Suspension and deposit feeders are widely distributed at a range of depths, including the inter-tidal zone. Their activities can produce a seabed prone to re-suspension due to its pelletal structure and high water content (Rhoads 1974, 271). Such seabeds are characterised by flat, featureless topographies.

Dense mattes of polychaete tubes may also influence the stability of sediments due to the binding influence of dense aggregations of tubes acting in conjunction with other biological processes (Bailey-Brock 1979, 643). There is some debate as to the precise nature of the tubes' influence on sediment stability. However, some flume tests (a marine version of a wind tunnel) carried out on sediments bound by algal mats and invertebrate tubes, have indicated that bound sediment had critical erosion velocities two to five times greater than unbound sediment. There is some

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[3] Barnes (1987) provides an extensive account of the zoology of invertebrates.

[4] Polychaetes can dominate near surface burrowing activity in some areas (Pye 1980, 183). Fish & Fish (1989, 136-144) offer a clear and concise introduction to polychaetes; a class of the phylum (group of related classes) Annelida characterised by division of the body into a number of similar, visible segments which includes earthworms and leeches. Polychaetes are not necessarily tube builders or members of the macro benthos. They are very widely distributed in the marine environment.

debate as to whether tubes stabilise sediment or cause local erosion and flume experiments have not always mirrored field observations (*c.f.*, Carey 1982; Eckman *et al.*, 1981). However, general opinion is that groups of tubes, as opposed to isolated tubes tend to assist in the stabilisation of sediment. Sediments modified by tube building and algal growth withstood velocities of 40 to 110 cm/sec (Scoffin 1970, 271). Similarly, flume experiments, isolating the effect of the tubes of the capitellid polychaete *Heteromastus filiformis* demonstrated an 80% increase in critical erosion velocity of the sediment three days after the introduction of the population of tube dwelling worms (Rhoads & Boyer 1982, 21).

The poorly understood role of other biological processes in such binding prevents establishment of a simple cause and effect relationship between the tubes and variations in critical erosion velocities.[5] Similar experiments and observations have lead to diametrically opposed conclusions which indicates that, when considering such questions, it is prudent to bear in mind the fact that:

"...It is the sum of all biological and physical effects within a given sediment which determines stabilisation or destabilisation." (Grant *et al.*, 1982, 660).

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[5] Excretion of bacterial mucus may also be significant in determining the critical erosion velocity of a specific area of sediment (Rhoads & Boyer 1982; Holland *et al.*, 1974, 191).

## 6.2.2 Crustacea[6] in Soft Sediments

The *Nephrops norvegicus (L.)*[7] (the Norwegian lobster) burrows to depths of 20-30cm creating shallow u-shaped tunnels (see fig. 102). However, the addition of turning chambers and the interconnection of two or more burrows can result in quite extensive complexes.[8] Roughly 10cm in diameter the tunnels can be up to 1m long and tend to occur in groups with large mounds of sediment at the burrow entrance. Densities of 3 to 5 burrows in 1 $m^2$ are not uncommon (Rice & Chapman 1971). Studies have shown that *Nephrops* burrows are often found to interconnect with those of the crustacea *Maeri loveni* creating substantial complexes up to 20cm below the sediment surface. Burrow complexes comprising many U-shaped excavations reaching a depth of some 20cm tend to result from the activities of colonies of this species rather than individuals and are typified by numerous openings on the sediment surface (Atkinson & Nash 1985, 112). Calculations of burrow volume have shown that an interconnected *Nephrops* and *Maeri* burrow system can have a volume of approximately 9766$cm^3$ (Atkinson *et al.*, 1982, 404-5).

The activities of *Calocaris macandreae (Bell)*[9] (fig. 103) illustrate the way in which extensive burrow systems can be created by a relatively small organism with little visible disturbance to the surface of the sediment. Two-level burrow systems are created.

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[6] Headstrom (1979) provides an accessible introduction to this class of animal.

[7] The Norwegian lobster (known as the 'prawn' in Scotland) is widely distributed on the continental shelf of Europe. It is found as far north as Iceland as far south as Morocco and as far east as Egypt. It supports a commercial fishery in a number of countries. Norwegian lobsters are found in depth ranges from 15m to over 800m, generally on muddy seabeds (Chapman 1980, 143-178; Howard 1982, 1-7; Hayward & Ryland 1990, 514).

[8] This has been demonstrated by resin casting (Atkinson & Chapman 1984, fig. 1, 17).

[9] C. *macandreae* is found in sub-littoral sediments throughout the east Atlantic to the Mediterranean. Highest densities are found in areas of the seabed where silt content is around 60%. Around the UK it is most commonly found off the northeast and northwest coasts including the Irish sea. It has been noted in depths of up to 100m (Atkinson & Nash 1985, 112; Nash *et al.*, 1984, 426; Hayward & Ryland 1990, 517).

The upper consists of interconnecting u-shaped tunnels; as many as 17 openings to the surface having been noted for some systems. The lower tunnels are distinctly circular and are approximately 2cm in diameter. These complex systems penetrate to a depth of 20-30cm.

### 6.2.3 Burrowing Fish in Soft Sediments

*Cepola rubescens* (L.) (the red band fish) is not the only example of a fish which excavates in soft muds,[10] but is notable for the size of its burrow (Atkinson *et al.*, 1977, 377).[11] These can be as much as 1m deep and 10cm in diameter expanding to form a basal chamber some 20cm in diameter. Despite showing a preference for muddy sediments it also appears to be capable of penetrating firmer substrates; gravel and shell fragments have been noted within material excavated from a burrow by this fish (*ibid.*, 374). Wilson (1953, 206) also observed *cepola* burrowing into gravel in an aquarium. A large mound of sediment typifies the burrow entrances and densities of 5 burrows in an area of $4m^2$ have been recorded (*ibid.*, 371).

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[10] See Rice & Johnstone (1972, fig 2, 28) and Nash (1980b) for descriptions of other burrowing fish.

[11] See Atkinson (*et al.*, 1977). This fish is eel-like in shape with a long slender body (up to 70cm). It is found in the Mediterranean and the east Atlantic from Britain to Senegal. Although believed to inhabit deeper water environments as well (70-200m), around the UK this species is found in the shallow muddy seafloors of the southwest and south coasts (Atkinson & Nash 1985, 112; Lythgoe & Lythgoe 1971, 215). Many aspects of the life-cycle and behaviour of this fish are not well known.

## 6.2.4 Bi-Valves

Various bivalves (organisms inhabiting shells consisting of two distinct and equivalent parts or valves *e.g.* mussels)[12] also burrow into sandy and muddy sediments. One very common variety are razor shells of the genus *Ensis.* Of the three species of *Ensis, Ensis siliqua* (L) is the largest reaching a length of 20cm and a width of 2.5cm.[13] Razor shells are very rapid, deep burrowers, often reaching depths of twice their shell length or more (burial depths of 40cms are known). Burrowing is achieved by pushing a 'foot' into the sediment and then employing muscular contraction to pull the shell down behind it (see fig. 105). Razor clams are filter feeders and they employ siphons to keep contact with the seawater above the burrow thus ensuring a circulation of water within the burrow itself. These bivalves live in fine sand and sediments with a depth range of intertidal to 35m. While the genus *Ensis* favours clean or slightly silty sand other razors clams are found in muddier sediments.

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[12] Fish & Fish (1989, 236-281) provide a concise account of the class Bivalvia from the phylum Mollusca found in the sublittoral zone around the UK. Not all bivalves burrow.

[13] *Ensis ensis* (Linneaus) is widely distributed in northwestern Europe and can be observed all around the UK in the intertidal and shallow sub-littoral zones. Preferred substrates are sand or muddy sand. *E. siliqua* is usually found in clean sand (Fish & Fish 1989, 270-1).

### 6.2.5 Crustacea in Hard Substrates

There are two species, found on coarser substrates as well as muddy sediments, which are worthy of particular attention; the lobster (*Homarus gammarus* (L.)) and the crab *Cancer pagurus* (L.)). Both are among the largest and most powerful members of the macro benthos. These larger organisms excavate in a manner which may result in the upward as well as the downward displacement of material.

The European lobster (*Homarus gammarus* (L.))[14] (fig. 106) is known to seek rocky crevice type habitats (Berril 1974, 797). It has been shown, particularly in the juvenile phase, to construct burrows in cohesive mud with interlinking tunnels and chambers (Howard & Bennet 1979, 436). The observed preference for seeking shelter by deliberately burrowing under solid objects is particularly relevant (Cooper & Uzman 1980, 99-112).

The Crab (*C. pagurus*)[15] (fig. 107) is of particular interest by virtue of the way it uses its claws in a 'bulldozing' action to excavate pits, which can be up to 10cm deep and 30cm in diameter, in coarser substrates; for example, 50% gravel, 35% sand and 8% silt/clay (Thrush 1986, 222). Mature specimens can grow to 30cm across the carapace and are relatively powerful for their size (Warner 1977, 70).

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[14] The European lobster is found from northern Norway to southeastern Sweden and Denmark, along the mainland European coast and around the United Kingdom and south to the Atlantic coast of Morocco. It also occurs throughout the coastal and island areas of the Mediterranean Sea (Cooper & Uzmann 1980, 99).

[15] Warner (1977) gives a comprehensive account of the biology and behaviour of crabs. C. *pagurus* is widely distributed in northwestern Europe and can be found in depths ranging from rock pools to 90m. larger specimens are usually found offshore and individuals can live for up to 20 years (Fish & Fish 1989, 341-2). Considerable research has focused on the seasonal migration and movement of crabs. Females are believed to sometimes move 200 miles in 18 months while males rarely move more than 20 miles.

### 6.3.6 Discussion

The impact of burrowing activity on archaeological material will relate to the manner in which burrows are created and the size of the resulting excavations. The prodigious quantities of sediment processed by tube building filter feeders might suggest that the activity of such organisms could contribute to the burial of archaeological material. However, different sized objects will be influenced to varying degrees. A small object coming to rest on a seabed influenced by filter feeding might quickly pass through the characteristic, shallow pelletal layer (1-3 cm). Preservation of substantial elements of structure may not be influenced to a significant degree. Indeed, many objects may not pass easily through dense aggregations of tubes - such aggregations are known to hamper the movement of other organisms through the sediment. Thus a relatively rapid, light covering of sediment may occur, but further, deeper burial leading to preservation may rely on other agencies. Fluctuations in the density of a polychaete community may eventually allow objects to pass through the sediment more easily - the presence of substantial, intrusive objects may be one cause of such fluctuation. But whilst such burial is inhibited, archaeological material may degrade significantly through exposure to other processes.

The potential role of tubes in sediment stabilisation has been noted. It would seem reasonable to suggest that artefacts or structure already buried beneath sediment modified by binding, whatever the agency responsible, would receive some degree of protection from re-exposure through current induced erosion. Yet field observations have indicated that the edges of areas of bound sediment are prone to erosion by scour. Cultural material directly below such a boundary (between bound and unbound sediment) might, therefore, be more readily re-exposed (Rhoads & Bowyer 1982). The influence of this form of sediment processing on artefact burial and preservation is not simple or easily described. It is intimately linked with general seabed dynamics and other mechanism of sediment deposition.

Burrowing crustacea are likely to be directly responsible for changes falling into the categories of burial, transport and alteration. The burial of structure is unlikely to be significantly affected by the burrowing activities of the larger benthic macro fauna. However, the collapse of burrows undermining or undercutting smaller objects in the sediment will tend to promote their burial. The fact that obstructions can provide attractive niches for such burrowing reinforces the suggestion. Indeed, man-made objects have been observed to be undermined in this way.[16] Complete burial is clearly unlikely to take place as the result of a single collapsed burrow or even repeated undercutting and subsequent subsidence of an object. Yet, if other factors such as net sediment deposition in the area are taken as constant, the influence of such events which lead to partial burial may be highly significant. Minor changes in the relationship between archaeological material and its surroundings may determine which objects eventually become fully buried and which remain largely exposed long enough to be influenced or removed by other agencies. Thus, the significance of larger, isolated burrows must be evaluated in terms of a system of checks and balances in which levels of preservation may be determined by slight alterations in any one of a number of variables.

Any suggestions as to rate of burial would be pure speculation at this stage. The number of potential variables involved in such a calculation is immense and the interelatedness of many mechanisms, although postulated, is actually poorly understood. It must also be borne in mind that the mobile or semi-mobile nature of some areas of seabed may mean that periods of re-suspension due to storm or wave action make a more substantial contribution to the initial burial of appropriately sized material than burrowing behaviour.

Transport of material within burrows and thus the alteration of stratigraphic relationships is clearly possible; whether as part of the excavation process or as a result of an object within the

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[16] See Cooper & Uzman (1980, 111 fig. 10, 109); Markey, pers.comm.

sediment having been undermined. Undermining of material within sediment would tend to transport objects downwards. Reference to observations on terrestrial worm action indicate that an object will continue to be influenced by such activity, and thus sink deeper, until it reaches a zone where such biological processes do not occur. The top 30 cm of sediment in muddy environments would appear to experience most biogenic alteration with the top 2-10 cm being quite thoroughly sorted (Pye 1980, 206). Alterations in stratigraphic relationships and associations may therefore be anticipated as a result of such activity. Limited research has indicated that objects can retain chronological ordering within soft sediments.[17] Yet the potential for the creation of a multi-period assemblage at the base of sediment influenced by intensive burrowing must be acknowledged.

The size of object transported within burrows will be limited by the size of burrow created and the digging action of the organism responsible. Excavation strategies among the species discussed tend to rely on fanning/sweeping actions or transference of pellets to the surface in the mouth or supported on chelae (pincer/claws) and periopods (appendages which can have specialised function *e.g.* feeding or walking). The red band fish has been observed to burrow by bringing material to the surface in its mouth (Wilson, 1953, 206; Atkinson 1977, 382). C. *macandreae* burrows by moving a bolus of material with periopods and chelae (Nash *et al.*, 1984, 434). The Norway lobster excavates by pushing material ahead of itself (Rice & Chapman 1971, 335). With the possible exception of a mature specimen of H. *gammarus,* C. *pagurus* is probably the only organism so far discussed which may displace anything other than the smallest of objects by its digging action alone. In addition, this species may also displace material upward as well as downward. Material brought to the surface may then be transported by other natural agencies or removed by, for example, sport divers.

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[17] See Keller (1973). The nature and possible influence of burrowing organisms are not considered in this study.

Alteration may result from physical abrasion by the hard carapace (outer shell) of burrowing crustacea. There is little doubt that the burrowing activities of some larger species are energetic enough to cause mechanical damage to delicate organic material. Furthermore, the occupation of a shelter created by an exposed or partially buried artefact (such as a stave-built bucket) by a mature lobster (H. *gammarus*) would also seem likely to result in mechanical damage and deterioration, if only through abrasion of the soft wood by a hard carapace. Such a suggestion is supported by the observation that lobsters appear to exhibit a preference for habitats of a size which allow them to maintain physical contact with the boundaries of the shelter (Cooper & Uzman 1980, 111).

Secondary alteration may also result from mechanical damage caused by abrasion. An abraded surface, or a relatively delicate object whose physical cohesion has been compromised, may be less resistant to other mechanisms promoting deterioration. Stability within an anaerobic environment is generally considered to promote long-term preservation of a wide range of objects (Robinson 1981, 4). Alteration may occur as an indirect result of burrowing activity when such behaviour results in the introduction of oxygenated water into previously anaerobic sediment - rapid, localised deterioration may result. The oxygen content of water within burrows, and thus available to oxygenate sediment, is little different from that on the surface. The $PO_2$ at the bottom of a C. *macandreae* burrow was found to be 96.1% of the surrounding water (Nash *et al.*, 1984, 434). The depth to which species such as C. *rubescens* can burrow seems particularly relevant when considering such disturbance. However, the action of even a small bi-valve, such as *Nucula proxima,* can increase oxygen penetration from 2 cm to over 6 cm from the surface (Rhoads & Young, 1970). The complex and extensive systems created by the interconnection of burrows of different species (see fig. 102) are noteworthy when considering the potential effect of pockets of oxygenated sediment.

## 6.3 The Effect of Burrowing Activity

The information presented above indicates that burrowing activity may have a significant influence on archaeological material on and within the seabed. In some respects the types of impact identified are not necessarily totally negative. Burial and sediment stabilisation are likely to assist in the conservation of the integrity of the archaeological resource. However, other types of direct and indirect impact which are likely to decrease the range and cohesion of archaeological material within a given area can be isolated, such as, alteration and transport. Methods of limiting such changes to deposits resulting from burrowing activity should therefore be sought.

# 7 Burrowing as a Formation Process

Three related points must be borne in mind when considering the study of burrowing as a formation process. First, burrowing may have had a more pervasive influence on the formation of a deposit than is evident from its observed condition and levels of current biological activity. Thus, it is important to attempt to account for the history of burrowing within the deposit. Second, burrowing is only one part of a complex set of relationships. Any attempt to isolate and quantify the precise effect of burrowing activity on a deposit is likely to fail. The influence of burrowing is intimately related to, and part-dependent on, the influence of other natural agencies. Third, the presence of archaeological material itself may influence the level and nature of burrowing activity in a given area. It is misguided to conceptualise the significant relationship as being that of the influence of the environment on the deposit - the deposit itself may contribute to the creation of a highly localised, atypical environment.

Material currently observed to be buried within the sediment was at one stage part of a surface deposit. Therefore it may have been exposed, possibly only very briefly, to the activity of those organisms which do not burrow deeply. This may be particularly relevant when considering abrasion and disarticulation of objects, including human remains, through feeding or habitat exploitation by larger crustacea The dynamics of deposition will be influential in determining the form of such surface deposits and the local environment will help determine the speed of burial. As the archaeological material becomes buried within the sediment, different organisms will become more influential. Yet, at each stage of the transformation from surface to buried deposit, the archaeological material will be exposed to some form of biological activity.

An additional temporal aspect of the study of burrowing as a formation process is the transient nature of some populations of fauna. For example, the fluctuation in the population of the burrowing red band fish (*Cepola rubescens*) inhabiting Halfway Wall Bay, Lundy. A survey conducted in the mid seventies (Pullin & Atkinson 1978, 19) indicated that the bay supported a population of 14,000 specimens. The population is now almost extinct in the area.[1] The potential disturbance caused to archaeological deposits by the former population is clearly significant. However, this past activity is unlikely to be evident on the surface of the current seabed. Moreover, it may not be detected, unless specifically sought, in excavation. Burrowing activity can also vary seasonally and can be affected by factors such as pollution. While it is necessary to avoid focusing solely on current biological activity, it may be the case that only the most recent events can be identified with confidence.

It has been emphasised that the influence of fishing activity cannot be understood purely in terms of the physical relationship between archaeological material and specific gear types. Likewise, care must be taken when attempting to isolate the influence of burrowing activity from within a complex system such as the interaction between physical and biological aspects of the seabed environment (*c.f.*, McCall & Tavesz 1982).[2] The potential synergism between scour and the burrowing activity of crabs can be highlighted. Scour around structure on the seabed may create niches suited to lobsters or crabs. The burrowing activity of the occupants of such a niche may widen the area of timber exposed and further natural scour may continue the process. When examining the end result, it is likely to be difficult to disentangle the precise influence of each mechanism - they are

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[1] Hiscock, pers.comm.

[2] A detailed discussion on the nature of the environment on the coastal seabed and its dynamics is far beyond the scope of this study. Barnes & Hughes (1988) provide a general introduction to marine ecology while Wood (1987) provides a very accessible and concise account of sub-tidal ecology. Hayward & Ryland (1990) offer a substantial review of the marine fauna of the British Isles and north-west Europe.

too closely interrelated. The relationship must be recognised and the net influence on the deposit considered, but attempts at further analysis may be of doubtful value.

The presence of cultural material may alter local environments in significant respects. Direct observations have been made on the way that the availability of new habitats can attract marine biota, increasing both the local abundance and diversity of organisms. An archaeological deposit on, or partly exposed on, the surface of the seabed will increase the number and diversity of habitats available in an area; particularly on flat, muddy seabeds (*c.f.*, Collins & Mallinson 1984, 73).

Large sections of structure on the seabed will affect the environment both physically and chemically. Such remains will have the potential to act as a catchment area for sediment, thus increasing the availability of sediment suitable for burrowing. They may also serve to promote localised scour, thus removing suitable sediment. Such structure-induced mechanisms may result in a pattern of sediment that differs markedly from the surrounding seabed in depth and composition. Inclusions of naturally occurring organic material in these deposits is also likely to be atypical. As the structure degrades and collapses, its physical influence on the environment (and *vice versa*) will change. As the structure becomes less prominent it is less likely to induce scour or sediment catchment. Thus the structure's influence on the physical suitability of the sediment for burrowing is also likely to alter through time. The assimilation of organic and metallic materials from such structures (particularly large vessels) into the sediment will further contribute to creating a deposit that is radically different from the surrounding matrix. Whether the net influence of such processes will be to create an environment more or less suitable for burrowing will depend on the materials involved and is likely to vary within the deposit itself.

Smaller artefacts might also be expected to influence local characteristics of a deposit and thus biological activity. For example, the decomposition of a cargo of organic material might offer a source of food for a number of organisms. Thus the amount of feeding related burrowing behaviour in the area would increase. Such activity would, in turn, affect the coherence of the deposit and related artefacts.

The precise nature and scale of such mechanisms will vary with the local current regime, the completeness, shape and orientation of structure and rate of sedimentation and thus burial. The potential combinations of such factors are numerous and possibly not always reconstructable from an observed seabed distribution.

Consideration will now be given to techniques which might be applicable to the study of this pervasive and significant phenomenon. An investigation of burrowing activity on a specific site will be presented. Observations made during the study and data from other sites will be used to address the question of the practical identification of burrowing as a formation process. Simple and complex properties of artefacts and characteristics of sediments will be considered as described in section 2.4.2. Implications for inference and analysis will also be discussed.

# 7.1 The Studland Bay Site

The Studland Bay wreck is believed to be a Spanish merchant vessel dating from the early 16th century. It is thought that the vessel may have run aground while seeking shelter in the unfamiliar approaches to Studland Bay near Poole, Dorset. Piracy was common in the area and it is also possible that the vessel was sacked and left to drift. Material representing roughly 30 Isabela Polychrome and Copper Lustre ware vessels have been found. The assemblage is currently dated to 1500-25 AD. The vessel is known to have been about 24m long. It is of carvel construction with moderately light frames. Originally, it was though the remains may represent a caravel but recent research suggests a galleon. The structure is closely paralleled by the Red Bay wreck believed to be a Basque whaling galleon dating to 1565 AD (Grenier 1984; Waddell 1986). The location of the site is shown in figure 109.

The site was discovered in 1984 when divers from Hamworthy sub-aqua club investigated an obstruction which had snagged the nets of a local fisherman, Mr. Randle. When recovered, the nets contained a timber approximately 3m with numerous treenails. Mr. Randle was trawling in an area that he had fished for some time and which he believed to be free of major obstructions. He had, however, noticed an increase in water depth in the previous few months. It is possible, therefore, that the discovery of the wreck was linked to it having been uncovered by local sediment movement. Mr. Randle had recovered a timber from the same general area a year previously, so the structure may have been uncovered to some extent for at least a year prior to the events of 1984.[3] Examination of the timbers remaining on the seabed also indicated previous episodes of exposure.

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[3] Letter from Mr. Randle, Studland Bay Archive, Poole Museum (see section 10.1).

The first part of the site to be discovered consisted of a run of timbers roughly 24m long and 4m wide. This area of structure has been described by Hutchinson (1990). The structure, made of oak, consists of the remains of twelve strakes comprising the whole length of the starboard side of the vessel. A number of patches had been added to the hull planking. There is very little curvature to the timbers in this area. Ballast stones (mostly less than 30cm across) were found on and around the structure. This part of the site will be referred to as area 1. A probe and metal detector survey in the area indicated the presence of additional buried material around the visible structure.[4] A project was established to record the site which was designated under the Protection Of Wrecks Act 1973 in November 1984.[5] From 1986-8 the site was surveyed and partially excavated. In 1988 a trial trench was excavated to provide information about the underside of the vessel.

Late in 1989, as the project was drawing to a close, a survey off-site revealed more material. This was located some 50m south-east of area 1. Investigation revealed floor timbers and part of the keel. This area will be referred to as area 2. A potential ballast trail between the two areas of structure was also investigated. 30m south of the keel a wrought iron gun and breech block and wooden debris were found. This area will be referred to as area 3. Figure 110 shows the relationship between the three areas.

Excavations in 1990 revealed the presence of a potential scour pit adjacent to the structure in area 2 (see fig. 112). No such evidence was found in area 1. This suggests that the structure in area 1 had always been relatively flat whereas the structure in area 2 formerly had sufficient relief to induce substantial scour. Such an observation lends weight to the suggestion that area 2

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[4] Jarvis pers.comm.

[5] The early years of the project are described by various articles in the diving press, for example *Sub Aqua Scene*, May 1985, 4-5; *Sub Aqua Scene*, April 1986, 30-1.

might represent the location of the initial deposit while area 1 represents an area of collapsed structure separated from the main site.

A trial trench dug in area 3 indicated the presence of archaeological material within the seabed associated with approximately 70cm of stratigraphy overlying geological strata. The trial trench in this area was continued in 1991 (fig. 113). In addition, test pits were dug to examine the nature and extent of the archaeological deposit. These were continued in 1992. Part of the keel was raised from area 2 and the stratigraphy around feature 307, a large concretion (fig. 113), was investigated.

### 7.1.1 The Study of Burrowing Activity

This study considers the influence of selected species of burrowing macro fauna within the three areas of the Studland Bay Site. A wide range of biological activity can be significant in determining the nature of an archaeological deposit. However, a survey of the influence of every organism currently active, or potentially significant in the past, on the site is beyond the scope of this thesis. The data presented in this study was collected during visits to the site made over 6 seasons. Many valuable comments and observations made by members of the project are also included.[6]

A brief account of the macro fauna present in each area is accompanied by a description of the apparent influence of burrowing activity. The general implications of burrowing activity for the formation, preservation *in situ* and analysis of the site are then discussed.

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[6] Particular thanks are due to Mr. Jarvis (Project Director, Poole Museum Services) for allowing me unrestricted access to the site archive. I am also especially grateful to Mr. Markey (Diving Director) and Ms. Baldock (marine biologist) who very kindly provided a great deal of additional information and photographic material.

General environmental conditions are similar in each of the 3 areas. Water depth is 12-13m and tides are usually less than 1 knot in strength.[7] The tidal regime in Poole Bay has been studied in detail by commercial concerns (BP 1991, 4-7) and sediment deposition and erosion has been modelled. The regime is complex due to the influence of the strong tidal race in and out of the Solent and the English channel. The area experiences a double high tide but the tidal range is one of the smallest on the south coast. The mean spring tide exhibits a range of 1.7m. Research has indicated general stability in terms of sediment movement with variations caused by local factors. The ebb tide (generally stronger than the flood) flows from north to south; almost directly across area 1 which is oriented east-west.[8] Members of the project feel that changes in the morphology of a nearby sandbank, Hook Sand (see fig. 109), which forms the east side of the main navigation channel to the north of the wreck may influence movement of sediment across the site. This local feature is known to change shape frequently and exposure and re-burial of material has been noted by local divers. The seabed surface consists of broken shell and a mobile sand/silt upper layer beneath which loose sands and gravels over silty clay. The coarsest material is believed to occur in the northern area of Poole Bay with the southern area, containing the site, characterised by relatively fine material on the surface (BP 1989).

The sea horizon and fetch are relatively restricted by the morphology of the coast and the presence of the Isle of Wight. Handfast Point shelters most of Poole bay from the prevailing south-south-westerly to westerly winds which occur, on average, 35% of the time. The site is exposed to winds from the east and south. The only direction in which the fetch exceeds 30km is directly south to France where it is still below 250km. Southerly

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[7] A seabed tide-meter was deployed on an artificial reef near to the site in 1991 (Collins, pers.comm).

[8] Observations made by members of the project and by the Archaeological Diving Unit indicate that the direction of prevailing currents may be responsible for consistently more substantial exposure of the northern edge of the structure within area 1.

winds account for less than 30% of average annual records.[9] The sea horizon, however, is greatest to the north. It is not thought that the site has been severely influenced by storm action during the current investigations. Hurricane force winds in October of 1987 led to fears for the integrity of the site but inspection revealed no physical damage and items of equipment left loose on the seabed were still in place.

A certain amount of sediment movement in the area is suggested by the circumstances surrounding the location of the original area of structure (area 1). In addition, over a 10 week period around October 1987, sediment depth over the site increased by 15cm, so relatively rapid local fluctuations can occur.[10] However, this factor is variable and observations made since 1989 do not necessarily suggest a continuing lowering of the seabed.[11] Initial attempts at contour surveys to establish any gradient in the local seabed were abandoned when it became clear that what was being recorded related to recent minor changes in sediment level.[12] The surface of the seabed in the area is also disturbed by trawling and bladed oyster dredging.

## Area 1

When work commenced in this area, a formal programme designed to record burrowing activity was not in place. Personal observations were made on the site during 1987 and 1988 but disturbance had already occurred with an unquantifiable effect on the biological community. However, the fact that trained marine biologists were amongst the volunteer divers involved in

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[9] Meteorological information is summarised in BP (1989).

[10] Markey, pers.comm.

[11] Markey, pers.comm.

[12] The Poole Bay area exhibits a gentle slope from deeper water in the south to shallower areas in the north. The gradient has been defined as 0.25% (BP 1989).

the excavation means that data can be gleaned from the site archive regarding the nature of burrowing within the deposit.

The structure was found to be resting on the surface of a grey, compact clay-silt substrate with abundant oyster shells. This substrate and the wreck was covered with a layer of sand and shells of which the lower 20-30cm was found to be relatively stable while the upper part was mobile. Between this sand layer and the hull planking was a fine layer of light grey silt.[13]

The structure consists of a substantial run of framing elements and outer hull planking which, on discovery, were largely covered by sediment although some wood was visible. Therefore the deepest deposits of sediment on the site (that is, the structure as opposed to the seabed around it) existed between the frames (fig. 114-5). It was in these spaces that the majority of finds were made.[14]

Razor clams (see section 6.2.4 above) were the dominant burrowing organisms noted in the inter-frame spaces and these animals can burrow sufficiently deeply to reach the base of the available sediment. The density of burrowing is also worthy of note. In one inter-frame space the remains of 17 individual animals were found. Of the empty shells, 7 were still hinged. Evidently, such remains could represent activity over a considerable period of time. It is also possible that parts of razor clams which had died elsewhere had been washed into the area. The majority of specimens noted in this study were oriented vertically in the sediment. This makes death *in situ* a more likely explanation for their presence. The burrowing action of the razor clam is unlikely to cause significant physical damage to most archaeological material and the presence of dense material in the inter-frame deposit may serve as a barrier to such an organism. However, the siphon action involved in the respiration of this organism, once established in the sediment, could be highly

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[13] Markey, pers comm.

[14] Markey, pers.comm.

influential in oxygenating anaerobic areas of the deposit and thus compromising organic preservation.

As work proceeded on the site, the edges of the outer planking were exposed. This provided niches which could be exploited by burrowing organisms (see fig. 116). Lobsters (H. *gammurus*) were observed inhabiting burrows 60 cm deep by 40 cm wide, dug below the edge of exposed timbers and planking (fig. 117); this supports observations noting a preference for burrowing against a solid surface (Howard & Bennet 1979). Such burrows extended beyond the width of a strake, thus leaving an area of relatively weak timber unsupported. The burrows exposed previously buried surfaces of the timber to aerobic and erosive environments. Localised scour, apparently triggered by the burrows, increased the exposure by widening the areas undercut; this phenomena was observed over a period of some weeks. The excavators commented that the scraping of hard carapaces against the relatively soft timber surfaces as the lobsters moved about was causing visible damage and thus contributing to the general degradation of the timber. Certainly this would contribute to the loss of potentially significant surface detail such as tool marks. A maximum of 3 lobsters were noted on the site at any one time.

Edible crabs (C. *pagurus*) were observed occupying burrows which undercut planking in a similar way. The burrows were smaller but comparable abrasive damage was observed. Crabs were considerably more numerous than lobsters. Squat lobsters (*Galathea squamiferma* [Leach]; fig. 108)[15] were noted occupying burrows which appeared to extend some way under the structure and into the sediment. No measurement of depth of penetration was attempted. The excavators did not feel that these burrows compromised the integrity of the structure in such a dramatic fashion as those noted above.

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[15] *Galathea squamiferma* (Leach) is widely distributed in northwest Europe and has been noted to exploit niches under stones as habitats (Fish & Fish 1989, 333).

## Area 2

It was possible to instigate monitoring of burrowing activity around the structure comprising area 2 in the season following its discovery. Some disturbance to the deposit had taken place during initial investigations. The effect of the limited excavation on the nature of the burrowing population actually observed on the site is unknown. Figures 118 and 119 show the timbers in relation to the seabed before substantial excavation has occurred but after the survey described here. As can be seen, the timbers lie almost flush with the seabed and many of the inter-frame spaces are dominated by groups of ballast material. The seabed itself is characterised by small stones and broken shell with coarse sand.

A survey of the visible burrowing activity was undertaken by the author. The intention was to compare observations concerning such activity with data recorded during the excavation of the deposit. Particular attention was paid to the possibility of establishing a link between known, recent burrowing and observed distribution and preservation of material within the deposit. This was not possible in area 1 as the location of surface indications of burrowing activity had not been recorded.

Figure 120 shows the recorded location of surface indications of burrowing activity. The assignment of species to burrowing events during the survey was done on the basis of the organism seen to be occupying the excavation at the time. Reuse of abandoned excavations by other organisms is a possibility. A number of excavations could not be associated with any specific organism.

Depth measurements noted in figure 120 must be regarded as minimum values. It was not always possible to ascertain whether the extremities of the burrow had been located. It is also recognised that the recorded activity is only representative of activity visible at the time of a survey conducted by an individual without substantial training in marine biology. Additional indications of current activity may not have been recognised.

## Discussion

The most notable result of the survey is the apparent intensity of burrowing. Three main categories of disturbance can be described. First, deep penetrations, usually occupied by squat lobsters. Re-use and possible widening of extant burrows by this species was suspected and observations made later tend to support this view. Figure 121 shows a pair of squat lobsters at the entrance to one such excavation (the location is marked as point B on fig. 120). The excavation below the rocks shown was at least 20cm deep.

The second major type of activity observed is characterised by relatively shallow excavations which undercut elements of structure and generally incorporate structure or ballast material as a 'roof' for the burrow. As shown on figure 120, timber 225 was found to be substantially undermined by a burrow - although the actual extent of the excavation could not be established. What is clear is that the timber was more fully exposed to aerobic conditions due to this activity than would otherwise be the case.

The third type of activity took the form of occupation of niches created by timbers having been undercut. The chronology of events involved in the creation of such niches cannot be determined with any certainty but it is probable that burrowing and scour interacted to produce the observed situation. As shown in figure 118, the ends of some timbers were exposed on discovery of the area. Excavation also exposed the side face of a number of floor timbers; figure 119 shows a part excavated area. Niche occupation was most marked at exposed floor timber - hull planking junctions.

Active burrowing was also indicated by the fact that at point A on figure 120 fine sediment of a different colour and texture to that of the seabed surface was observed in a fan-like distribution around a burrow entrance (see also fig. 123). The occupant of the excavation appeared to be a species of crab (not identified but unlikely to be *C. pagurus*.) Other instances of crab activity were noted, largely related to fairly shallow excavations beneath stones, and niche exploitation of fissures and eroded areas in the structure. In contrast to area 1, very little burrowing activity by razor clams was recorded. No immediate explanation can be offered for this anomaly although the greater number of ballast stones in the inter-frame spaces of area 2 as compared to area 1 may be significant.

There is a strong correlation between the location of excavations and the location of ballast stones. Not all of the ballast stones present on the site are marked on the survey. However, it is notable that, although there were a number of ballast stones around which there were no visible burrows, there were very few burrows which were not associated with ballast stones. This phenomena may be explained by the preference of many burrowing organisms to commence excavations in a niche created by an obstruction on the seabed. The timbers, being virtually flush with the seabed, did not tend to present such opportunities, whereas the ballast stones clearly did so. In this case then, the presence of the timbers might not have been the spur to burrowing activity so much as the presence of the ballast stones on the surface of the site.

The possibility that this apparent relationship stems from burrows already within the sediment contacting an obstruction and being directed toward the surface must also be considered. If this were the explanation, then perhaps more burrow openings might be expected alongside timbers away from ballast stones, as these too would present obstructions to burrows within the sediment. It is likely that both mechanisms were involved in the creation of the observed distribution.

## Comparison of Survey and Excavation

Investigation of area 2 produced indications of burrowing activity that were not revealed by the pre-disturbance survey. Figure 122 shows an abrasion left on a timber by burrowing activity. The lining of sediment in figure 122 actually represents part of a complete relict tube that was noted in excavation. Tubes were also noted in the deposit away from timbers.

It seems most likely that the organism responsible for the abrasion and visible tubes is a species of *Thallasinid* shrimp. It is thought that the species involved is one of the *Upogebidae* family, probably *Upogebia deltura* (L.) (see fig. 104). Live specimens of *Upogebia* have been caught in softer sediments in Poole harbour. The behaviour of this animal is not well known. It has been observed in aquaria where it was seen to maintain existing burrows by a bulldozing action using its claws. It has not been observed in controlled conditions creating new burrows. The feeding habits of the animal have not been described in detail and specimens are thought to live for approximately 1 to 3 years.[16] Live specimens of such animals were noted during the excavation of the deposit (fig. 125) and a resin cast of a burrow created by *Upogebia* has been recorded (fig. 124). It is believed to prefer sandy sediments and it is important to note that many *Upogebia* burrow openings have been detected on flat seabed, away from substantial surface obstructions, in the area of the site.

In discussion with team members it became clear that similar animals and parts of tubes had also been noted in the inter-frame spaces of area 1 but were not recorded at the time. Numerous relict tubes were noted around the edge of the area 1 structure when the seabed was excavated to investigate the underside of the timbers and to search for signs of a scour pit. Examination of photographs of exposed timber in area 1 reveals abrasions similar to those noted in area 2 (see figs. 114-5).

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[16] Mallinson, pers.comm.

Figure 126 indicates the extent of past activity within the area 2 deposit - the surface of the timber in view (the side of floor timber number 225) has been substantially abraded by burrowing activity. No ballast stones were present immediately above the abraded area and no concentration of current activity was indicated by the pre-disturbance survey of burrowing.[17] Figure 128 reveals the depth of disturbance to the inter-frame deposit. A u-shaped abrasion caused by burrowing activity is clearly visible etched onto the side of timber 229 at the southern end. Such abrasions were not evenly distributed within the deposit.

It is not possible to date burrowing activity on the basis of these abrasions alone. However, it was possible to identify distinct abrasions associated with a complete burrow tube; distinct abrasions associated with surviving traces of sediment lining from such tubes; and abrasions which appear to have been obscured and or crossed by other burrow-related abrasions. This might suggest a process of some duration. Thus, it can be concluded that the level of burrowing activity revealed by the surface survey did not indicate the actual extent, location or history of such activity within the deposit itself.

## Survival and Distribution of Material

Relatively few artefacts were recovered from area 2 as compared to area 1. Finds included elements of a pump, a few pieces of ceramic and some organic material.

It is not possible to draw any conclusions concerning the location of the finds of ceramic material in relation to burrowing activity. Survival of organic material, however, may have been substantially influenced by such behaviour. The discovery of some organic material demonstrates that conditions within the deposit were not necessarily prejudicial to preservation of this

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[17] See dive log SB90/05 in Studland Bay Archive, Poole Museum (see section 10.1).

class of evidence. The material which did survive, however, was found within the limber holes in floor timbers.[18] This location may have shielded the material from the aerobic conditions and abrasion resulting from intense burrowing within the inter-frame spaces. Material exposed to this activity is likely to have deteriorated as a result and the residue may have been assimilated into the matrix.

## Area 3

A trial trench was excavated in this area over two seasons (see fig. 113). Observations were recorded by team members in the first season (1990) and personal observations were made during the second and third seasons (1991-2). Discussion commences with burrowing activity noted around material on the surface of the seabed. The nature of such activity revealed by excavation within the seabed deposit is then considered.

Several large artefacts were visible on the surface of area 3 and were inspected in 1989. Project members had noticed that a lobster (H. *gammurus*) was inhabiting a burrow under a wrought iron gun in 1988.[19] When observed in 1989 this burrow completely undermined one end of the artefact (see fig. 127). Team members believed that the lobster had taken advantage of and enlarged a depression originally created by scour although this cannot be stated with certainty. The exposure of the underside of the object may be significant both in removing mechanical support and in exposing new surfaces to abrasion and aerobic conditions. Squat lobsters and crabs were also observed

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[18] See dive log SB90/06. SB89/18 also describes the location of a find of rope and straw not associated with a limber hole. It may be significant that no burrowing activity was recorded in this location in the surface survey. It should be emphasised that this was an isolated find of organic material outside of limber holes in this deposit although caulking material was observed associated with concretion along the garboard seams (SB89/20).

[19] See dive log SB89/07.

to be occupying niches provided by the presence of the object on the seabed.

The second major feature that was visible on the surface of the seabed was a substantial timber labelled as feature 306 (figs. 129-31).[20] No specific burrowing activity was noted when this object was first inspected. However, during recording, which involved turning the object over, significant features were observed. One edge of the object exhibited substantial surface abrasion accompanied by extensive penetration of the timber (see fig. 131). Initial observation led to the conclusion that some of the voids may have been tree-nail holes. However, a lining of modified sediment within each cavity indicated a biological origin. It is possible that some of the holes represent modified tree-nail holes but the morphology of the majority does not suggest that this was generally the case. As can be seen from figure 131, some of the burrows are totally enclosed in the timber for part of their length. The cavities lacked the calcite lining which typifies the activity of organisms such as the shipworm *Teredo* known to be able to move through timber (Robinson 1981, 12-14). The most likely agent of the observed damage was again *Upogebia*. This phenomena does not appear to have been recorded previously. It is possible that the burrows which penetrated the wood did so in areas where other biological processes had already created niches - the possibility exists that *Teredo* holes were widened by *Upogebia*.[21] However, *Teredo* burrows elsewhere on the site have been observed to follow the grain of the wood. The burrows of interest exhibit a more random pattern.

Examination of the surface which had formerly been in contact with the seabed also showed considerable evidence of burrowing related damage. This part of the timber was almost completely

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[20] The precise nature of this object has not been identified although it seems unlikely to be either a mast-step or part of a gun carriage (Adams & Hildred, pers.comm.). It may be part of the pump assembly (Markey, pers.comm.).

[21] Abrasion tracks caused by squat lobsters (G.*squamiferma*) have been noted on timbers that have previously been softened by small burrowing bivalves (Mallinson, pers.comm.).

covered by interconnecting very shallow abrasion tracks (fig. 130). Small areas where tool marks survived revealed that substantial loss of such data is likely to have occurred as a result of this activity.

No substantial penetrations into the timber were noted on this or other faces except very close to the edge described above. There was a perceptible difference in colouration and hardness between the wood on the edge that had been penetrated and the darker, harder timber elsewhere. This might indicate that the area where penetration occurred consisted of sap-wood or was simply more degraded and therefore softer than the rest of the object.

In 1990 and 1991 a trial trench was excavated in area 3 to examine the seabed deposit. Figure 132 shows the north section face of the trial trench dug in 1991. Substantial burrowing was observed. The presence of *Upogebia* was most clearly evidenced but other organisms were also noted. Razor clam activity was evident in the top 20cm of the deposit which largely consisted of transient sand, shell and 'hard pan' - a dense amalgamation of sand and shell. No razor shells were noted within the archaeological layers. Crabs were quick to occupy niches revealed by the excavation of the trench causing minor collapses and slumping. Burrowing by a large lobster (*Homarus*) caused similar problems.[22]

The main indicator of burrowing activity noted during the excavation was the presence of tubes formed of modified sediment as had been seen in area 2. Two forms of tube were noted. The most abundant consisted of sediment modified to a clay-like consistency. The majority of tubes were roughly 4cm in diameter although some were only 2cm. Some of the larger diameter tubes appear to have been filled with sediment at some stage and then a smaller diameter tunnel was excavated within the tube. Individual live specimens of *Upogebia* were observed within both sizes of tube during excavation. The smaller tubes may have been

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[22] See dive log SB 91 10.

occupied by juvenile or female animals. In certain areas tubes which were of a much harder consistency were observed. These tubes had sufficient residual strength to allow their removal in large sections and were generally infilled when observed. It is believed that such tubes are formed by a combination of the mucus which binds the burrow walls and traces of iron in the sediment.[23]

The tubes did not survive equally in all contexts. Instances of a tube entering a context and emerging below it without a connecting segment within the context itself were observed in section. There was no clear consistency in terms of which contexts did or did not contain relict tubes. However, as indicated in figure 133 burrows did cross dissimilar layers and this resulted in longitudinal traces of obviously intrusive sediment within contexts.

Context 21 (see fig. 132) was exposed in plan. Initially it appeared to consist of mixed organic material. Further excavation revealed that it was a part-degraded piece of woven matting (see fig. 134). The layer was very dark and very distinct from the surrounding matrix. Relict burrows were clearly visible as lines of lighter coloured sediment running through the dark layer (see fig. 136). The lighter sediment had been drawn into burrows from other contexts. Whereas much burrowing activity in the seabed was vertically oriented, activity related to context 21 generally exhibited a horizontal trend. This apparently atypical incidence of lateral travel may be a result of the less compact nature of the context and its high organic content making it attractive to the burrowing fauna.

A comparison between degraded and undegraded areas of the matting indicates that burrowing was highly significant in compromising the physical cohesion of the material. Areas where the layer was intact tended to be in the proximity of pieces of firewood which may have acted as a barrier to the animals.

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[23] Collins, pers.comm.

Indeed the presence of substantial timber elements did seem to generally moderate the influence of burrowing. Some smaller wooden objects were apparently shielded from abrasion to some extent by overlying larger elements. This resulted in localised instances of very good preservation in a deposit which produced many abraded wooden objects.

Abrasion was not the only type of damage related to burrowing caused to wooden artefacts. In a number of places the abraded track of a burrow could be followed along the edge of a timber. The track itself was surrounded by an area of discoloured and degraded wood. This appears to have been a result of oxygenated water within the burrow destabilising anaerobic conditions in the immediate area.

The general extent of burrowing in the deposit is indicated by figure 137 where relict tubes are visible at the top and base of the section. The surface of the geological clay on which the seabed stratigraphy rested also showed signs of burrowing activity. It was heavily pitted and contained deposits of intrusive material including relict tubes. In certain areas the stratigraphy of the deposit was completely replaced by a matrix of consolidated burrow tubes.

### 7.1.2 Discussion

In section 6.3 it was concluded that burrowing activity should, in general, be considered as having an adverse effect on the integrity of a deposit. This case study supports that judgement. Borrowing has prejudiced the survival of specific classes of evidence, most notably soft, organic material. It has compromised the *quality* as well as the *quantity* of certain classes of evidence. This is most marked in relation to data which can be derived from examination of tool marks. Such surface features are likely to suffer heavily through abrasion and subsequent deterioration of timber faces. Information concerning fastenings is also likely to be lost through this process. These observations reaffirm the need to seek techniques to reduce the effect of burrowing on a deposit that is to be conserved *in situ*. This is discussed further in chapter 8.

A general characterisation of burrowing activity as harmful to the integrity of deposits is supported by work conducted in North America during the National Reservoir Inundation Study (Lenihan 1981, vol. I, 174). A variety of faunal impacts were noted in the study including processes such as the damage caused by grazing cattle trampling on a semi-submerged prehistoric hearth.

In the Folsom Reservoir, California, the burrowing clam *Corbicula fluminea* was noted to have comprehensively disturbed the top 10cm of a midden deposit (Site CA - ELD - 201). As the deposit was only 30cm deep in total this impact was regarded as severe (*ibid.*, 133). The effect of the burrowing of the clams was compounded by the fact that racoons found them a readily available and abundant food source. Their foraging activities increased the disturbance to the midden. The impact of mussel activity on a submerged land site was also dealt with by May (*et al.*, 1978,117 & fig. 9, 116). The site, an Archaic rock shelter, had been submerged for 18 years through reservoir construction. It was noted that the bottom of the shelter was marked by numerous depressions with a density of 10-20 per m$^2$ in some areas. These were caused by the activities of freshwater mussels which can grow to lengths of 10-16cm and can burrow 30cm into the sediment. Lithic material, such as waste flakes and projectile points, was observed within some of these depressions.

Further evidence is provided by observations made during the 1987 season of work on the site of the *Kennermerland* located off the Outskerries (part of the Shetland Islands).[24] Excavation took place within gullies, which characterise the topography of the

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[24] Accounts of previous work on the site have been published which include detailed descriptions of the local topography and environment (Price & Muckelroy, 1977; Muckelroy 1978, 177-181). A final season of excavation took place in 1987 (Dobbs & Price 1991).

site. The working face of the excavation was usually advanced at a slight angle reducing the likelihood of collapse of the section face. At a chosen location this was carefully cut vertically in order to observe and record the stratigraphy. The next day the section was found to have partly collapsed although the sea had been very calm. On recutting the section, crabs were observed to have burrowed into the upper layer of loose stones and gravel so causing the noted disturbance. On removal, the crabs quickly burrowed back under the stones. Individuals roughly 12cm across the carapace were seen levering themselves under stones of the order of 30 x 15 x 10cm with relative ease (fig. 135). They did not, however, appear to burrow into the consolidated deposit that lay below the loose stones and gravel.[25]

Although the actual loss of information through disturbance caused during normal excavation procedure was minimal, the potential for damage is clearly considerable (*c.f.*, Muckelroy 1978, 43). The localised lowering of the seabed produced by the excavation of a trench exposes material previously buried beyond the reach of local species to the potentially adverse effects of burrowing noted above.[26] The side burrowing activities of crabs (Warner 1977, 5) seem ideally suited to damaging vertical faces, destroying stratigraphy and, during excavation, necessitating the further cutting back of section faces. An analogous situation can result from scour. Thus while strategies are required to limit the adverse influence of deposits not under excavation some thought should also be given to preserving the integrity of the resource even while it is being exploited archaeologically.

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[25] Dobbs & Adams, pers.comm.

[26] See McKee's (1982, 110) observations on the site of the *Mary Rose.* Trenches were left open over the winter and when inspected revealed a number of burrows dug into the section faces by fish and crabs. Areas of significant section collapse appeared to be related to the burrowing activity (McKee, pers.comm.).

## 7.2 Identification of Burrowing Activity

What contribution can this study make to the development of practical means by which it can be established whether, and to what degree, a deposit has been influenced by burrowing? As discussed in section 2.4.2, a number types of evidence can contribute to such a judgement; the nature and structure of the sediment; recognition of burrows, or physical traces of burrowing that may survive in some form if sediment is modified during the burrowing process; parts of burrowing fauna may be found within the sediment itself. In addition, simple properties of artefacts, such as damage patterns, and complex properties of artefacts, such as spatial distribution, may be utilised in making inferences relating to past and present burrowing activity.

### 7.2.1 Ecofacts

Thin, humic films of soil and ecofacts such as 'worm grit' are well known indications of burrowing activity in terrestrial contexts (Barker 1977, 120 & see fig. 40, 121). McBrearty (1990 126) notes that recent termite mounds are very conspicuous and that fossilised termitaria have been recognised in ancient deposits (Upper and Lower Laetoli beds). They occurred as both cast and matrix fossils of hard calcite and softer clay, sometimes cemented within eolian volcanic deposits. Stein's (1983, 283) specific observations on worm action (see section 6.1, 189) are supported by the observation of worm casts in locations ranging from the surface of the midden (2m above the surrounding plain) to the bottom of the observable midden deposit some 2m below the land surface. This study has produced some comparable data.

General characteristics of bioturbated marine sediments have been established by workers such as Johnson (1977, 280-1) mainly through coring. Such sediments are generally typified by their relative homogeneity - no morphological differences being observed between the lighter coloured upper oxygenated layer and the lower anaerobic strata. This is attributed to the recycling action of the macro benthos and to the rapid recolonisation of faecal matter by microbes. In the shallow inter-frame spaces of areas 1 and 2 of the Studland Bay site the observed stratigraphic sequence was ostensibly simple. Particle size was noted as uniform[27] save for increased size of shell inclusions at the surface and the presence of a layer of very fine sediment at the bottom of the deposit. Some differential colouration was observed during excavation due to oxidisation of anaerobic sediment. In addition, although particle size was ostensibly consistent throughout the inter-frame space in area 1, some parts of the deposit were noted as darker than others. This may represent organic material thoroughly assimilated into a homogenised deposit. The implications for analysis that attend such an observation are discussed below.

Intrusive sediment within contexts resulting from burrowing was also noted in area 3 (see above). There is no reason to believe that such traces will not persist for a considerable time if subsequent disturbance does not occur. Paradoxically, in a stable seabed, further burrowing activity may be the most likely agent of removal of such traces. Observable differences in colouration of sediments caused by juxtaposition of oxygenated and anaerobic quantities of the same material would not be expected to persist however.

The surface evidence of burrowing noted during the survey of area 2 certainly provided an obvious indication of some types of recent and ongoing activity. However, the dominant and most readily identifiable indication of burrowing activity past and present was the relict burrow tubes noted in areas 2 and 3 (and retrospectively acknowledged to have been present in area 1). As previously noted, relict tubes were not consistently present throughout all contexts in area 3. Therefore absence of tubes

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[27] Observations were made *in situ* and sediment has been analysed, but no quantitative data on particle size is available.

cannot necessarily be used to infer complete absence of activity within an area of the deposit.

The length of time for which such tubes, left undisturbed, will survive is not known and the temporal extent of activity which the observed tubes represent cannot be established with absolute certainty. However, observations made during excavation support the contention that the deposit has been influenced by the burrowing of *Upogebia* for a substantial part of its history. This is well illustrated by layers surrounding context 21; matting, now known to be reed (see figs. 132 & 134). During excavation of this layer it was noted that hardened burrow tubes existed directly beneath intact areas of matting. No infill was seen within the burrows but only the very top portion was visible. One explanation for this phenomena is that burrowing activity was continuing as this context formed. The deposition of the matting sealed the tube and the matting itself was then quickly covered. Rapid coverage of the matting would seem to be required for survival of the material given the very insubstantial nature of the single layer of weave.

Such an explanation would require the observed tube to have survived for several hundred years. Traces of fossilised burrows have been noted by geologists and there is no pressing reason to discount the possibility that hardened tubes have survived for such a period. Traces of iron in sediment will contribute to the hardening of the initially soft mucus bound structures.[28] Alternatively the tube might represent a more recent burrow that originated away from the context and which stopped on encountering the straw layer. The tubes could not be followed for any distance during further excavation. However, this explanation would have to account for the fact that numerous burrows passed through the layer of matting; indeed the layer contained evidence of considerable activity.

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[28] Collins pers.comm.

The contention that burrowing activity by *Upogebia* is of some antiquity within the deposit is further supported by excavation around the large concretion in area 2, feature 307.[29] This revealed numerous *Upogebia* burrows fully enveloped by concretion. It is not considered feasible for *Upogebia* to burrow through concretion. It is likely that the concretion was formed at the same time as, or indeed after, the burrow tubes which were then encapsulated and so preserved. It was not possible to follow the burrow tubes within the concretion into the surrounding matrix although many apparently unrelated tubes were observed in the deposit itself. This suggests a degree of disturbance to the matrix around the concretion which removed evidence of the extension of the tubes from the concretion. Continued bioturbation and scour may be the most likely agents of such disturbance. Thus, the presence of the relict tubes also indicates that the matrix around the concretion cannot be considered as unmodified. In addition, the discovery of rope running underneath feature 307 may indicate contemporary salvage efforts.[30] However, the potential complexity of the deposit and the difficulty of arriving at a simple estimate of degree of disturbance is provided by the presence of an intact barrel hoop in the sediment close to the concretion (fig. 138). Although this exhibited some abrasions caused by burrowing its survival hints at considerable variability in terms of intensity of disturbance within even a relatively restricted area.[31]

Further evidence of burrowing was provided by abundant shells of dead animals, particularly razor clams in area 1 and in the upper 10cm of area 3. Shell material is likely to survive well in low energy environments. No dead specimens of *Upogebia* were found within tubes or within the sediment. Despite this it is possible that durable parts of burrowing crustacea will survive for a considerable time within the sediment and thus be detectable

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[29] See dive logs SB 92 08; SB 92 09.

[30] See dive log SB 92 12 and finds record 738.

[31] See dive log SB 92 11.

during an investigation, particularly if sediments are analysed microscopically. Such remains have been noted within section faces during excavation.

It is clearly important to distinguish intrusive faunal material from anything which might actually represent debris relating to food preparation or consumption. Representation of body parts can be a useful guide as to whether faunal remains represent an animal which died in its burrow or part of a dead animal that has been washed into the site and buried. With crabs, for example, the legs tend to fall off within weeks after death. Presence of leg parts in the stratigraphy might well indicate *in situ* faunal remains.[32] The remains of a crab, with leg parts, were found some 30cm below the present seabed level during the excavation of a site in Yarmouth Roads, Isle of Wight (see below).[33]

In addition, it was possible to identify certain areas of disturbance by the presence of slipper limpets, *Crepidula fornicata* (L). This animal was accidentally introduced to UK waters along with imported American oysters in 1890 (Fish & Fish 1989, 214-5). Its presence within a layer would therefore indicate formation of a context some time after the original depositional event.

### 7.2.2 Simple Properties of Artefacts

If significant inference could be drawn from ecofacts then the same is true for cultural material. This study produced evidence that simple properties of artefacts, such as damage patterns, can be used to infer burrowing activity. Not every incidence of abrasion on a timber or wooden object can be clearly linked to burrowing behaviour, and certainly not to a specific animal. However, the observation of relict tubes in intimate association with abrasion tracks and isolated instances of damage to wooden

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[32] Laverack, pers.comm.

[33] Watson, pers.comm.

artefacts allows a link between cause and effect to be made with some confidence.

Abrasions such as those noted within this deposit are likely to last some time if they remain buried. Exposure to current borne abrasives may remove diagnostic features quite rapidly. It is also evident that continued burrowing by the same organism within a deposit can itself serve to remove clear indications of individual tracks. However, intense activity of this nature appears to create its own characteristic surface as shown in figure 126.

It has been shown that ecofacts such as relict burrow tubes can be used to consider the history of burrowing within the deposit, simple properties of artefacts can offer similar opportunities. There were abrasion marks on the tops of timbers in area 2 which were morphologically very similar to those visible on the faces of timbers (see fig. 139). There was also *Teredo* related damage but this was clearly distinguishable due to the smaller size of the excavations and the calcite linings of the burrows within the timber. Using the phenomena observed within the deposit as a guide it can be concluded that these marks represent the bottoms of former burrows. Lowering of the seabed which exposed the timbers also served to remove other evidence of these excavations, *e.g.* the tubes noted elsewhere.

The abrasions then, provide support for the uncontentious supposition that the site was formerly more deeply buried than when discovered. They also tend to lend weight to the suggestion that the deposit has been exposed to disturbance by *Upogebia* previous to the exposure of the timbers which lead to their discovery. That is, the indications of activity noted in the inter-frame spaces does not necessarily only represent burrowing which commenced after the exposure of the timber. The implications of this will be discussed further below.

### 7.2.3 Complex Properties of Artefacts

No substantial progress has been made in relation to the use of complex properties of artefacts, such as spatial distribution and artefact inventory, in the practical identification of burrowing as a formation process. Erlandson (1984, 787) concludes that the activities of the pocket gopher (*Thomamys bottae*) on land produce a bimodal distribution of material within a deposit. Finds were quantified according to the level at which they were found and two main clusters were isolated. The largest occurred at 20-30cm below the surface, a second was noted at 50-60cm. This bimodal characteristic was reflected in observed gopher burrowing behaviour. Shallower burrowing is undertaken to locate food and deeper burrowing for habitation and breeding. Bocek (1986, 595-7) concurs with Erlandson. Bocek's observations are refined in terms of size of object; smaller finds were clustered nearer to the surface and larger ones deeper. This study has not produced any comparable data. No convincing evidence of alteration of spatial relationships due to burrowing activity can be presented. No archaeological material was observed within burrow tubes and no conjoinable fragments of pottery could be identified in separate contexts which may have been separated through the influence of this process. Biologically induced alterations of spatial relationships have, however, been noted.

Figure 140 shows an area of timber exposed by erosion on a site near Duart Point in the Sound of Mull. The deposit is thought to represent the remains of a small Cromwellian vessel lost in operations against Mull in 1653.[34] During survey work on the site the presence of a number of crabs, believed to be C. *pagurus*, was noted. At the location shown on figure 140, archaeological material was observed being displaced by the burrowing action of a crab.[35] The animal is just visible at point A. Point B marks the bottom of a small stave-built container which has been displaced from below the timber running left to right. This rests on a

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[34] Martin, pers.comm.

[35] Figure and observations supplied by Mr. Liscoe.

mound of sediment which has been pushed out from below the timber. At point C a fabric covered wooden button has been displaced from the same area.

Similar activity has been noted elsewhere. Burrows, seen to be occupied by crabs were noted in Larne Lough, Northern Ireland in 1990. The bed of the lough consists of fine sediment, thought to be significantly polluted. A very soft pelletised layer 2cm deep overlies a thick anaerobic layer of darker compact sediment. There are considerable quantities of man-made debris on the Lough bed. At one point, hessian sacking was noted, overlain by a dense agglomeration of debris such as cans and chain. A burrow, occupied by a crab (C. *pagurus*) had penetrated the hessian sacking (the burrow was delineated by the jagged edges of the damaged hessian. Along one edge the cultural debris had been comprehensively undermined. Elements which appeared to have originated above the sacking, had tumbled into the burrow and now occupied a position below it. Thus the burrowing resulted in physical damage to organic material and the alteration of spatial relationships.

The role of such activity in the process of burial was also illustrated. A modern glass whisky bottle was noted, half buried in the sediment. The buried end was lying in a hollow. This seems to have been created by the burrowing activity of a crab. A steep depression was visible either side of the bottle and there was a gap below the bottle. The crab was observed re-excavating the burrow beneath the bottle, which appears to have subsided after having been undercut by the original burrow excavation. It is possible that the bottle had rolled into a existing excavation. However, the orientation of the bottle, the fact that its top surface was completely exposed and the gap noted between the lower surface of the bottle and the sediment are highly suggestive. It is not possible to predict how far the process would have continued. But what is clear, is that once the bottle has been partially buried, its relationship to the seabed, and the various mechanisms affecting material resting upon it, has been changed as compared to when the bottle was fully exposed on the surface.

Once the burrow was abandoned, natural sedimentation would cover the part of the object below the sediment surface level.

These examples do illustrate the potential for biogenic modification of associations. The significance of such alterations will vary from case to case. Displacement of material from one context into another might be regarded as problematic - particularly given the difficulties which might attend subsequent identification of the process. Modification of associations within a single context may pose fewer problems in terms of analysis and inference.

Artefact inventory within the deposit is very likely to have been influenced by burrowing activity. Yet, a relative paucity of organic material within a deposit which appears to offer favourable preservative conditions, could be the result of a number of other factors; these include scour and actual absence of the material in the past. On the evidence of this study, past burrowing activity might be inferred more reliably by the observation of patchiness in organic preservation within an apparently cohesive deposit, rather than by a total lack of that class of evidence. This may particularly be the case if dense material, which could not be penetrated by burrowing organisms, is located above or close to the observed areas of organic preservation.

A number of possible methods for inferring the influence of formation processes in a deposit were suggested in section 2.4.2. This study has shown that such methods can be useful when applied to the study of burrowing activity. However, despite some success, problems are evident. First and foremost is the species specific nature of the bulk of the data discussed. While some progress has been achieved in isolating regularities which can be used to assist in identifying the past activity of one specific animal, *Upogebia*, other organisms left no similarly obvious traces. For example, no unequivocal sub-surface indications of the activity of squat lobsters, the dominant species noted in the surface survey of area 2, were recognised. This may reflect a lack of sophistication in this study which prevented recognition of evidence that was there or allowed confusion between traces left by different animals. It may also result from the above noted tendency for squat lobsters to reuse existing burrows.

It may be impossible, in practice, to distinguish between slight abrasions made on an object by two different species sharing certain characteristics - such as a hard carapace. When considering such abrasions it is also important to note that vast majority of such marks were on relatively soft wood. Other types of material, such as ceramic, would not be conducive to having such readily identifiable marks mapped onto them. Additionally, many burrowing organisms will not excavate in a manner which creates such marks. It is therefore the fortuitous combination of a specific form of behaviour and a specific material type which has resulted in simple properties of artefacts persisting to be observed in excavation and utilised in analysis.

Some suggestions have been made concerning the duration and history of burrowing activity, again largely relating to one species. The availability of evidence relating to such temporal considerations is likely to be highly variable depending on the specific characteristics of each deposit and the burrowing community. While observations presented here may indicate that burrow tubes can persist for a considerable time evidence suggests that excavations in muddy sediments infill quite readily once the burrows are no longer actively maintained (Atkinson 1974, 251). Pye (1980, 198) is of the opinion that *nephrops* burrows only last a few months while Rice and Chapman 1971, 341) state that tunnels require regular attention if they are to remain open. If the burrow simply collapses, or fills with sediment identical to that through which it was excavated, then it may be very difficult indeed to detect subsequently, even if the deposit is sectioned. Additionally, if the burrowing activity takes place within one homogenous layer, or as a layer is being formed then the differences in compactness and composition (between infill and the surrounding matrix) may not be lasting or marked enough to be detected at a later date.

Where burrows occur in firmer substrates, however, they have been observed in excavation (Collins & Mallinson 1984, 70). Evidence from the Yarmouth Roads site,[36] off the Isle of Wight, demonstrates that recognition of burrowing as a formation process can be achieved in deposits not dominated by *Upogebia*. The site consists of substantial elements of structure preserved in pockets of deeper sediment within an area of seabed with high clay content (Watson & Gale 1990; see fig. 164).

Data relating to burrowing activity on this site falls into two categories. First, activity was noted during excavation and survey. Squat lobsters (*Galathea*) were observed burrowing against timbers to a depth of 20cm (Werz 1987). The erosion which accompanies such activity has been discussed above. More germane to the current discussion are the phenomena recorded in section which can be interpreted as the result of burrowing activity at earlier stages of the formation of the deposit. Sections recorded on the site are shown in figures 141 and 142. A number of features have been highlighted.

At point A on section 1 (fig. 141) evidence indicative of burrowing around a timber is visible. A discrete pocket of sediment with stone and shell inclusions can be seen. This may represent an infilled burrow created when the timber was exposed during an earlier phase of the formation of the site. Similar excavations, as indicated above, were noted around timbers on the current seabed. It is possible that the feature may represent scour rather than burrowing. A wider area of potential disturbance to context 011 can be seen to the left and right of the timber in the form of depressions. These may represent infilled scour around the timber. However the discrete nature of feature A and the depth of penetration compared to the breadth of this disturbance may militate against scour alone being responsible.

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[36] Detailed environmental reports concerning the site and the surrounding area are held in the site archive at the Isle of Wight County Archaeological Centre.

If burrowing created this feature, then the suggestion that burrowing is an ongoing process during the formation of a site is supported. It is not possible to identify the animals responsible for the observed disturbance, but crabs and squat lobsters are likely candidates. No disturbance can be observed linking the feature under discussion to the present seabed surface. However, it is possible that such evidence was not recognised when the section was recorded. Further support can be derived from phenomena observable in section 2 (fig. 142).

At point A it can be seen that layer 014, brown-grey sandy silt with organic inclusions, has been disturbed. Intrusive material from layer 011, light grey silty clay with fragment of dense clay, can be observed. This is particularly clear at points B and C. As with the feature noted in section 1 there does not appear to be disturbance linking these features with the surface. This is not conclusive evidence of the biological origin of the features nor that the disturbance occurred while the seabed was at a lower level. However, the recorded section is highly suggestive of burrowing related disturbance to layer 014. There were no indications of intrusive material from layer 010, grey-brown silty clay with large shell inclusions and iron stone pebbles, within layer 011. This would tend to support the suggestion that the burrowing occurred while layer 011 was at or near to the seabed surface.

Two main conclusion can be drawn. First, stratigraphic information from the Yarmouth Roads wreck tends to support the characterisation of burrowing as a pervasive process during site formation. Second, careful observation during recording can lead to some progress in describing the history of burrowing within a site rather than only the most recent events.

# 7.3 Implications for Inference and Methodology

This discussion does not, and should not, seek to pre-empt the full publication of the site. Any remarks made here must be set against the eventual detailed interpretation of the various deposits in post-excavation work. The aim is to highlight points which might assist in understanding the nature of the deposits which are to be analysed and can be extended to inform work on similar sites elsewhere. The influence of burrowing within two very different types of deposit is examined in this study; the inter-frame spaces of areas 1 and 2 and the seabed in area 3. The relatively shallow inter-frame deposits will be considered first.

The relatively simple stratigraphic sequence recorded in the inter-frame deposits may indicate a genuinely straightforward situation, there is little benefit in seeking complexity where it does not exist. The distribution of material is shaped primarily by the form of the structure and this factor may be more significant that any other. The possibility that complex stratigraphy within the frame spaces was homogenised by intense burrowing activity should also be considered. Such 'micro stratigraphy' could provide data relevant to the study of the formation of the deposit and to reconstructing the original associations of artefacts.

Unquestioning acceptance of the existence of a single context could lead to an overly simplistic interpretation of the history of the deposit. It may be taken to indicate a single depositional event rather than a complex sequence.[37] Whether or not complex stratigraphy has been obscured cannot be proven. Detailed

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[37] McBrearty (1990, 125) notes that clay and silt particles brought by termites from depth effectively bury the existing land surface, which is subsequently obliterated by continued burrowing. Such a succession of fine grained sediment stratified above a coarser deposit may be wrongly interpreted by the archaeologist as reflecting a shift to a lower energy depositional environment rather than being identified as an artefact of intensive burrowing.

particle size analysis can demonstrate homogenisation and precise sampling might reveal the persistence of micro lamination. However, the pre-bioturbation condition of the deposit could not be reconstructed with certainty by examining the homogenised result. The intensity and potential duration of bioturbation which can be inferred from evidence presented above, is likely to be sufficient to have a profound influence on the nature of the deposit under discussion. In the analysis phase it is clearly very important to consider the potential role of biological activity in the creation of contexts rather than simply as an agent of disturbance to a pre-existing deposit.

The inter-frame spaces in areas 1 and 2 have so far been discussed together. However, while ceramic material was abundant in area 1 very little artefactual material was found in area 2 which contained more ballast stones. Full explanation of this must await detailed consideration of the dynamics of deposition and post-depositional history of the whole site. However, the existence of such a difference could cast some doubt on the comparability of the two deposits. It is possible that the inter-frame spaces in area 2 may not have contained very much cultural material anyway; either because the material was simply not present, or through the spaces having been fully exposed and current swept for a period before refilling with sediment. The latter scenario might also explain the apparently simple stratigraphical sequence and lend weight to the argument that no homogenisation of a formerly more complex deposit has occurred.

The fact that the inboard side of the hull planking did not show indications of erosion, save at the edges, weighs against this suggestion. Treenails exposed by excavation, for example, retained clear spoke-shave marks. The interior face of planking also exhibited patches of a resin type substance which deteriorated rapidly after discovery (see fig. 143). These features would be highly unlikely to survive exposure to the current borne abrasives and aerobic conditions necessitated by the current-swept inter-frame space model.

To propose that all vertical provenience within the inter-frame deposits is meaningless due to biological disturbance of the context is, however, unjustified. The presence of dense material which prevents penetration by burrowing organisms can clearly introduce variability; that is, not all areas within one inter-frame space will necessarily have been influenced to the same degree. Detailed interpretation of spatial relationships may well require moderation by reference to the potential influence of burrowing. Yet it would certainly be unwise to excavate the inter-frame spaces as a single unit thus disregarding the possibility that significant data exist even if some degree of homogenisation is accepted. Indeed, it is only through careful recording of spatial relationships in a deposit known to have been modified by burrowing that the nature and extent of the influence of the process on such data will be determined.

At the most basic level of analysis, the choice of excavation strategy to be applied in examination of seabed deposits within the Studland Bay site might be reviewed in the light of experience gained. The trench excavated in area 3 was 1m wide. The fact that it exposed a probable junction between natural and archaeological deposits (see below) created a complex deposit. However, the extensive burrowing activity also contributed to making excavation by context problematic. Relict tubes and blurring of boundaries caused by bioturbation meant that many contextual relationships were more evident in section than in plan. Work was particularly affected in areas where the deposit consisted entirely of consolidated tubes which removed interfaces between layers and in effect split the section into two halves - with precise relationships between layers on either side of the disturbance obscured.

A wider trench might be more appropriate to reduce the loss of data from areas of intense tube building; the relatively restricted width of the trench did tend to exacerbate the problem of detecting disturbed boundaries in plan. Such a strategy has drawbacks. There are significant practical implications relating to time, cost and an increase in the area of the deposit disturbed by investigation, without a guarantee that critical relationships will not be obscured in a wider trench as well. There is no guarantee that tubes would not be abundant in any location chosen but a wider trench might provide better opportunities for observing contexts in plan.

Despite the problems noted above, meaningful contexts do appear to survive in the seabed deposit of area 3 (see fig. 132). Interfaces between layers were usually distinct in section and artefact assemblages can be associated with specific contexts. Artefacts which might be characterised as domestic or personal in nature, such as shoes, combs, wooden bowls and a possible inkwell were found associated with context 18. Larger elements of the ship's structure , such as filler pieces, large bolts and hull planks, were found in context 17 and in the interface between the archaeological deposit and the transient layer of sand. This might indicate lighter debris from the initial break up of the vessel having been washed out and subsequently covered by heavier material as the remaining structure collapsed.

Such observations may serve to undermine suggestions of significant modification of contexts within the inter-frame spaces made above. However, the relatively shallow, narrow, nature of the inter-frame spaces as compared to the seabed deposit in area 3 is considered to be significant in this respect. That is the activity was more narrowly focused and thus more intense in effect. Multiple contexts survive in the seabed and some characteristics of the deposit do not indicate that all of the observed layering was necessarily created in a single, dynamic, chaotic event. This could support the former existence of a more complex sequence in the inter-frame spaces; that is, a very simple depositional history for one part of a site seems less plausible if a closely related part exhibits a complex sequence.

Pottery found in context 18 (fig. 132) may have been broken *in situ*; there are numerous conjoining pieces without erosion on the fractures. This might suggest a relatively high energy depositional environment or post-depositional activity.[38] The orientation and condition of the single thickness of rush or straw matting which constitutes layer 21 however, indicates a less turbulent depositional phase. It seems unlikely that the matting, which is very thin, would have survived if it was not covered quickly. The fact that it is oriented horizontally indicates that it is likely to have come to rest on an existing flat surface and to have done so in a relatively low energy environment.

An examination of the layers above and below the straw matting also indicate the way in which burrowing might have modified contexts in the trench and could influence interpretation. Layer 13 above 21 appears to consist of essentially the same material as that below it, layer 17 and 18 (fig. 132). The only apparent difference is flecks of black organic material in layer 18. These seem to derive from layer 21. It is possible that bioturbation has played a part in drawing this material down into the lower layer. The creation of the apparently different context 17 may be a function of the location of a number of large pieces of wood which modified the extent of the bioturbation visible in section. Context 16 appears to be directly related to sediment catchment around a large piece of firewood. Thus it can be suggested that contexts 21, 13, 16, 17 and 18 could have been created during one depositional sequence. Apparent differentiation results from post depositional burrowing induced modification, not from separate depositional events.

If it is accepted that burrowing can have a significant influence on a deposit, then it should follow that describing such activity is an important part of site assessment as a prelude to management oriented decision making. For example, are attempts at preservation *in situ* justified by the potential inferential value of the deposit? Does this study offer any indications as to how such assessments should be conducted?

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[38] Although experimentation on land has demonstrated that burial and subsequent soil compression can cause fractures in ceramic material (Mathewson *et al.*, 1992, 79-87).

The actual extent of disturbance to area 2 is unlikely to have been inferred from the pre-disturbance survey. Equally, inspection of the surface of area 3 did not reveal clear indications of the extent of the influence of burrowing on the deposit. The history of burrowing within the deposit, which does appear to have relevance to its analysis, could not be studied in detail through such non-intrusive methods.

Specialists in burrowing behaviour may be able to make certain inferences based on the data collected in the survey that would allow a more refined estimation of the level and nature of activity within a deposit. It is also the case that conclusions based on observations made in this study can be applied to other deposits where *Upogebia* is known to be present. However, as already noted, the behaviour and distribution of *Upogebia* is not well known so precise information on which to base such predictive judgements may not be available. For instance, the nature of the sediments within a deposit are likely to be very significant in determining the level of burrowing activity. To apply such a principle to any assessment of likely levels of disturbance it is necessary to know the sub-strate preferences and maximum burrowing depth of the range of animals which may be active in an area. It is also necessary to determine the actual nature of the sediment present within the deposit. The first set of data may be available to some extent but will vary dramatically from species to species. The second set of data will not be available in any detail from a surface inspection alone.

The situation is further complicated by any attempt at developing a temporal perspective. It may be argued that the history of burrowing activity does not require detailed consideration if the site is to be preserved *in situ* rather than excavated and studied. The main task in such a situation would be to reduce the magnitude of changes to the deposit over time. Quite properly, this focuses attention on current rather than past biological activity. Yet failure to consider the temporal aspect may lead to a superficial assessment of the inferential value of the deposit on which resources are to be expended to promote its survival.

Problems associated with a surface survey are highlighted by consideration of the potential relationship observed between location of ballast stones and burrowing activity during inspection of area 2 (see section 7.1.1, 217). On the basis of the surface survey alone it might be postulated that disturbed areas of the deposit would concentrate around the ballast stones (see fig. 120). Evidence produced in excavation suggests that this is not the case and that such a concentration may only relate to the most recent activity. Sub-surface burrowing related disturbance was found in areas not in proximity to stones. Deeper burial of area 2 is likely to have covered the ballast stones noted in the survey. Other surface features on the former seabed, unreconstructable now, may have had comparable influence leading to the observed disturbance elsewhere in the deposit. This may be tending toward speculation, yet the essential point remains that the phenomena observed during the survey were not reliable indicators of the condition of the deposit as a whole. Indeed, taken alone they may have lead to an underestimation of the influence of biological activity.

Non-disturbance survey can be augmented by intrusive methods that do not involve full excavation. Techniques for characterising the benthic community of specific areas are well developed (Holme & McIntyre 1984).[39] Resin casting has a proven track record in the investigation of burrow architecture (Atkinson & Chapman 1984) and has been applied to problems in marine biology, paleoecology and palaeontology. Burrow entrances are located, resin is poured into the opening and left to set. Small casts formed in this way can be raised by hand quite easily but experience has shown that the retrieval of deeper or more complex examples can involve very extensive disturbance to a deposit (Pemberton *et al.*, 1976, 791). This and the possibility of resin contaminating artefacts or samples, which might otherwise

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[39] Rees (*et al.*, 1990) provide a detailed account of a project designed to study the effects of pollution by monitoring marine benthic communities. Survey methods for obtaining quantitative data are described and an extensive bibliography is provided.

have been useful for scientific dating, may make casting unsuitable as part of an assessment strategy not otherwise involving excavation.

Coring has also been used with some success to investigate open and relict burrows. Canadian workers studying the shrimp *Axius serratus* note severe disturbance to stratigraphy caused by burrowing. This animal can create burrows over 2.5m deep with an average density of 9 burrows per $m^2$. Cores taken to investigate the activity of this organism show that skeletons of recent marine foramanifera have been carried down and emplaced in Pleistocene lacustrine clays (Pemberton *et al.,* 1976, 791; fig 2, 790). One core sample showed 6 burrow intersections over a length of 1.2m. Computer simulations used to model the effect of the burrows indicated that in areas of average burrow density it would be impossible to retrieve an undisturbed core sample. The researchers conclude that accurate geological stratigraphic analysis requires recognition and avoidance of burrowed areas.

Specific methodologies related to coring exist for determining the level of disturbance to sediment by, among other things, bioturbation. These have been applied to archaeological problems underwater. Such techniques are particularly useful because they can be used to infer past as well as recent activity. Murphy (1991, 36-50) considers archaeological site location through core analysis. By assessing the degree to which sedimentary and geochemical strata within a core sample are distinct, the origin of layers can be inferred. Lack of stratification in core samples was accompanied by the presence of fragments of tube-worm (polychaete) and sea urchin spines within most of the sediments investigated at the Douglass beach site. Murphy (*ibid.,* 43-44) concludes that bioturbation has been a continuing process in the formation of this multi-period deposit.

Disturbance caused to a deposit by coring must be set against its proven potential as a method of data collection. A similar disadvantage attends the use of any of the range of towed dredges or remotely operated grabs which can be employed to sample the macro benthos (Eleftheriou & Holme 1984, 140-216). These latter techniques are likely to be considered too destructive to be used on-site; some workers may well apply the same stricture to coring in any form. It may be argued that such techniques can be used in the area around a deposit in order to infer the level and nature of activity in the area of interest without undue disturbance to archaeological material.

This strategy has obvious merits. However, such off site data may have limitations in the assessment of past or potential future disturbance to a deposit. This is because such a methodology assumes comparability between levels of activity within the deposit and within the seabed around it. This may not be a secure assumption. Indications of burrowing activity within the deposit have been noted but the significant data came from excavation. If biological survey indicates the presence of a particular burrowing animal in the area around a site, to what extent should this be taken as an indication of activity within the deposit?

The possibility that archaeological deposits can be particularly attractive to burrowing organisms has been noted elsewhere. Lenihan (1981, vol I, 174) observes that, where a range of sediment types are available, burrowing activity along reservoir margins appears to be more intense within archaeological deposits than within sterile areas. Higher organic content and less compacted soil within the archaeological deposits are suggested as possible explanations for this phenomena. Observations made during this study tend to support such a view.

A comparison between the north and south section faces of the 1991 trial trench in area 3 is relevant to a consideration of variability in the intensity of burrowing activity within the Studland Bay site. By chance the trench was dug along a junction between natural seabed and the archaeological deposit. A section cut across the trench appears to reveal scour associated with the edge of the archaeological deposit (fig. 144).

Examination of the extent of scour in the natural clay around the limits of the deposit within the trench tended to confirm this impression. This produced a situation where the opposing section faces were dissimilar. The north face is shown in figure 132. The south face consisted of laminated oyster shell to a depth of 40cm. Occasional pieces of pottery were noted in the top 20cm. The regular, horizontal lamination of the shell and unabraded condition of the pottery sherds do not suggest a mobile seabed. Rather they indicate relative stability in areas deeper than 5-10cm below the surface of the seabed.

The intensity of burrowing in the north section face of the trench in area 3 has been noted. In contrast there was no evidence of a comparable level of such activity in the south face. Some burrows were observed in the top 10cm, demonstrating that tubes could survive as in the archaeological contexts. The organically rich and less compact secondary deposits related to the wreck material might offer a substrate more conducive to burrowing than the bedded layers of oyster shell. Indeed, where resin casting has been used to obtain information about the burrow architecture of *Upogebia*, the presence of oyster shell has been noted as a major factor in determining the burrow shape.[40] The considerable depth of oyster shell in this part of the deposit was not consistently present elsewhere, although some shell was generally observed in the upper layers of the seabed.

The suggestion that *Upogebia* activity may be different in the natural seabed is supported by the results of a series of test pits dug around area 2 and 3 (see fig. 113). The presence of laminated layers of oyster shell does appear to have acted to inhibit burrowing activity in certain areas.[41] In addition, test pits which contained secondary or wreck related deposits, particularly areas associated with scour, tended to exhibit burrowing activity at a greater depth than those which contained apparently

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[40] Collins, pers.comm.

[41] See test pits 40 (SB 92 13); 47 (SB 92 18); 50 (SB 92 18) Studland Bay Archive.

undisturbed, natural seabed.[42] However, it should be noted that information concerning burrowing activity was not recorded to the same level of detail in each test pit as the sampling programme was conducted over an extended period and involved volunteers with a range of experience.

Figure 111 shows a sediment profile created by analysis of test pit data. As can be seen, there appears to be significant variation associated with the presence of wreck deposit. This phenomena may be due to the fact that scour and associated burial of material removed part of the layer of sediment with very high clay content which underlies much of the seabed. Although some biogenic disturbance to the top of this natural clay, burrows did not penetrate into it for any distance.

In 1989 an artificial reef was established in proximity to the site as part of a research project investigating lobster populations and mobility (Collins *et al.*, 1991). Within 18 months, considerable *Upogebia* burrowing activity was noted around the edges of the blocks used in its construction. This phenomenon accords with observations made elsewhere concerning availability of niches as spurs to burrowing activity. Artefactual material on the surface and characteristics of the deposit itself may therefore have combined to create a localised atypical level of activity. A number of inspections of the seabed around the reef have also been conducted as part of the project. Although no precise measures of density have yet been obtained, the researchers responsible do not believe that there is clear evidence of more intense activity around the wreck deposit than in the natural seabed. They are more inclined to regard the distribution of *Upogebia* as patchy and have also noted very marked seasonal variation in population density.[43]

Research on the site of the *Sea Venture*, (Adams 1985) lost in 1609 off St. George's Island, Bermuda has also produced data

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[42] See test pits 29 (SB 92 03); 30 (SB 92 03); 31 (SB 92 04); 53 (SB 92 06).

[43] Collins & Mallinson, pers.comm.

which might cast some light on this question. Following recognition that the deposit had not been as badly disturbed by previous investigations as believed, a detailed study of inboard and outboard stratigraphy was conducted (*ibid.*, 276).

During excavation of the seabed outboard of the surviving hull structure in 1988, presumed invertebrate activity within the deposit was noted.[44] This took the form of tubular burrows between 1.5 and 2cm in diameter (fig. 145). Some were more or less vertical while others, generally smaller, meandered through the sediment, seemingly at random. During the following excavation season (1989) the *Thallasinind* shrimp, *Axiopsis serratifrons* was identified as the likely agent of the noted disturbance. These 'mole shrimps' are common in the clean coarse sand in the reef areas (Sterrer 1986). Considerable care was taken to investigate the possibility of material having been displaced within burrows but no objects were observed that appeared to have been influenced in this way - despite the fact that a number of artefacts were found within the deposit which could fit into the tubes such as pins, beads and shot. Burrows were noted in close proximity to the remains of a leather shoe (fig. 146) but no abrasion marks or areas of degraded organic material comparable to those noted at Studland Bay have been reported.

The intensity of activity varied across the site but preliminary assessment of its distribution indicated a concentration in areas of the deposit that were not compacted and had a relatively high organic content, most likely to derive from assimilation of material from the wreck into the sediment (Ferrari & Adams 1990, 143). The potential complexity of the relationship between the character of the deposit and burrowing activity deserves consideration. Is it possible that bioturbation was itself responsible for the observed assimilation of organic material into the matrix, which then encouraged further activity? It was observed that boundaries between layers remained relatively distinct and this may be used as a reasonable indication that bioturbation has not seriously disturbed the contexts. Yet the

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[44] Adams, pers.comm.

probability that bioturbation occurred during the creation of the observed stratification, as was suggested for Studland Bay, and may therefore have had a role in determining its nature, should be appreciated.

The difficulty involved in ascertaining whether a sampled area of deposit or seabed is 'typical' in so far as the observed level of burrowing activity is concerned is evident. Yet it does appear that data derived from marine biological studies on population distribution and density of specific species should not be used without qualification to predict levels of current or past burrowing activity within archaeological deposits, and therefore potential levels of preservation.

# 8 Burrowing Activity: Management Options

Discussion of strategies relating to mitigating the effect of commercial fishing gear necessarily involves consideration of the cultural aspects of the process and the ability of the fishing industry to resist any attempts to impose restrictions. No comparable complicating factors require consideration in this context.

Two basic strategies for preventing burrowing activity from damaging a deposit can be identified; removal of burrowing organisms; introduction of a barrier between the burrowing organisms and the archaeological deposit. It may be possible to use chemicals to remove or deter burrowing organisms, in much the same way that insecticides may be used on land. Significant technical difficulties are likely to attend the introduction of the chemicals to the sediment and to restricting the resulting changes to the limits of the deposit. Maintaining the concentration of whatever substance is chosen at an appropriate level to achieve the desired effect over a long period would also present problems. Regular monitoring and replenishment would be required which may increase cost significantly. It would also be necessary to ensure that only the targeted species were affected. More widespread alterations in the biological community might lead to adverse changes to the deposit unrelated to burrowing. For example, loss of vegetation might lead to increased erosion. It must be questioned whether the level of knowledge relating to such matters has reached the point at which such precise controls can be applied.

The removal or discouragement of burrowing organisms, whether by introduction of chemical deterrents or other means, might not be acceptable to other conservation interests. Therefore, promoting this approach would run counter to a perceived need to incorporate archaeological concerns into wider conservation oriented lobbying in order to sway public and political opinion. Additionally, the introduction of chemicals to the sediment may have unpredictable effects on the archaeological material itself. A long-term change in the burrowing community of an area therefore appears unlikely to be practical or ethically acceptable.

The introduction of a physical barrier to halt penetration into the archaeological deposit is likely to be a more viable option. This strategy, as with that discussed above, has the highly significant drawback that it can only be implemented on known sites. There does not appear to be a readily identifiable, practical method by which unknown or unlocated elements of the archaeological resource can be afforded any protection against the adverse effects of burrowing activity. Thus, any strategy developed will fall short of the ideal outlined in section 2.4.4.

## 8.1 Protection of Terrestrial Deposits

Research on land has lead to a number of conclusions regarding reducing the magnitude of changes to a deposit derived from burrowing. Methods of dealing with both vertebrate and invertebrate activity have been explored. In both cases, preferred strategies are based on site burial and the introduction of layers through which the burrowing organisms cannot pass. Knowledge of the preferred substrate of organisms allows burial environments to be designed which inhibit activity. Wilkins (1989, 212) observes that most vertebrates prefer a friable soil, usually a mixture of sand, loam and gravel, with intermediate moisture content. Burrowing may therefore be reduced by introducing a covering with high clay content and either very high or very low moisture level. High clay content will also inhibit invertebrate activity (1989, 183) although a combination of a layer of concrete and pesticide is recommended to provide 'seal off' protection for a deposit (*ibid.*, 192).

## 8.2 Protection of Marine Deposits

In chapter 6 a considerable amount of data derived from marine biological research was presented. It is clear that detailed information on burrowing behaviour is available for relatively few species. This will inevitably hamper the implementation of effective protective strategies. In section 5.3 a range of options involving burial to provide physical protection against the impact of fishing gear on archaeological deposits were reviewed. Some of the strategies considered would, as a by-product, also provide some defence against specific forms of burrowing activity. However, the practical and financial drawbacks of the various options highlighted apply equally in this context. Indeed, the question of justifying capital outlay and continuing maintenance cost is even more pressing if the chosen strategy has not been designed with a specific process in mind. The result of substantial expenditure may be unpredictable at best.

It has not been possible to identify a substantial corpus of published material derived from commercial research relating to mitigation of burrowing activity underwater. The search has not, however, been entirely fruitless. Scientists experimenting with the cultivation of clams from juvenile broodstock to commercial maturity have gained some practical experience in the use of netting to provide a barrier against crabs. Their work is based in the Menai Straits, Wales, and the clam beds occupy substrates ranging from soft mud to firm sand. Considerable attrition of the sample through predation by crabs (C. *pagurus*) resulted in experimentation with a variety of mesh types. Before netting could be successfully employed, various conditions had to be met. The netting must retain the clams but allow passage of food bearing water to ensure good growth conditions. The net must also be sufficiently rigid to prevent crabs from manipulating it and crushing then eating the clams through the mesh apertures. A final, but vital point, is that any protective measures implemented must be readily reversible to allow examination and harvesting of the shellfish.

Rigid meshes containing more than 500g of plastic per $m^2$ proved effective crab barriers. Lighter nets, although providing some protection, were less successful. The effectiveness of lighter material can be improved by raising the mesh 5cm above the seabed or by using two layers of netting. The edges must be anchored and buried to prevent crabs from burrowing beneath them. In addition, the mesh tends to become heavily fouled within a year and cannot prevent burrowing animals in their larval form from entering the clam beds.[1] The netting has been shown to increase siltation locally, presumably by slowing current speed and thus promoting deposition. This is regarded as a disadvantage for the fishery but maybe advantageous when part of an attempt to offer protection to archaeological material.

The tendency for crabs to cause localised collapse during excavation and between seasons has been highlighted. Without underestimating the difficulties involved in handling rolls of netting underwater, it seems that the experience of the fishery scientists can be particularly valuable in developing methods of protecting trenches and section faces in the short term. Clearly, selection of mesh size would have to take cognisance of the specific characteristics of the local crab population.

Detailed description of the behaviour of individual animals may lead to the design of strategies to protect sites. Evaluation of the designs will rely on experimentation and field testing. Valid results are likely to result from long-term monitoring programmes and have the drawback that the true effectiveness of the chosen method may not be assessed without re-exposure and examination of the deposit. Such experimental programmes, while necessary, are therefore likely to be expensive in terms of both financial resources and use of the finite resource represented

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[1] Spence, pers. comm. It was suggested that a good combination for the purposes of covering archaeological material might be prawn net made from twisted terylene. Rolls of netting usually about 2m wide and several hundred metres long are available in a variety of mesh sizes.

by the surviving archaeological record. Any opportunities to gather relevant data from ongoing research should therefore be seized. Thanks to the co-operation of the project team, burial and subsequent re-examination of part of the structural remains in area 2 of the Studland Bay site provided an opportunity to assess the effectiveness of one simple form of site protection in limiting the influence of burrowing activity.

## 8.3 The Studland Bay Site

The Studland Bay project has been described in section 7.1. After partial excavation, area 2 of the site (see figs. 118 and 119) was re-buried in August 1990. The covering consisted of woven polythene sheeting overlain by a single layer of sandbags. A double row of sandbags was placed around the edge of the sheeting. Efforts were made to cover the sandbags with sediment.

This method of burial of limited areas of deposit is probably the cheapest after simple sediment dumping. It therefore serves as an appropriate case study; practical considerations dictate that cost will be a major factor in determining the selection of burial method, cheapness and demonstrated effectiveness would therefore be an attractive combination. The method was not chosen with the primary aim of inhibiting burrowing activity although the prevention of lobster and crab colonisation of niches below the edges of hull planking was a stated concern. Yet it can be seen that this strategy is characterised by the basic principle of interposing a protective layer between the deposit and the burrowing animals.

Inspection of the buried deposit in 1991 indicated that the sediment level in the area had re-established itself and that many of the sandbags were no longer visible.[2] Occupation by crabs of niches between sandbags was observed. It was noted that, where plastic sacks had been used as sandbags, the crustacea had penetrated the material and occupied the half emptied bag. This reduces this effectiveness of the sandbag as a means of weighing down the covering sheet. It appeared that no woven polythene sandbags had been damaged in the same way. In the very few areas where the covering sheet was visible, no evidence of penetration was recognised.

It is known that the covered area was subjected to oyster dredging

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[2] ADU Inspection, see appendix 3, lines 69-76.

in 1991. The only damage that resulted seems to have been the displacement of survey pins and the displacement of some sandbags.[3] The covering sheet was not extensively exposed or disturbed by this occurrence. In 1992, a personal inspection of the site revealed that, subsequent to the 1991 inspection, the covering sheet had been disturbed. 50cm of the western end of the keel was exposed. The cover as a whole had been physically dragged back off the keel, probably as the result of a single event, rather than having been exposed by erosion and then displaced by current. This was indicated by the fact that there was no slack in the cover which could be pulled back over the exposed timber. No other damage to the area was observed. The agent of this disturbance has not been identified conclusively but shellfish dredges or dragging anchors are likely candidates.

Part of the 1992 research plan on the site involved recovering a sample of the western end of the keel. This provided an opportunity for controlled removal of the covering sediment and sandbags in August. During this process no penetration of the covering sheet was evident. Crabs were the only burrowing animals noted in the sandbag and sediment layer above the sheet. The covers were carefully removed and a detailed inspection of the exposed surface was carried out immediately. Burrowing activity was noted and a plan of surface evidence was produced; the result is shown in figure 147. Excavation around the keel followed and this provided an opportunity to examine the sub-surface evidence of burrowing.

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[3] Markey, pers. comm.

## 8.4 Discussion

This case study is only concerned with burrowing activity. The effectiveness of this burial method as regards reducing changes resulting from other processes is not of central concern. However, on removal of the covering sheet, a layer of grey, apparently largely anaerobic, sediment was exposed. This changed colour as it oxidised subsequent to exposure.

The covering sheet is believed not to have been penetrated at any point. Yet the method of burial described above had clearly not prevented disturbance to the deposit by burrowing organisms, believed to be *Upogebia*. A number of burrow entrances were identified at the western end of the keel adjacent to the timber. Several others can be seen some distance away from the timber. It was possible to demonstrate interconnection between some of the visible burrow entrances during excavation.

As can be seen from figure 147, one burrow could be followed from the edge of the covering sheet to the keel timber. The burrow was visible on the surface because the covering sheet had formed its 'roof' therefore removal of the sheet revealed the lower part of the tunnel within the sediment. Excavation demonstrated that the burrow passed along the top of the keel timber, down the side and then penetrated further into the seabed. The actual extent of the burrow's penetration into the seabed was not established. In addition, excavation prior to removal of a section of the keel revealed previously unrecorded areas of planking. Apparently recent, that is unabraded, *Upogebia* tracks were noted on these timbers suggesting further activity within the covered deposit.[4] Burrow tubes were also observed.

While lateral travel of 1.8m can be demonstrated (see fig. 147) it is not clear whether the observed track represents movement from the edge of the sheeting towards the deposit or movement in

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[4] See dive log SB 92 16.

the opposite direction. It is possible that the animal responsible was buried within the deposit when the sheet was put in place. Studies performed on *Upogebia stellata* (L.) have confirmed that the animal is a filter feeder and therefore requires contact with the water column.[5] The burrow systems created by this shrimp comprise u shaped structures and are highly maintained. While *Upogebia delatura* has not been subject to such close study, coverage of burrow entrances by the sheeting may have prompted the burrowing revealed by the tracks as a means of achieving free contact with the water column.

The burrow in question did not penetrate deeply into the seabed except around the keel timber. Did the animal, moving in from the edge of the covering sheet, encounter the timber and, as observed elsewhere, appear to deliberately burrow against a hard surface or obstruction. Alternatively, is this phenomena an indication that the burrow did indeed originate within the deposit at or below the keel timber?

These observations have significant implications in terms of deposit protection. If the travel represents movement away from the deposit, then it might be suggested that burial under a covering sheet may be an effective means of purging parts of a deposit of such animals. Yet there is nothing to indicate that excavation of this lengthy burrow represents abandonment of burrows within the deposit itself. As noted above, it may have served to ensure that occupation could continue. Whatever the explanation, the extent of lateral travel remains impressive and must be accommodated in the design of any burial strategy, a point discussed further below.

Figure 147 shows that a greater number of excavations were observed in the part of the deposit closest to the western end of the keel as compared to the more easterly part of the exposed deposit. Consideration of the number of observed burrow entrances in an area clearly has limitations as a method of

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[5] Nickell, pers.comm.

assessing intensity of activity. Single burrow complexes may have a number of entrances. Such data should be used cautiously in the drawing of inference. Yet, there would seem to be spatial variation in density.

It is possible that the disturbance to the edge of covering sheet, noted above, exposed this area to greater disturbance. However, the possible extent of lateral travel below the sheeting indicated by the burrow described above (and there is no reason to consider this a maximum value) suggests that if proximity to the edge of the sheet alone determined the level of disturbance, then the higher density of excavations might be expected to extend further along the timber. Perhaps a more relevant factor is that the area of higher apparent levels of activity coincides with the area of the deposit previously disturbed by excavation prior to reburial in 1990. The process of backfilling after this earlier excavation resulted in the western end of the keel timber being surrounded by a relatively uncompacted, organic matrix with few inclusions. During re-excavation of the timber in August 1992 this context contrasted sharply with the matrix surrounding the keel in unexcavated areas. Here the matrix was far more compacted and had dense shell inclusions below a shallow layer of sand. It may be that the former deposit type is simply more conducive to the burrowing activity of *Upogebia*.

The woven polythene and sandbag combination under scrutiny in this case study was not intended to combat burrowing activity in general and had certainly not been selected after explicit consideration of the behaviour of *Upogebia*. However, the fact that it was possible to inspect the area before during and after burial has allowed useful data to be retrieved.

A combination of data retrieved during the study of burrowing on the Studland Bay site, and experience gained with this method of site burial, allow a number of conclusions to be drawn regarding the practicalities of actually achieving a reduction in changes derived from *Upogebia* activity. During this study *Upogebia* burrows have been traced in section from the surface of the seabed to 50cm below it. Occupied burrows have been detected at a depth of 60cm below the seabed but could not be traced directly to the surface. It has also been possible to observe lateral travel of 1.8m. As noted, there is no reason to assume that this is a maximum value. For the purposes of this discussion it would be more appropriate to treat it as a minimum bound. Establishing a true maximum value is likely to be problematic.

Information relating to substrate preference is even less clear as the burrows have been observed in most contexts encountered, including those with a relatively high clay content. On the basis of limited observation, a matrix with large shell inclusions seems to be the least conducive to burrowing activity although very high levels of clay content may be expected to reduce activity as well. Controlled experimentation could do much to refine knowledge of this aspect of *Upogebia* behaviour and would seem to be an eminently practical proposition.

Imperfect as these observations are, how can they contribute to an effective site burial strategy? Unfortunately, while indicating the likely parameters for the design they do not point to a simple solution. Rather, they tend to indicate the possible implications of a serious attempt to preserve *in situ* even a discrete deposit within a site, such as the structure described above, let alone a larger area.

The project described above does not prove that *Upogebia* cannot penetrate a woven polythene sheet but does indicate that, at the very least, it does not do so readily. It therefore seems likely that a form of impenetrable barrier can be placed over a deposit. A covering sheet could be used in conjunction with the introduction of a surface layer of a sediment type known to inhibit burrowing. Yet this would only provide protection against activity proceeding downward. The possibility of significant lateral travel in from the edges of a covered area or out from the deposit in order to maintain existing burrow systems must also be considered. Two strategies may be adopted. First, extend the covering to beyond the known range of lateral travel. Second, extend the barrier downward to the depth to which the animal is known to burrow, therefore blocking movement through the sediment in either direction.

Both options significantly increase the resource implications of protective burial; the necessity and expense of regular monitoring and maintenance of the deposit post-burial is regarded as a necessary feature of any strategy. The logistical implications of the extension of a protective sheet approximately 70cm downward into the sediment all around a deposit are daunting. The likely level of disturbance caused to the surrounding seabed, which itself may contain archaeological material, is an additional and significant cause for concern when evaluating this option. So too is the difficulty likely to attend efforts to gain access to the deposit at a later date.

It may appear therefore that an extension of the protective sheet beyond the limits of the deposit is a more practical proposition. The effectiveness of such a method would rely on the precision with which the extent of lateral travel of burrowing activity can be established. However, it may be possible to reduce the scale of this problem in terms of movement into the deposit by careful treatment of the edges of the covering sheet. On a number of occasions the relationship between surface features and burrowing activity has been noted. If the edges of the sheet, with any anchoring arrangement required, were buried below the level of the natural seabed rather than weighted on the surface, fewer such niches may be presented. Such an arrangement would be very vulnerable to local changes in sediment level and the effort involved in installation should not be underestimated. Additionally, further disturbance to the seabed, while not on the scale of the deep burial option, may present problems in sensitive areas of a deposit.

Ideally, there should be no animals active in the deposit when it is covered. Taken to its logical conclusion, the requirement to bury a sterile deposit, rather than one containing live organisms, might necessitate complete excavation of a considerable area to a depth below the known burrowing range of the animal and backfilling with clean sediment. The level of protection could be increased by backfilling with a matrix known to inhibit burrowing. It is evident that the level of disturbance to a deposit involved in preparing it for protective burial, according to this scheme, would be totally incompatible with principles of minimum disturbance and preservation *in situ*. An alternative, and in some respects less invasive, method of sterilisation of the deposit, the introduction of chemicals, has already been judged to be problematic on technical and ethical grounds. This said, it may be acceptable to implement a burial strategy without such sterilisation in the knowledge that such effort may achieve a reduction in the intensity of activity if not a complete cessation.

The above is not intended as an exercise in demonstrating the futility of attempts at preservation *in situ*.[6] It is intended as a statement of the need to consider in detail what is required to actually achieve a specific level of protection. This will lead to a clearer understanding of the manner in which modifications to the ideal strategy, made for whatever reason, alter the nature of the protection afforded to a deposit. Without such an understanding the ability to predict the long term result of burial will be severely limited and may call into question the choice of expenditure on preservation *in situ* as opposed to preservation by record. Additionally, while the creation of a sterile deposit may be almost impossible when treating an unexcavated area of a site, it may be possible to achieve much of the stated ideal when undertaking, for example, reburial of material for long-term storage after examination. Similarly, while substantial measures seem to be required to reduce the influence of *Upogebia*, species which penetrate less deeply into the sediment, such as some crabs and lobsters, may be excluded from a deposit more easily.

While this study has concentrated on one animal, any strategy actually adopted must take all potentially harmful processes into

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[6] The burrowing activity of rabbits within earthworks presents not dissimilar problems on land. Strategies aimed at the exclusion of rabbits through fencing or through population control have been mooted but severe practical problems attend their implementation (Barclay 1994, 25-7).

account as far as is possible. Yet it is regarded as axiomatic that all processes are unlikely to be dealt with equally effectively and that all the processes which may influence a deposit are unlikely to have been identified. Some degree of compromise will be necessary to achieve a workable, affordable protective strategy which produces predictable results.

# 9 Conclusions

## 9.1 Commercial Fishing Activity

That archaeological deposits can be profoundly changed through the influence of certain types of fishing gear is not likely to be seriously questioned. The utility of considering material from an apparently highly disturbed context, however, might be debated with some vigour. The link between plough damage and fishing gear has been explored in chapter 4 and it is valuable to return to that discussion now. Perhaps the most significant area of consensus in studies of plough action is the identification of the ploughzone (the topsoil directly impacted by ploughing now or in the past) as a type of context requiring specific study and evaluation. Such study might be guided by a paradigm summarised as follows; data from the ploughzone should not be excluded from detailed consideration without demonstration that they are, in fact, not useful for the proposed research. This study has certainly indicated that there may be specific limits to the usefulness of certain types of data due to the influence of fishing gear. It is has not produced support for an approach which treats surface distributions *per se* as unworthy of any serious attention.

### 9.1.1 Future Work

The success of further work directed at description of regularities in the effects of fishing gear on simple and complex properties of artefacts will depend on a number of factors. Refinement of the interpretation of physical attributes such as those noted in section 4.2 requires a corpus of comparable data. Collection of such a body of information demands the adoption of standard methods of recording and presentation of information. The method used in this study to tabulate observations and represent sherd dimensions might form a useful basis for the collection of such data from a range of assemblages. However, this should be augmented by the development of terminology and methods of illustrating fractures and other attributes which facilitate comparative research. Enhanced ability to link observations concerning physical attributes with information about the distribution of the material of interest on the seabed is particularly desirable.

In section 4.2.10, certain limits to the type of analysis that could be performed on pottery retrieved from oyster dredges were acknowledged. One inference that could be drawn from this is that more sophisticated analysis might be justified if a better sample of material were obtained. But it is appropriate to consider what 'better' means in this context. Experimental archaeology could provide examples of ceramic which are known to have been impacted by a specific design of fishing equipment under controlled conditions. The resulting damage could be observed before environmental processes or other sources of secondary damage obscure the features of interest. However, the utility of ascertaining the nature of damage or magnitude of displacement resulting from a single or small number of contacts with a dredge might be questioned. Assemblages encountered in the field may have been exposed to prolonged activity and so adequate treatment of the problem would seem to demand long-term studies. Whether the results derived from such work will justify the resources required by producing data superior to that which can be obtained from assemblages of the kind examined here is not evident. Equal care is required in justifying experimentation aimed at elucidating questions of fishing gear derived transport of material. As previously noted, detailed reconstruction of pre-impact distributions may not be a practical proposition, but enhancement of understanding of the influence of fishing activity on site assessment and area survey may be very valuable.

Even when sufficient clarity of purpose has been established, it would be quite wrong to seek refuge in glib assertions that such research will provide ready solutions to the problems which have been identified. Cowen and Odell (1990, 599) note the unpredictable return from experimental work. They observe that, while multiple experiments directed at testing the results of one such exercise may be a worthy undertaking, the aggregate data resulting may be no more informative than that obtained from the first experiment. However, these difficulties should serve as a spur to the development of carefully targeted research programmes rather than as a justification for inactivity. There would seem to be abundant opportunity to link studies of the impact of fishing gear on marine flora and fauna with data collection relevant to archaeological concerns. It should also be noted that logistical difficulties associated with rigorous experimentation underwater have been circumvented by some involved in the study of the impact of fishing gear on oil and telecommunication installations. Rather than performing trials at sea, meaningful results have been obtained by towing relevant components of gear across dry land.[1] This may introduce problems associated with changing densities of archaeological material in air as opposed to underwater and varying sediment characteristics. However, such an approach may offer the possibility of close observation and relatively economic data collection.

In section 5.6.1 (183), it was suggested that developments in marine nature conservation might also serve archaeological interests through facilitating management of specific activities in protected areas. The Marine Protected Areas (MPA) concept is intended to have relevance to as many interest groups as possible (Gubbay 1990, 8). However, reconciling the interests and requirements of various nature conservation interests is itself a

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[1] Main, pers.comm.

substantial task.[2] It should not be assumed that incorporating archaeological interests will be straightforward in practice. Kellerhan and Kenchington (1991, 14) conclude that, with regard to nature conservation, managers will often be faced with a choice of ecologically suitable areas for protection, therefore, the dominant criteria for selection of boundaries for protected areas will tend to be socio-economic. While the need for pragmatism is fully accepted, there may be few occasions when archaeological heritage managers can choose between a variety of locations which are equally suited to management in practical terms and which offer a very similar range of cultural resources.

Coincidences of interest have been recognised by nature conservation agencies (English Nature 1993d, 8). Yet aspects of marine nature conservation and allied coastal management policy can be identified that may not be compatible with archaeological priorities. The promotion of managed retreat, that is, allowing coastal defences to be breached and a new equilibrium to be established rather than attempting hard engineering solutions, provides a good example. Such policies are widely endorsed by conservationists and are perceived as creating new habitats *e.g.* coastal saltmarshes (Pethick 1993, 167-168). However, the potential impact of such a policy on coastally situated archaeology is considerable. The concept of maintaining environmental capital may also pose problems. In general this approach recognises that loss of resource in one part of a managed area can be compensated for by proportionate gain elsewhere (English Nature 1993b, 52). The finite and non-regenerative nature of the archaeological resource means that this concept has limited application to the management of archaeological resources. Yet, the recognition of critical capital (elements of the resource which must not be lost) may allow archaeological concerns to be accommodated to some extent (English Nature 1993d, 9-10).

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[2] Progress in developing the concept has been delayed by failure to move beyond consensus on the general desirability of the areas to consensus on the detail of their implementation (Gubbay, pers.comm.).

Likewise, best practice in terms of archaeological conservation may not further the aims of nature conservation. For example, the protection of a deposit by burial may well reduce the number and diversity of habitats in an area; particularly where the wreck deposit serves as an area of hard substrate and relief in an otherwise flat area of silty seabed. Equally, while longlining has been suggested as a method of commercial fish capture which might be appropriate for use in archaeologically sensitive areas (see section 3.2.3 and 5.6, 181), a decline in certain bird populations has been linked to entanglement in baited lines.[3]

There is no suggestion that such problems cannot be overcome through liaison and co-operation. However, despite real advantages that may accrue from co-ordination of effort with the marine nature conservation lobby, it is clearly necessary for archaeologists to recognise the difference between protection afforded to archaeological material as a by-product of other initiatives and the actual existence of shared objectives.

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[3] Published data is not available but a decline in the population of the wandering albatross (*Diomeclea exulans*) has been directly linked to entanglement in lines. In British waters, gulls are thought to be particularly vulnerable. Further, *circa* 44,000 albatrosses of various species are believed to be killed on Japanese longlines in the southern ocean each year (Harrison, pers.comm.).

## 9.2 Burrowing Activity

The need to consider the influence of burrowing during the fieldwork and analysis phases of a project has been demonstrated. Questions about the nature of viable non-disturbance assessment of deposits thought to be influenced by burrowing activity have also been raised. However, the results of this study do not suggest that burrowing necessarily renders a deposit inferentially valueless. As noted in section 7.3 (246), more detailed analysis of samples of sediment could provide quantitative measures of bioturbation. In addition, further effort could be directed towards assessment of the nature of burrowing activity within archaeological deposits as compared to surrounding areas through quantitative approaches. However, in both cases the results would have to be used with caution due to the fact that a major influence of bioturbation in the study deposit appears to be the introduction of a high degree of intra-deposit variation with regard to preservation and context.

The practical problems involved in affording protection to a deposit against the activities of a specific animal, *Upogebia,* have been underlined. The need to consider options other than conservation *in situ* have also been emphasised. Given the pervasive influence of this animal in certain areas and the attrition to surface detail on timbers resulting from its activity, a basic drawn record of structure may be insufficient as a preliminary to reburial. Casting techniques are sufficiently advanced to allow the creation of detailed records of marks and fastenings on structural elements underwater (Murdock & Daley 1982). Casting in combination with other survey methods may be an acceptable if pragmatic alternative to attempts to totally eradicate burrowing. Yet, significant problems remain, both ethical and practical. Should the underside of timbers be exposed, with attendant destabilisation, to allow casting? If this is done, has the deposit been disturbed to the extent that subsequent, substantial expenditure on sophisticated reburial techniques may be of questionable merit? A considerable degree of pragmatism may be required to secure data before it is lost; particularly if present limits on capabilities and resources are matched against increased knowledge of the rate of attrition of the resource and the diversity of significant destructive agents.

While the nature of the biological activity described in this study might best be viewed as, 'a little damage done often' the cumulative effect is believed to be significant. Prior to the publication of his work on earthworms, Darwin was criticised for crediting such an apparently feeble organism with so great an influence in determining the nature of soils. His salutary response was to reflect upon the problems created by,'...that inability to sum up the effects of a continually recurrent cause' (Darwin 1981, 21).

### 9.2.1 Future Work

With reference to terrestrial deposits, Wilkins (1989, 213) stresses that there is a pressing need to describe, in relevant terms, the ecology and behaviour of individual burrowing species which may influence archaeological sites. Such descriptions should include:

- Design of burrow systems- depth / diameter of tunnels *etc.*
- Soil requirements including moisture content, sand / loam *etc.*
- The role of the water table in determining burrow characteristics
- Geomorphic effects such as amount of soil moved, disposition of excavated soil, importance of subsidence.
- Behavioural tendencies of a species to actively relocate rocks, bones or cultural objects.

This research agenda has considerable relevance to the study of such activity underwater. It also reflects one of the central themes of this study; the data which is perceived as fundamental to the design of site protection strategies overlaps almost completely with the data required to refine the study of burrowing as a formation process. Some progress has been made in the collection of such data underwater. The disturbance to deposits by freshwater mussels described in the National Reservoir Inundation Study (Lenihan 1981, vol. I, 134) has been noted already. Observations indicated that 95% of the mussel disturbance occurred in water between 1 and 3m deep. Medium to fine silt over clay appeared to be the favoured sub-strate. However, this data was not utilised in discussion of specific options for site protection in connection with this particular impact.

Progress is likely to result from co-operative research during which marine biological techniques are applied to archaeological problem domains. An open ended research programme seeking to describe the activity of every burrowing animal may not be a practical proposition - although it would be a worthy undertaking in its own right. Some form of prioritisation is necessary. It may be possible, with advice from marine biologists, to isolate the most prolific burrowing species currently known and compare available options for site burial against relevant behavioural data. Controlled experiment could offer a useful way of observing these phenomena more closely without compromising cultural material or site stratigraphy. Aquaria based experiments pose few of the logistical problems associated with experimental investigations of the influence of fishing gear on archaeological material. Investigation of sediment preference may be a particularly useful line of enquiry in determining the nature of burrowing activity and identifying options for its mitigation (*c.f.*, McBrearty 1990, 130-131).

## 9.3 The Study of Formation Processes

This thesis has sought to contribute to the study of formation processes in UK coastal waters. Some formality has been imposed on the collection, presentation and analysis of data and the method set out in section 2.4.1 does appear to offer a useful and adaptable framework for the description and study of a range of processes. Propositions relating to specific formation processes have been presented and evaluated. The results indicate that sufficient regularity exists in the influence of certain processes to permit anticipation of the formulation of low-level principles which may allow the past influence of these processes to be inferred. However, case specific limitations on the security with which such regularities can be described are evident.

The need for caution when attempting to isolate the influence of a single process from within a complex system has been highlighted. The difficulty of studying and accounting for the influence of behavioural and cultural elements of formation processes has also been affirmed. Overall, some support is provided for Trigger's judgement (1989, 361) that, while archaeologists may apply elements of Schiffer's approach profitably, it is not necessarily with the expectation that his full programme will be realised.

Schiffer's terminology has generally proved useful; the categorisation of simple and complex properties of artefacts aids clarity of discussion. The division of processes into C (cultural) or N (non-cultural) has also been utilised. Yet such a division may, in some respects, operate at too high a level for the purposes of meaningful characterisation of formation processes. In section 1.1.2 broad consensus regarding the significance of non-cultural transforms was noted. It was also suggested that discussion concerning the manner in which they should be studied is considerably less disputatious than that concerning cultural or behavioural processes. This observation might support the simple C - N division as it can be seen to have significant analytical implications. However, the addition of further broad categories of transform may be appropriate. One potential sub-group might be formed of transforms deriving their unity from the fact that their study necessitates detailed consideration of mechanical aspects of a process but also requires close appreciation of cultural and behavioural factors (*e.g.* agricultural ploughing and certain forms of mobile fishing activity). This sub-group therefore, like C and N transforms, is associated with specific analytical implications and may best be viewed as a sub-set of C transforms. Schiffer does recognise that his basic categories can be qualified and subdivided (Schiffer 1976, 12-19; 1987, 7). It is also true that a plethora of variations on a theme may be undesirable. However, some development of the basic taxonomy may be necessary in order to provide a truly useful framework around which detailed discussion of methodology can be built.

This study has stressed the value of applying explicit methodology with due regard to theoretical issues but without allegiance to a single theoretical approach. The accommodation of a wide variety of techniques and ideas has been advocated. Indeed, the process of testing alternative explanations against new data may well provide one method of moving towards objectivity without aspiring to a 'scientific' claim to factual knowledge (Trigger 1989, 400). But, as a result of this work, has the case for rigorous study of formation processes been advanced; that is, have significant conclusions been reached that could not reasonably have been reached based on casual consideration of observations and recourse to 'folk knowledge' ?

In section 1.2.2 approaches based on 'common sense' were found wanting. However, common sense, in this context, should be clearly distinguished from insight gained through intuition which is recognised as a valid, if mercurial, element of inquiry (*c.f.*, Bass 1983, 102-3). The value of intuition is in no way denied as a means of approaching problems posed by empirical observation in the first instance. However, it should be accompanied by willingness to present consequent, supporting arguments in a manner that encourages discussion as opposed to anticipating acceptance. Is, however, a demand for the rigour that explicit method can help bring about, any more than a manifestation of a desire to affirm that archaeology is not, in fact, merely speculative fiction (*c.f.*, Kelley & Hanen 1988, 6-28)?

As indicated in chapter 1 (6-7), there certainly is anxiety concerning what is truly verifiable about the past. Equally, in times of financial stringency and rapid change within the discipline, a need to show that archaeology is worthy of political and financial support may be perceived. This can partly be achieved through demonstration of the fact that working methods are not haphazard. While not accepting that much recent endeavour amounts to crude scientism (Shanks & Tilley 1992, 243) it does appear that an ostensibly 'scientific' approach is, in some quarters, automatically associated with such respectability. Indeed, the fact that science based courses currently attract a higher level of funding than arts based courses within higher education provides an eminently pragmatic reason for casting archaeology as a science.

Such factors will play their part in determining the character of archaeological practice. However, the value of the conclusions drawn in this thesis and their role in forwarding the study of formation processes can be expressed in the following terms. Observations have been made and evaluated within an explicit though non-rigid structure. This has been done in a way that facilitates the use of data in the analysis of deposits other than those the data were originally obtained from. There is, however, no implication that a single correct method to apply to this field of study exists. There is no presumption that conclusions offered here are necessarily better than those which might be offered elsewhere, yet insights have been gained that might not have emerged from a less structured approach. The information gathered in this study is presented as the beginning of a dialogue which can be conducted in a rational manner.

The number of processes which have the potential to contribute to the formation of any given deposit is likely to be considerable. It is probably neither possible nor desirable to study the origin of all relationships. Many of them may be insignificant and it is surely true that a mechanical, over-rigid approach has little relevance in this context. Schiffer (1987, 292) suggests that increased knowledge of the general conditions that favour or curtail the operation of specific processes will allow archaeologists to "...expeditiously rule out some processes and assign high probabilities to others". The preferred method by which the objective evaluation of such restrictions is to be achieved, however, is not made clear - particularly within poorly studied areas of interest. This study does not necessarily indicate that such judgements can be made easily or reliably.

Evidence presented in chapter 3 (62) might suggest that a high percentage of the seabed in UK coastal waters is likely to have been influenced at some time by fishing gear. It is possible to identify specific areas of seabed where certain modes of fishing are very unlikely to have been prosecuted. Additionally, accurate information on recent and current activity can be gathered from official sources and oral testimony. Yet determining whether resources should be directed at seeking evidence of past activity is more complex.

Registers of fishing vessels can be used to chart changes in overall effort, but the place at which a vessel was registered may bear little relation to the area in which it fished. The literature of the Great Fisheries Exhibition of 1883 includes summary charts of fishing activity (Anon 1884). This type of data is useful to a degree, but it does not allow assessment of activity on individual sites. In a given inshore region there may be several fisheries exploiting different environments, topographies and species. Therefore, to be of use, any maps or charts purporting to show historic fishing activity must be sufficiently detailed to reveal such niche exploitation.

The limited success of restrictions on fishing activity has been noted in section 5.4.1 (162). Some areas were open to trawling for some time before eventual closure; how long does it take for an area to be considered 'trawled'? In addition, where statutory restrictions are ignored, a single impact by a vessel operating illegally may have a profound influence on a deposit. Thus, records of transgressions, which may only account for successful prosecutions rather than the true level of illicit activity, must be noted as well as the prohibitive legislation itself. The case of the explosives dump at Birch Point (section 4.3.1) indicates that, even when observance of statutory restrictions would appear to be very much in the interests of the fishermen, total absence of the proscribed activity is not assured.

In section 7.3 (248-251) the possibility was raised that archaeological deposits may support atypical burrowing activity in comparison to areas of natural seabed in the vicinity. It was concluded that prediction of the nature and level of burrowing activity within a specific deposit, based on regional or even local species surveys, may therefore be less than secure. Thus, in practice, the judicious selection of processes to be investigated alluded to by Schiffer may again be problematic. Such observations also have implications for the application of technologies such as Geographic Information Systems (GIS) to predictive modelling of levels of preservation and threat.[4] In the creation of data sets to be used in investigation of such problems, it is often necessary to assign certain values to areas in order to draw comparisons and derive new data. If there is a significant level of difficulty in determining appropriate values (*e.g.* presence or absence of mobile fishing over time, level and nature of faunal activity) then the accuracy of any model derived will be severely compromised.

Oxley (1992, 105) notes the popularity of site classification models. These have been based on perceived levels of preservation or the zonation of the seabed into areas of specific

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[4] Gaffney & Stanic (1991) provide a useful introduction to GIS and archaeology. The proceedings of the annual conference Computer Applications in Archaeology contain a substantial number of papers which explore the application of this technology to practical issues associated with Archaeological Heritage Management (for example, see Andresen 1993, 91-192).

environmental conditions thought to have affected the preservation of particular artefact types. Data presented in this study have implications for the formulation of such models.

Muckelroy (1977; 1978, 160-165) proposes a five part classification of wreck sites running from coherent to scattered. He also discriminates between continuous and discontinuous distributions. Parker (1981, 311-312) cites technological and environmental reasons for not simply transposing such a system from a north Atlantic to a Mediterranean environment. He presents a categorisation of wreck sites based on the coherence of the deposit in terms of artefact inventory, preservation and the extent to which elements of the distribution of the original assemblage are exhibited by the observed distribution. Gibbins (1990 , 378 -379) proposes a classification system which combines those proposed by Muckelroy and Parker with particular reference to Mediterranean deposits. In discussing such schemes he contrasts Muckelroy's concern with general spatial distribution with Parker's apparent concern for overall preservation.

All three classifications are useful in the context of characterising wreck data in a general sense (see also Cederlund 1980). However, the extent to which such schemes can serve as a taxonomy for the detailed classification of sites is limited (*c.f.*, Gibbins 1990, 378). Each of the above schemes does imply consideration of inferential value and evaluation of the significance of distributions of material is a recurrent theme. However, classification according to the apparent form of a deposit must be clearly distinguished from characterisation of the nature of the data that might be obtained from it. Work undertaken in this study illustrates that deposits of apparently similar form may, due to having been influenced by different formation processes, possess fundamentally different characteristics in terms of inferential potential.

In section 3.1.11 it was shown that the influence of fishing gear is generally most marked on surface and near-surface material. Section 4.3.1 illustrated the magnitude of changes to a surface distribution that may derive from trawling. What is the value then, of a classificatory scheme which essentially characterises surface morphology if the intention is to assess the inferential value of the deposit as a whole? The potential of the surviving sub-surface deposit may well be underestimated. Equally, burrowing can be shown to have a significant role in reducing the range and quality of material within a deposit (section 7.1.2, 224-6). A broad morphological classification based on surface evidence may, in this case, tend to overestimate potential.

The value of classification schemes as a heuristic device should not be underestimated. However, over-reliance on unrefined schemas to aid in management decisions is unwise. Any implication that inferential value is a constant associated with specific forms of deposit is particularly problematic; especially during any ranking process in advance of statutory protection, or when making a case for mitigation of development related impact. All of the authors mentioned above have stated, or implied, that there is a need to reflect the true level of variability within and between deposits in any treatment. Yet practical and ethical constraints may influence the extent to which more flexible schemes can be applied. The degree and nature of archaeological intervention necessary to adequately characterise a large number of deposits may be beyond available means. In addition, the nature of the work required might not conform to the ethics of minimal disturbance investigation (*c.f.*, Watson & Gale 1990, 190-192).

Enhanced awareness of the difficulties of adequate characterisation may be contrasted with the present demands of archaeological heritage management. There is an emphasis on the delivery of supportable, one might say defensible, economic and ostensibly consistent evaluations of deposits in advance of development (*c.f.*, Murray 1993, 106). 'Common sense' assumptions (see section 1.2.2) concerning inferential value may be appealing in such circumstances. They are less challenging to a mechanism which anticipates discrete scoring of attributes and seeks certainties around which to plan expenditure and schedule projects. Assumptions that scattered sites are of low significance as compared to apparently more coherent deposit may be readily accepted by those asked to treat the judgement of archaeological heritage managers as a material consideration within planning or development control processes.

A determination to improve treatment of archaeology in marine development control mechanisms is laudable. The need for formalised assessment of deposits is genuine and pressing. But excessive willingness to collude in the reduction of complex problems in order to mollify external agencies may serve to retard deeper understanding of factors crucial to actually achieving the goal of conservation.

There is no intention to deny the possibility of achieving useful classification schemes for deposits. Undoubtedly, they have a role to play in the development of digital databases which may require indexing on controlled values for rapid retrieval. Coarse discrimination between deposits will be feasible. Yet, the obvious conclusion is that different approaches are required for different purposes with the corollary being that the purpose the classification is intended to serve must be stated explicitly. Further, decisions based on such schemes must take into account the nature of the investigation that has led to a deposit being assigned to a specific category. This process of weighting should be the subject of as much thought as the formulation of the classification schemes themselves. The need for substantial discussion concerning assessment of deposits and their subsequent curation is a theme which will be returned to below.

### 9.3.1 Future Work

An essential element of the approach advocated in this study is that consideration of formation processes should be routine and begin with enlightened data collection on-site. While professional archaeologists may be inclined to accept such an injunction without demurring a significant proportion of field projects are conducted by avocational volunteers who may be less inclined to do so unless compelling reasons are offered.

The existence of this problem is a function of the present structure of the discipline yet it cannot be ignored. The case for explicit method in the study of formation processes must be made forcefully and persuasively if such research is to develop through accumulation of a body of data against which ideas and propositions can be judged. However, long-term progress may ultimately depend, on short-term acceptance of the inherent value of an explicit approach designed to promote rigour. This is because major, demonstrable benefits may not accrue until a considerable amount of data has been collected and analysed.

The approach utilised in this study owes much to concepts and techniques developed in terrestrial archaeology. Future research in this area can benefit from more cross-pollination, indeed, greater integration and exchange of ideas should be a specific aim. However, it would be a mistake to attempt to transplant approaches uncritically from one environment to the other. An example of the need for caution is provided by Harris's work relating to the analysis and representation of stratigraphic sequence (Harris 1989). Essential elements of his concept of stratigraphy may not be compatible with analysis of certain submerged deposits. Harris and Brown (1993, 10-20) affirm that the study of interfaces, the surfaces on which occupation actually occurred, is the defining characteristic of the approach. They concede that geological methodology, though perceived as limited, will play its part in the interpretation of stratification created mainly by geological processes but containing archaeological material. If stratification within a shipwreck site is largely natural in origin, what is the actual significance of recordable interfaces?[5] This situation may be contrasted with a submerged land site where stratification may have formed through long periods of human occupation prior to inundation.

The usefulness of the Harris Matrix as a means of demonstrating relative chronology through illustration of stratigraphic sequence is demonstrable (Gerrard 1993; Stucki 1993); as a graphic aid to analysis it can be applied successfully on submerged sites (see Watson & Gale 1990, 188). However, the attendant principles must be applied in a manner that respects differences in the character of deposits.

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[5] Sassoon (1978, 36-7) has suggested that, due to the nature of shipwreck deposits, stratigraphic analysis underwater need only extend to ascribing one of three contexts to material; reliability of association with wreck not doubted; association open to doubt; not associated with wreck. Yet when questions more complex than 'is this item part of this total assemblage or not?' are posed the limitations of such an approach are made particularly apparent. Smith's (1981, 102-5) report on the *Defence* demonstrates the value of analytical methodology and attention to formation processes (specifically the dynamics of deposition) in resolving anthropological detail from a deposit apparently susceptible to intuitive treatment (Switzer 1978).

## 9.4 *In situ* Conservation

The results of this study support the assertion that research into the formation of the archaeological record complements research regarding its conservation and *vice versa*. Data relevant to analysis of the formation of deposits has been shown to be relevant to the design of strategies for limiting the magnitude of changes to deposits in the future. The complexity introduced by behavioural phenomena has been shown to be a problem common to both areas. Wildesen's concept of the integrity of the resource (see section 2.2, 32) has proved very useful in appraisal of strategies for mitigation of processes judged to have a negative effect. The contrast between options suited to reducing the magnitude of changes caused by fishing activity and burrowing is instructive in this context. The former may best be dealt with through control of activity across an area, the latter can only be approached on a site specific basis with significant intervention on the seabed.

Various approaches to *in situ* preservation have been discussed. Yet, the possibility that preservation *in situ* is not, in fact, the best option must always be considered; particularly given potential limits on what can actually be achieved in reducing the influence of certain processes (*c.f.*, Bryant 1989, 104). Wildesen (1982, 75) argues that knowledge of the nature of the archaeological resource, and the use to which it is to be put, can allow the establishment of a 'threshold of concern' implemented on a site by site basis. For example, it may be decided that 20% severe disturbance to a site can be tolerated but any further impact should be prevented. The general concept has much value as a pragmatic attempt to reconcile *in situ* conservation and development in a formalised rather than *ad hoc* manner. However, a strategy reliant on detailed knowledge of specific sites appears inappropriately limited as a management tool in the context of current UK marine archaeological heritage management. Indeed, major dredging works undertaken near Rotterdam demonstrate a more general weakness in the approach. The dredging was thought to be likely to impact a substantial but unquantified and unlocated archaeological resource. Paradoxically, it was *because* the resource was largely unlocated and unquantified and therefore, potentially, relatively undisturbed, that attempts at mitigation were felt to be justified (Adams, Holk & Maarleveld 1990, 7-8).[6]

The National Reservoir Inundation Study in North America considered 5 impact zones (Lenihan 1981, vol. I, fig 5.2 , 209). In zone 2, the shoreline where wet and dry cycling occurs, excavation is considered the most effective option for mitigation and that elsewhere "...a real commitment to adequately prepare a site for inundation with the goal of indefinite preservation...may be far greater than the cost of excavation" (*ibid.*, 223). These conclusions were reached after consideration of a specific problem - freshwater inundation of terrestrial sites. However, the argument that effective *in situ* conservation makes better use of scarce financial resources clearly need not hold true in every case. Such a claim may be supportable in specific instances, for example, where the actual end result of the conservation strategy applied can be thoroughly evaluated. However, our current knowledge of the true result of specific strategies is not generally based on long-term experimentation or quantified data and opportunities for such evaluations may be limited. Archaeological heritage managers presently risk expending considerable sums of money on measures which do not have a predictable long-term result.

Is there a pragmatic case for using part of the resource to demonstrate the value of the products of high standard archaeological excavation? Public and fellow archaeologists'

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[6] Technical discussion of the dredging activity involved is provided by van de Ridder (1987). A by-product of the mitigation work was, in accordance with Wildesen's contention, an increase in knowledge of formation processes. For example, the potential role of unpredicted and atypical topographic features in promoting levels of preservation which are atypical for a general location was highlighted as was the considerable distance over which structural elements derived from one vessel can be spread (Adams, Holk & Maarleveld 1990, 106; 150).

expectations of work underwater may be raised, thus rendering poor work, no matter who undertakes it, unacceptable. Funding agencies may be persuaded that valuable knowledge can be reliably retrieved and the results obtained from certain commercial operations will be put in perspective. Thus progress, although via a different route, will be made in securing the integrity of the resource. In a similar vein, Grenville (1993, 131) states that future research agendas may not develop successfully if present research interests are not pursued fully. The need to make the best use of a finite resource is not disputed, but the need to assess every option critically is clear. This said, over-reliance on data collection in advance of destruction, or the short-term tactic of relocating the damaging activity, should be avoided. The need for effective *in situ* conservation will not diminish and failure to confront the issue will simply inhibit progress towards development of the necessary methods (*c.f.*, Thorne 1991, 1).

### 9.4.1 Future Work

There is a pressing need for directed and properly funded research to develop integrated strategies for *in situ* conservation which have been tested in the field. There is also a particularly acute need for data concerning the changes to deposits caused by such protective strategies - for example the effect of sediment compression caused by burial. Without such information it will be difficult to select appropriate options.

The availability of funding for research of this nature is currently unpredictable. In terms of the application of techniques in the field, there is a lack of clarity concerning potential sources of Government money. There is no assurance that levels of provision for terrestrial monuments will be reflected in the treatment of deposits underwater.[7] Yet, while the resources

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[7] The grant awarding agency that assists with monument protection on land in England, English Heritage, does not currently fund work underwater - although the situation is under review. However, its Scottish equivalent, Historic Scotland, has recently made grants to assist with site investigation and stabilisation. It is also not clear whether or not the Department of

necessary to undertake such research might remain elusive, policy related developments may increase opportunities to demonstrate the need for effective measures. Planning policy guidance provided for the coastal zone via PPG 20 (DOE 1992a) includes notice that advice contained in PPG 16 (DOE 1990a), which confirms archaeology as a factor in the planning process, should apply. Significant principles commonly derived from PPG 16 include conservation *in situ* as the option of first choice and anticipation of developer funding should archaeological intervention be necessary (Wainwright 1993, 416). However, as planning powers do not extend below low water, other mechanisms are required to promote a more satisfactory regime further offshore. A draft code of conduct for seabed developers produced by the Joint Nautical Archaeology Policy Committee[8] promotes *in situ* conservation as the option of first choice. However, the code also recognises that, currently, developer funding of archaeological work will be on a voluntary basis. The revised European Convention on the Protection of the Archaeological Heritage includes underwater sites in its scope (Anon 1993, 403) and obliges signatories to promote developer funding of pre-development evaluation in order to assess the need for archaeological work (article 6).[9] UK ratification of the Convention might provide a lever with which to move marine developers towards funding appropriate protective measures.

There is need for progress in other areas too. Most particularly, there is an urgent requirement for the development of a framework within which *in situ* conservation can be achieved as an element of long-term policy rather than as a reactive measure

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National Heritage, which currently administers the Protection of Wrecks Act 1973 (see appendix 3) consider that its obligations extend to funding deposit stabilisation and conservation.

[8] An *ad hoc* committee of interested parties formed to lobby for better provision for archaeology underwater (see JNAPC 1989; JNAPC 1993).

[9] The 'polluter pays' principle was explicitly stated in earlier drafts but political considerations led to some dilution of the wording (Trotsvig 1993, 414).

aimed at resolution of site-specific problems.[10] It has been suggested that the potential cost of physical protection of deposits may lead to a restricted number being afforded such treatment (section 5.6, 178). This implies some form of selection process with attendant problems of potential bias in the sample of the resource ultimately conserved for future study. The need for provisional criteria for selection in advance of improved knowledge of the actual nature of the data-base is accepted and is reflected in the previous discussion concerning classification of deposits.

This raises significant questions concerning the manner in which value is assigned to individual components of the archaeological resource. While this is not the place to explore this problem in depth, real tensions between different types of value may be anticipated; rarity; importance to a particular area of research; symbolic value to a community; and amenity value (*c.f.*, Henry 1993, 8-10).[11] In addition, the extent to which the idea that archaeological material is by definition worthy of study and sensitive treatment, derives from archaeologists rather than common consent must also be recognised (Carman 1991, 178). While these aspects of the material may not be self evident to those outside of the profession, the benefits which might flow from a well informed, sympathetic public are widely acknowledged (O'Keefe 1993, 411):

"Leaders in American archaeology perceive that better public understanding about archaeology will lead to more preservation of sites and data, less site looting and vandalism, greater support for the curation of archaeological collections and records, and a demand by the general public for more interpretation of and participation in archaeology." (FAR 1990, 3.2, 1).

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[10] Other workers have identified the need for an equivalent approach to site management on land (Berry 1994, 1-2).

[11] Guidelines accompanying the US Abandoned Shipwrecks Act 1987 explicitly recognise the variety of values that might be associated with a sites. When management plans are to be formulated a consultative procedure is recommended which seeks to reflect this diversity (ASA 1990, 50131-2).

It must be hoped that, ultimately, judgement based on academic criteria will prevail in policy formulation (*c.f.*, Fowler 1993, 5). As discussed in section 2.2, research questions and priorities will change and therefore the overall goal must remain the preservation of the resource's ability to answer research questions now and in the future. This said, there is clearly a difference between attempting to conserve the physical components of a site and strategies for conservation of specific conceptions of value; symbolic value to a community may persist despite severe physical attrition while deposit burial might significantly reduce amenity value. It can also be argued that, while objectives must be set on the basis of academic criteria, approaches used to achieve them and the degree of success attending such efforts will be extensively influenced by non-academic, non-professional interests. Public sympathy can be a powerful weapon in the cause of seeking Government support, just as alienation of sectors of the public might cause significant problems. Yet it is, in this context, appropriate to consider just how varied is the 'public' here referred to as a homogenous entity; there are those actively interested in the past, those content to have occasional contact with the past via museum displays and those who have little interest in the past but considerable interest in the disposal of tax revenues. Public interest, no matter how ill-defined and diverse a phenomena, should be recognised as a material consideration (Mayer-Oakes 1989), but are the aspirations of some elements of society simply incompatible with the objective of resource conservation? If so, this should be recognised explicitly.

Some have drawn attention to the dangers which attend a self-appointed, academic elite exerting control over access to the past (Shanks & Tilley 1992, 24 & 65). It is acknowledged that any conception of a totally objective academic view of the value of any component part of the archaeological resource is naive. It is also true that fundamental differences may exist between priorities espoused by research oriented workers and those involved full-time in the administration of heritage management policy. However, the lack of a strong academic input creates the danger of allowing purely administrative priorities to dominate; leading to emphasis on development of a system whereby performance can be judged by the number of deposits examined and graded over the financial year.

The degree to which research agendas and priorities are currently sufficiently developed to provide the necessary input to policy formulation in the UK might be questioned. However, the development of an explicit approach to selection of deposits is an essential corollary to research into viable techniques to achieve preservation. Any such policy is likely to be open to criticism but an *ad hoc* and essentially speculative application of costly techniques will serve archaeology and the taxpayer poorly. An explicit policy allows bias to be detected and therefore rectified or compensated for to some extent in subsequent analysis and management decisions. Improved knowledge of the location and condition of the resource being managed is fundamental to the formulation of such a policy (JNAPC 1989, 9-10) and attempts to obtain such data are underway at a national level in England.[12]

During a debate in the House of Lords, Lord Hesketh, referring to conservation oriented legislation, stated that "...It would be wrong to introduce further piecemeal legislative changes which are not founded on any clear idea of what needs to be done or what overall is the best way forward." (Gubbay 1990, 8). Gibson (1989, 705), commenting on the failure of the Nature Conservancy Council to establish a marine reserve around the Isles of Scilly, suggested that a fundamental problem had been the failure to demonstrate complete credibility for the need for the reserve. Attempts to gather support for protective measures for archaeological material underwater may also founder if effort is not dedicated both to demonstrating irreparable damage to the integrity of the archaeological resource and to the production of

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[12] As noted in section 5.5., note 86, compilation of records of archaeology in the territorial sea of England is underway at national and local level. Although compilation has not begun on a formal basis the need for similar inventories in Scotland and elsewhere has been recognised in strategic documents related to conservation in general (SWCL 1993, 29) and in specific proposals to improve treatment of submerged archaeology (SUAF 1992, 4).

proven management strategies with a supporting conceptual framework. It is hoped that work undertaken in this thesis has made a contribution in both respects.

# 10 Bibliography

## 10.1 Location of Archive Material

**CNA Archive (Council for Nautical Archaeology)**
Royal Commission on the Historical Monuments of England
Green Lane, Maybush
Southampton

**Murray Archive**
Scottish Fisheries Museum
Harbour Head
Anstruther
Fife

**Southampton Water Ceramic Assemblage**
Southampton Archaeological Unit
Eagle House
Southampton
Hampshire

**Studland Bay Site Archive**
Poole Museum Services
Waterfront Museum
Waterfront
Poole
Dorset

**Yarmouth Roads Ceramic Assemblage Archive**
**Yarmouth Roads Site Archive**
**Ryde Middle / Bramble Bank / Solent Ceramic Assemblage**

Isle of Wight Archaeological Centre
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Clatterford
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## 10.2 Personal Communications

The following codes indicate the nature of the contact with the individuals named below:

*INTERVIEW*
Information was gathered via a formal interview

*DISCUSSION*
Information was gathered via an informal interview / meeting

*CORRESPONDENCE*
Information was supplied via written correspondence

*RSI*
A response was supplied to a request for specific information

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# 10.3 Bibliographic Material Cited in the Text

## Abbreviations Used in the Bibliography:

***AA***
American Antiquity

***AAMT***
Advances in Archaeological Method and Theory

***CAA***
Computer Applications in Archaeology

**CBA**
Council for British Archaeology

***SFRP***
Scottish Fisheries Research Report, Marine Laboratory, Victoria Road, Aberdeen.

***SFB***
Scottish Fisheries Bulletin, Victoria Road, Marine Laboratory Aberdeen

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**HMSO**
Her Majesty's Stationary Office

***IJNA***
The International Journal of Nautical Archaeology

***JAS***
Journal of Archaeological Science

***JFA***
Journal of Field Archaeology

**JNAPC**
Joint Nautical Archaeology Policy Committee

***MM***
Mariner's Mirror

**RCHME**
Royal Commission on the Historical Monuments of England

# A

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# B

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