FISHING IN MESOLITHIC EUROPE

Vol. I

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Abstract

Although there is increasing evidence for the importance of fishing to Mesolithic peoples, many questions concerning fishing methods and extent of exploitation of aquatic resources remain unresolved. This is the first study for five decades to draw together various strands of contemporary knowledge in order to provide an overview of fishing during the Mesolithic period in Europe.

Utilisation of fish as a resource is discussed on the basis of the evidence provided by site location, dietary reconstruction from faunal remains, the nutritional value of fish, and the chemical analysis of human and animal bone.

The fishing practices of European Mesolithic populations are reconstructed from the evidence provided by artefactual and faunal remains. Temporal and spatial variations in fishing activities are assessed. Methods of fish capture are determined in several ways; by examination of the range of fishing gear attested in the archaeological record, by comparison with modes of operating this gear in traditional and modern fisheries, by an investigation of the biology and behaviour of the fish species recovered and, lastly, through statistical assessment of the co-occurrence of fishing gear and fish fauna in archaeological contexts. This is supplemented by information drawn from ethnographic analogues.

It is inferred from these studies that Mesolithic fishermen had a sophisticated understanding of the use and manufacture of employed technologies, fish biology and behaviour and the impact of hydrological conditions on fishing practice.
Declaration

I declare that this thesis was composed by myself and that the work included was carried out by myself unless otherwise stated in the text.

Signed

(Catriona Pickard)

Date 07 11 02
Acknowledgements

I wish to thank:

Clive Bonsall for supervision, guidance and discussion.

Alan Barnard for supervision.

Catherine Stewart and Hugh Stewart for providing translations of Eastern European texts.

Pat Storey and Ian Morrisson for technical support.

Ben Pickard and Katy Pickard for their support and understanding.
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Chapter 1

Introduction

The expansion in Mesolithic research since the 1970s has greatly increased the body of available data relating to fishing practices in this period. The importance of fish as a resource to European Mesolithic populations is evident from several areas of archaeological investigation; recovered artefacts, faunal remains and the results of stable isotope analyses (e.g. Stjernquist et al. 1953; Schuldt 1961; J Coles 1971; Srejović 1972; Payne 1975; Aaris-Sørensen 1976, 1980a; Lepiskaar 1976; Mellars 1978; Srejović & Letica 1978; Straus 1979, 1991a, b; Andersen 1981, 1985, 1987a, b, 1989a, 1991, 1995; Wilkinson 1981; Noe-Nygaard 1983; Trolle-Lassen 1984; Price 1985, 1989a, b, 1990, 1995; Woodman 1985b; Lentacker 1986, 1994; Straus & Clark 1986; Prinz 1987; Loze 1988a, b; Renouf 1988, 1989, 1991; Matsikianen 1990, 1995; Le Gall et al. 1992; Mordant & Mordant 1992; Lubell et al. 1994; Morales et al. 1994; Malm 1995; Meldgaard 1995; Pedersen 1995; Schmitt 1995; Skaarup 1995a; Verhart 1995; Löugas 1996; Sampson 1996; Bonsall et al. 1997, 2001, Richards & Mellars 1998, 1999; Kriiska & Löugas 1999; Richards & Schulting 2000; Schulting & Richards 2001). J G D Clark (1948a, 1952) provided the first major overview of Mesolithic fishing activities. Despite the increase in archaeological investigation of the Mesolithic period and the many studies of Mesolithic fishing activities published since the inception works of J G D Clark there has been no subsequent reappraisal of fishing practice. All recent studies are spatially and temporally limited. The aim of this thesis is to collect and analyse the available data on Mesolithic fish remains and fishing technology from across Europe to provide an up-to-date overview of Mesolithic fishing practices.

1.1: Definition of the Mesolithic

Recent debate over the definition, and even the validity, of the term Mesolithic makes it necessary to detail the scope of this study. The term Mesolithic, coined by Westropp in 1866, was applied to the last prehistoric period of Europe to be recognised (Rowley-Conwy 1988). There is still no precise definition of the term owing, in part, to the fact that this period was originally viewed as a hiatus in European occupation and therefore difficult to characterise either temporally or by material culture. Lartet & Christy (1875) and de Mortillet (1890) were the first to propose that the lack of cultural remains was the result of a gap in knowledge rather than a genuine hiatus in occupation. This was supported by finds of microliths in association with modern faunal assemblages at sites such as Mas d’Azil, Ariège, France (excavated by Piette). Despite such finds, initial impressions of the Mesolithic as a period of climatic and cultural impoverishment persisted until relatively recently (propagated by
the influential work of Childe [1942]). Since the 1960s, (following the work of J G D Clark [1954] at Star Carr), Mesolithic sites have become a focus of archaeological research. The research has led to

"contemporary scholars portraying the Mesolithic as a dynamic and critical period in the evolution of human culture." (Price 1987:229)

However, there is still disagreement over what constitutes a valid definition of the Mesolithic. Though there is merit in the criticisms levelled against the generally accepted definition of the Mesolithic (namely, the combining of chronological and cultural delimitations), few authors have proposed an unflawed redefinition to take its place (e.g. Rozoy 1978, 1984; Dennell 1983; Zvelebil 1985, 1995a; Blankholm 1992; Castleford 1996; Radovanović & Voytek 1997).

The widely accepted definition is that of hunter-gatherer communities existing from the post-glacial period to the advent of agriculture (e.g. Kozłowski 1973; Price 1987; Prinz 1987; Voytek & Tringham 1989; Zvelebil 1995a).

"Mesolithic means simply early postglacial hunter-gatherers, nothing more...the term has significance only as that period between the end of the Pleistocene and the introduction of agriculture." (Price 1987:230)

This definition is applied in this study. The cultural, environmental, temporal and geographical limitations inherent in such a definition are acknowledged. As prescribed by Lourandos (1997) the temporal and spatial scales analysed will be explicitly stated throughout.

An arbitrary chronological delimitation of the end of the Pleistocene/beginning of the Holocene is taken as ca. 10,000 BP (9650 cal BC). Recent dating of ice cores from Greenland indicate that climatic amelioration actually began somewhat earlier, between ca. 11,600 BP (11,550 cal BC) and ca. 10,900-10,700 BP (11,000-10,900 cal BC). Changes in observed material culture post-date this by some centuries: this time-lag has been related to the gradual spread of forest flora subsequent to climate change and corresponding human adaptation to the changing environment (Eriksen 1996; B Coles 1998). The lower limit of the Mesolithic is determined by the time-transgressive adoption of agriculture across Europe (defined in terms of the occurrence of wheat and barley), evident in south-east Europe from ca. 8500 BP (7550 cal BC) and in north-west Europe from ca. 5500 BP (4350 cal BC) (Price 1987).

1.2: Definition of Fishing

In the existing literature there are numerous definitions of fishing. Definitions vary most noticeably between archaeologists, anthropologists and authors discussing modern and traditional fisheries (e.g. Hewes 1942; Wilkinson 1981; von Brandt 1984a; Ingold 1988; Pålsson 1991; Jackson et al. 2001). Anthropologists tend, on the whole, to categorise fishing in terms of what they consider it is not —
namely, not hunted or gathered resources. Consciously or not, there has been a move away from this definition of fishing as a distinct activity in archaeo-ichthyological studies toward dividing the exploitation of aquatic resources into two categories: as either gathered or hunted resources depending on the mode of capture. This is perhaps an attempt to reduce the distinction traditionally placed between aquatic and terrestrial subsistence activities. The ambiguity in the determination of tool function and use and the varying definition of what constitutes a hunted, gathered or fished resource, would suggest such definitions are, if not meaningless, impractical in archaeological terms.

For the purpose of this study fishing is defined as the capture or collection of fish by any method. Fishing technology, then, concerns all implements used in the capture of fish and their mode of operation.

1.3: History Of Archaeo-ichthyological Studies

The discovery of scales in archaeological contexts is first mentioned in the 15th century records of Josafa Barbaro who excavated mounds for treasure in 1438 (Casteel 1976a). The first documented archaeo-ichthyological study was the analysis of remains from the medieval site of Dorestad in the Netherlands by H. Schlagel conducted in 1842 (Clason 1986). As with many studies of the late 19th and early 20th centuries only 3 large species were identified — catfish (*Silurus glanis*), pike (*Esox lucius*) and sturgeon (*Acipenser sp.*) — which may reflect excavation and recovery methods and the lack of suitable reference collections rather than prehistoric fisheries aimed only at the exploitation of these three species. The quality of early works varied. As early as 1882 Kessler had published an analysis of the fish remains recovered from sites on Lake Ladoga, Finland, which detailed minimum numbers of individuals (MNI), estimated size distribution, and reconstructed fishing areas and water quality from the behaviour and ecology of the species identified (Casteel 1976a). Rau (1885) noted the relationship between Upper Palaeolithic sites with fish remains and the distribution of rivers with runs of migratory species. Such studies should have acted as a prototype for subsequent development and improvement. Until recently, however, reports on the faunal remains from many sites failed to include a detailed description of the fish fauna — listing, at most, only the species represented. Some recorded only that fish bones were present using vague terms to quantify their occurrence. Rau (1885) also published a comprehensive survey of the European and North American ‘Stone Age’ fishing implements and methods of operation. In 1911, Kishinouye’s work on prehistoric fishing in Japan was one of the first occasions where a specialist was brought in to identify fish fauna from water processed samples, where microscopes were used to aid recovery and identification of remains and where a study of temporal differences in species exploitation was undertaken (Casteel 1976a). The inception of ichthyology as an archaeological specialisation did not occur until the 1970’s with the work of G. Desse and R. Casteel (Casteel 1976a; Desse & Desse-Berset 1996). Although the present-day practices of archaeo-ichthyologists originated in the late 19th and early 20th century studies these
practices were not widely adopted until the latter part of the 20th century and unfortunately, still have not been universally adopted.

Descriptions of the Mesolithic as a period of cultural impoverishment (Childe 1942) persisted as recently as the 1970s. This, combined with less advanced on-site and post-excavation recovery techniques (and therefore limited assemblages), resulted in erroneous views of the fishing practices and economic basis of Mesolithic groups:

*e.g. "As far as it is possible to tell from the rather sporadic nature of the palaeontological evidence from the settlements of eastern Europe, there was no specialization in the exploitation of any one animal species for food or raw materials apart from the Kunda culture...There may have been a greater concentration on the exploitation of fish at some settlements, for example, those on the banks of rivers, or on large forest animals at others, but in no case to the exclusion of other resources at their disposal" (Tringham 1971:62).

As recently as 1975 J G D Clark stated that,

"the only fish of much economic importance caught at this time in the west Baltic area was the pike...The fact that it occurred so invariably on Boreal sites with adequate bone samples and in such quantity...argues that it was systematically harvested" (1975:143).

Pike (*Esox lucius*) may have been systematically harvested in the Mesolithic but it is now recognised that many more species were actively exploited. A lack of assemblages and faunal specialists led to most site reports only recording that fish bones were recovered from a site with no attempt made at species identification or quantification (Wheeler & Jones 1989). Moreover, the recovery of terrestrial animal remains at many Mesolithic sites led to such conclusions as,

"Whether one turns to sites like Villingebæk or Vedbæk dating from the earlier part of the Atlantic time or to the numerous assemblages from sites of late Atlantic times, the most striking conclusion to emerge is that the main source of protein came from terrestrial mammals...Common, Greenland and ringed-seals, as well as killer whales and dolphins, were evidently caught from time to time, but only the grey seal and porpoise made really considerable contributions. Most, if not all, fur-bearing mammals also yielded meat and served to exaggerate even more the contribution made from land mammals...Fish were predominantly caught in salt water and it is worth noting that only cod and flounder were very frequently represented" (J G D Clark 1975:191-192).

More recent excavations and subject specialisation from the 1970s (particularly in areas with good preservation conditions such as Scandinavia) have revealed a wealth of sophisticated fishing gear and an abundant variety of prey. The development of recognised recovery and analytical techniques for aquatic fauna was stimulated by the increasing awareness of the emergence of cultural complexity at prehistoric riverine sites (Limp & Reidhead 1979). It is only with the recent widespread wet sieving of samples to increase faunal recovery that a clear picture of the scope and scale of Mesolithic fishing
practices at sites across Europe has become apparent. This necessary focus, in the 1970s and 1980s, on methodology has not eliminated variation in archaeological practice. Differences in the extent and techniques of excavations, sampling and post-exavcation procedures, identification, quantification and publication standards constitute a major problem in synthesising the existing data on fishing practices in the Mesolithic. Evidence pertaining to Mesolithic fishing practice varies considerably in reliability. These problems will be addressed with particular attention paid to the standardisation of excavation practices, quantification of data and publication of reports.

Since the work of J G D Clark (1948a) there has been no synthesis of the artefactual evidence for Mesolithic fishing activities. Finds of fishing gear have been examined only on a local scale. Generally, descriptions of the finds are given with little information concerning their mode of operation. Brinkhuizen’s (1983) extremely cursory overview sought to assess pre- and proto-historic fishing technology from north-western Europe but there has been no comparison of the data from Mesolithic sites across the various regions of Europe, incorporating the large number of finds that have come to light since the 1950s. It is acknowledged that recent excavations of Mesolithic sites have yielded few new categories of fishing gear but have greatly increased the number of sites and the number of artefacts related to fishing, indicating the overwhelming importance of fishing to many Mesolithic groups. Studies of fishing artefacts tend to concentrate on the origin and development of these implements or focus on artefact morphology, avoiding the difficulties of interpreting function (e.g. Breuil 1926; Hornell 1929b; Curwen 1941; A J H Godwin 1946; J G D Clark 1948a; Went 1951; Rostlund 1952; de Rohan-Csermak 1963; Nishimura 1975; Jenkins 1974; 1991; Taksami 1975; Forman 1980; Cleland 1982; Brinkhuizen 1983; von Brandt 1984a; Feustel 1985; K M Stewart 1989; E Martin 1995; Zaliznyak 1997). For example, Von Brandt (1984a) goes as far as to suggest that weirs may have originated in the pre-sapiens stage of human evolution through the observation of the concentrating properties of natural obstacles to fish movement and migration (no evidence supporting this assertion is presented). No discussion of the origin or possible routes of development of various types of gear from observations of nature or adaptation from terrestrial hunting practices will be undertaken here. It is considered unnecessary in terms of the Mesolithic use of fishing technology and futile in terms of the lack of archaeological evidence concerning functional origins of gear and the dating of its inception.

Archaeologists usually analyse fish assemblages with the aim of elucidating prehistoric subsistence or exploitation patterns and temporal variations therein. Results have then been incorporated into discussions of social organisation and complexity. However fish remains have a wide range of other applications and have been used to indicate the prehistoric distribution of species (Wheeler & Jones 1989), distinguish natural from artificial assemblages (Noe-Nygaard 1983; K M Stewart 1989; Stewart & Gifford-González 1994), document the appearance or extinction of species (Casteel 1976a; Wheeler & Jones 1989), reconstruct climate and environment (Le Gall 1984; L Jonsson 1988; Enghoff 1989, 1994a, 1995; K M Stewart 1989; Rick & Erlandson 2000), reconstruct fishing methods

The results of the analyses of fish assemblages are generally reported separately from descriptions and interpretations of fishing gear. This is a consequence of the separate disciplines of zooarchaeology and material culture studies. Most faunal reports give, at most, a summary of any implements recovered and possible fishing techniques used and vice versa. Published reports therefore tend to be a ‘sum of the parts’, without the holistic interpretation that would provide a profitable approach to reconstructing the ‘whole’ of fishing practice. Many studies are simplistic, lacking a complete understanding of the fish biology, ecology and behaviour. Collation and interpretation of the data from all aspects of research will be undertaken in this thesis to enhance understanding of Mesolithic fishing practices.

1.4: Aims of Study: Key Questions to be Addressed

There are a number of unanswered questions and contentious issues in the field of Mesolithic fishing.

1. Was there a shift to increased fishing in the Holocene and, if so, why?

2. To what extent were the various Mesolithic groups exploiting aquatic resources?

3. What types of resources were exploited and where were they harvested? Was there a consistent preference for certain types of fish across Europe?

4. Was offshore fishing practised? What role did watercraft play, if any?

5. What types of gear were being used?

6. Can a study of ethnographically observed groups provide new insights into Mesolithic fishing activities?

7. Can multi-functional implements be assumed to have a fishing function?
8. Is there evidence for the use of fishing techniques that are specifically adapted to the different environments of rivers, lakes and seas?

9. Is it possible to determine, from the fishing implements recovered, the range of prey species exploited at sites without faunal remains?

10. Can identified fish remains be used to predict fishing strategies?

11. Did Mesolithic fisherman show an understanding of fish biology and hydrological conditions and adapt fishing strategies accordingly?

12. Do fishing methods remain constant through time? Is there evidence for development of fishing technology through the Mesolithic?

13. Is there evidence for variation in fish practices on the local, regional or Pan-European scale that is not simply related to local species availability or topographical/hydrological differences?

14. How can future excavation, processing, quantification and interpretation be improved?

1.5: Thesis Contents

This thesis aims to address these questions through a review of the relevant literature (not restricted to archaeological texts) coupled with a meta-analysis (overview of many published data sets) of fish remains, fishing technology and fishing-associated finds detailed at Mesolithic sites across Europe. Four approaches to this problem are incorporated: ethnographic sources, archaeological evidence, knowledge of fish biology and behaviour and an understanding of fishing gear technology (Figure 1.1).

In Chapter 2, the use of fish as a resource is assessed. The apparent intensification of the exploitation of aquatic resources at the end of the Pleistocene and the beginning of the Holocene will be discussed. The nutritional value of fish is assessed. The role of fish in Mesolithic diet across Europe is reconstructed from the results of stable isotope analyses of human and dog remains.

The ethnographic and ethnohistoric record (Chapter 3) can elucidate implement function and indicate the mode of operation of the various types of fishing gear under varying hydrological conditions. It can further suggest the use of fishing methods, types of fishing gear and fish products commonly recorded in ethnographic/ethnohistoric literature that would not survive in the archaeological record. The validity of this approach is discussed.
recorded in ethnographic/ethnohistoric literature that would not survive in the archaeological record. The validity of this approach is discussed.

Chapter 4 provides an introduction to the gear of non-industrial and ethnographic fisheries and expected archaeological remains of fishing gear. It will be argued here that an assessment of function in addition to morphology is essential for the classification of Mesolithic fishing gear, given that morphologically identical implements can have a range of different functions. The concepts involved in the use of artefactual and faunal remains to reconstruct Mesolithic fishing practices (in Chapters 6 & 7), based on the operational parameters of the fishing technology and the behavioural patterns of the target fish species, are discussed.

A detailed analysis of the biology, ecology and behaviour of the range of fish species known to have been exploited by Mesolithic groups (Chapter 5) is used to provide a model for each species, predicting spatial and temporal availability and vulnerability to capture. The model is applied in Chapter 6 and 7 to support hypotheses relating to Mesolithic fishing practices.

Chapter 6 details the construction of a database of artefactual and faunal remains. This data is extracted from over 600 published European Mesolithic sites and unassociated finds (Figure 1.2). This is the first time such an extensive overview has been undertaken.

Analysis of the database provides information concerning temporal and spatial variations in fishing practice in Mesolithic Europe and also highlights previously unseen correlations between fishing gear and faunal remains (Chapter 7).

The implications of the results, in the context of Mesolithic complexity and related issues, are addressed in Chapter 8. A case study illustrates the detailed information concerning fishing practice that can be derived from the artefactual and faunal evidence of a single site (Tybrind Vig, Denmark) using a holistic approach to interpretation.

Finally, Chapter 9 contains a synthesis of the key findings of this thesis.

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1For Linnean nomenclature and full description of fish species see Glossary of Fish Species and Table 5.2.
Chapter 2
Fish as a Resource

2.1: The Exploitation of Fish

There is an apparent intensification in the exploitation of aquatic resources in the Holocene. This is suggested by an increase in the quantity and diversity of fish fauna in archaeological deposits, the innovation and sophistication displayed in fishing gear manufacture and by the possible processing of fish remains for storage.

Binford states that

"understanding .... this temporally correlated shift to the increasing use of aquatic resources [is] one of the major problems archaeologists have yet to address" (1990:134).

It is uncertain whether this is a real phenomenon or the result of deglaciation, eustasy and isostasy, and consequent preservation bias. As Yesner (1980) points out, with fishing offering so many benefits (see Section 2.2 below), archaeological evidence for this activity would be expected prior to the Late Palaeolithic.

2.1.1: Evidence for the Exploitation of Fish in the Lower and Middle Palaeolithic

There is both artefactual and faunal evidence to imply the exploitation of aquatic resources prior to the Late Palaeolithic. Fishing may have been conducted by the earliest hominids — it should not be viewed as a late development in human history. The contextual finds of fish remains indicate fishing activities from the Lower Palaeolithic (Desse & Desse 1976). Fish bones recovered at the Early Pleistocene site of Olduvai Gorge may indicate that fishing was first practised by hominids ca. 1.6 million BP (K M Stewart 1989). There is evidence from across the Old World to suggest that fishing and coastal resources gradually became more important over time (Yesner 1980; Pálsson 1991; Price 1995). Exploitation of aquatic resources, indicated by the association of fish remains and shellfish with hominid activity, dates to the Lower and Middle Palaeolithic in Europe. Fish remains are associated with hominid activities at the Acheulean site of Hoxne, England (Wymer 1982). Exploitation of coastal aquatic resources is inferred from the marine shellfish and fish recovered in Middle Palaeolithic...
Vernell, south Spain, and on hearths at St Germain les Vaux, Lorraine, France, has been interpreted as evidence for fish processing dating to ca. 200,000 BP (Cleyet-Merle & Madelaine 1995). Exploitation of freshwater and marine resources in Mousterian times is evident at Salzgitter-Lebenstedt, north Germany, Grotte du Salpêtre, Midi-Pyrénées and Abri Vaufrey, Dordogne, both France, La Naulette, Belgium, and in many cave deposits along the Mediterranean coast (Johnstone 1980; Bahn 1982; Wymer 1982; Le Gall 1984; Stiner 1993). At Tito Bustillo and Cueva Millan, Spain (ca. 39,000-37,000 BP), the lack of fish cranial bones has been interpreted as evidence for the processing of fish elsewhere (Muniz 1984). Though intriguing, the lack of cranial bones may relate to preservation factors rather than transport of fish at this early date (see Section 6.5.1).

Until recently it was thought that the first indications of significant contributions of fish to the economy came from Haua Fteah, Libya, and the Klasies Rivermouth site, South Africa, in deposits dated to ca. 80,000–50,000 years ago. However, recent finds from the Semliki Valley, Zaire, push back the dates for significant dependence on aquatic resources and fish, making the capture of fish at the Klasies Rivermouth site in the Middle Stone Age quite likely. Currently revolutionising views on early human behaviour, the finds of simple and uniserial barbed bone points in Middle Stone Age contexts (contemporaneous with the Middle Palaeolithic of Europe) at three sites of Katanda, Katanda 2 and Katanda 16 in the Upper Semliki Valley, prove that hafting techniques were sophisticated at this time (Yellen et al. 1995). The two complete points measure 130mm and 142mm and have square cut, uniformly spaced barbs similar to certain finds of Mesolithic date (Figure 2.1 and 6.8). The basal morphology suggests secure hafting to a base indicating that these points were spearheads rather than harpoons. Dates by association, obtained by electron spin resonance, thermoluminescence, amino acid racemization and Uranium-series methods, place these points in the range ca. 89,000 BP (Brooks et al. 1995; Yellen et al. 1995). These points were found in association with the remains of large catfish (Clarias sp. and Synodontis sp.) and, on this basis, a function in subsistence fishing is suggested. The behaviour of these bottom-dwelling species indicates that they would have been most vulnerable to capture during the spawning season when they migrate to shallow waters near the lakeshore. Other bone points from Middle Stone Age contexts include examples from Blombos Cave, South Africa (ca. 60,000–50,000 BP), made from seal bone with a fire hardened tip and indentations interpreted as traces of binding. Their faunal association implies use for the capture of large fish, seal and dolphins (Henshilwood et al. 2001, 2002).

It is generally accepted that projectile points came into widespread use in the Upper Palaeolithic ca. 35,000–25,000 BP in Europe (Shea 1997). However, spears have been recovered from much earlier, Middle Palaeolithic contexts. The use of thrusting spears is implied in the Lower Palaeolithic (ca. 500,000 years ago) by impact marks on faunal remains from Boxgrove, England (Thieme 1997). The earliest known examples of actual remains of throwing spears come from Schöningen, Germany, and date to ca. 380,000–400,000 BP (Steane & Foreman 1991; Dennell 1997). Shea (1997) states that wooden spears of this type were simple, expeditiously made implements. However, despite the early
date, the three spears of spruce wood (each ca. 2m in length) are technologically sophisticated, with the tip formed from the hardest part of the wood. Dennell (1997) notes that the centre of gravity of the spears is a third of the way along the shaft as in the modern javelin. Given the sophisticated design, it is possible that even at this date throwing spears had some antiquity. A shorter thrusting spear was also recovered at Schöningen. Steane & Foreman (1991) claim that the spear point from Clacton, England, in deposits dating to ca. 300,000 BP, is possibly the point of a fish spear. Wymer (1982) favours a function in the pursuit of large terrestrial game. The spears cannot be linked to a particular prey species, but it would be more reasonable to state that such implements could have been used for the procurement of fish. It is certain that spears from Middle Palaeolithic contexts were used for the capture of large terrestrial game from the example recovered at Lehringen, Germany (dated to ca. 115,000–125,000 BP) in the skeleton of an elephant (Steane & Foreman 1991). Middle Palaeolithic tools with traces of mastic and micro-wear analyses imply knowledge of hafting technology in Africa and Eurasia at this time (Shea 1997).

2.1.2: Evidence for the Exploitation of Fish in the Upper Palaeolithic

In their assessment of Upper Palaeolithic fishing activities Richards et al. (2001) conclude that,

"Direct archaeological evidence for aquatic resource exploitation during this time period is still comparatively rare." (2001:6531)

However, there is evidence from the artefactual remains of fishing gear and the faunal record that the exploitation of fish does increase in the Late Palaeolithic and through the Mesolithic. The technology required for large-scale exploitation of aquatic resources was in place by at least the Upper Palaeolithic in Europe.

Many types of fishing gear and large-scale fishing practices are first apparent in the Holocene and it is therefore generally assumed that it was at this point that fish took on a primary role in economy (J G D Clark 1965, 1975; von Brandt 1984a; Pálsson 1991; Stewart & Gifford-González 1994). Most of these implements appear in a sophisticated form implying a long history of development and refinement. This would suggest that much of the fishing gear evident from the Mesolithic record originated in the Palaeolithic but has seldom been preserved in pre-Holocene contexts. There are many pre-Holocene finds of implements that could have been used for fishing and the technology required for the manufacture of all types of traditional fishing gear is evident from at least the Upper Palaeolithic and occasionally in Middle Palaeolithic (in Africa, the Middle Stone Age) contexts.
2.1.3: Fishing Gear in the Upper Palaeolithic

The technology for line fishing was available in the Upper Palaeolithic. Although there are no secure pre-Holocene finds of fish hooks, there are many finds of bi-points that may have served as gorges. Feustel (1985) details implements found at the Palaeolithic sites of Predmosti, Czech Republic, and Mezin, Germany, which may be hooks, but the interpretation is not certain. Bi-points (first interpreted as gorges by Abbé Breuil in the 19th century) have been recovered from Upper Palaeolithic contexts at Grimaldi Cave and Romanelli, Italy; Rochereil, Dordogne; La Rochette, Indre-et-Loire; La Madeleine, Ardèches; and La Ferrassie, Dordogne; all France; and Kesslerloch, Switzerland — Figure 2.2 (Lartet & Christy 1875; Rau 1885; Sollas 1911; J G D Clark 1965; Kozlowski & Kozlowski 1979; Johnstone 1980; Feustel 1985; Cushing 1988). Breuil also interpreted finds of small, shaped pieces of bone from Upper Palaeolithic contexts as parts of composite hooks (Figure 2.3) but analogous implements have not been observed in use in traditional fisheries.

As in Mesolithic contexts, the greatest number of finds of implements possibly used in pre-Holocene fishing, are spear and harpoon points. This is in part due to the multi-functional use of such tools. Barbed and simple bone and antler points recovered from a number of Magdalenian contexts at sites in the south of France and north Spain (e.g. Mas d’Azil, Ariège; La Grotte des Eglises, Ariège; La Madeleine, Ardèches; Grotte de Lortet, Hautes-Pyrénées; all France; and El Castillo, Spain) and from the Final Upper Palaeolithic site of Kesslerloch in Switzerland (Magdalenian deposits) were linked to fishing activities in the 19th century when the sites were first excavated, based on analogy with fish spear/harpoons of Native American groups (Lartet & Christy 1875; Rau 1885; Sollas 1911; M W Thompson 1954; Le Gall 1984). Sauvage (1875) suggested that examples from the Périgord caves (e.g. Figure 2.4) were used for the fishing of salmon (Salmo salar) and pike (Esoc lucius). Many of these points have grooves running part of their length, which, it is suggested, were filled with poison (Lartet & Christy 1875; Sollas 1911). Is it unlikely that channels for poisons or to allow blood flow were necessary for fish capture.

The choice of raw material (antler was preferred) for the production of projectile points of various forms implies a sophisticated understanding of the elastic properties of bone and antler from at least the Aurignacian period, ca. 40,000 BP (Knecht 1994). The increase in fish remains at sites through the Upper Magdalenian and Azilian has been attributed to the introduction of the harpoon, which is generally accepted to be associated primarily with fishing on the basis of morphology and ethnographic observation. Straus (1991b) notes a coincidence of the find location of projectile points with the distribution of Atlantic drainage salmon streams in France, from which a function in fishing is inferred. Pokines & Krupa (1997) found a significant association of 31 barbed points with large quantities of fish (over 1000 mainly Salmonidae vertebrae) in Lower Magdalenian deposits at the cave site of El Juyo, Santander (Figure 2.5).
Composite slotted points are known from the Upper Palaeolithic. These implements combine the cutting power of lithics with the elastic resilience of antler/bone (Bergman 1993). This type of implement maximises blood loss, which may suggest it was most appropriate for terrestrial game hunting.

The spear thrower, which extends reach, makes its first appearance in the Upper Palaeolithic with secure finds dated from ca. 22,000 BP (Figure 2.6) (Garrod 1955; Knecht 1994; Hutchings & Bruchert 1997). The spear thrower was generally replaced in the Late Glacial by the bow and arrow (Bergman 1993).

The bow and arrow is also first evident in the Upper Palaeolithic (Rust 1937). It increases the range of resources available and can be fired much more rapidly and more accurately than the spear, even when the spear is used with a spear thrower (Feustel 1985; S E Churchill 1993). In excess of 100 pine-wood arrow-shafts with notched tips for hafting of the stone points were recovered from Ahrensburgian levels at Stellmoor, Germany, ca. 10,500 BP (Rust 1937). Bergman (1993) suggests that these were tipped with tanged points, bound with sinews to the arrow-shaft. Three types of arrow shaft are known from Ahrensburgian deposits. Two of these types would have had flint inserts.

The earliest European evidence for textiles and basketry comes from impressions of woven fibres on fragments of ceramics from the Moravian sites of Predmosti, Dolní Věstonice and Pavlov I (Figure 2.7) (Adovasio et al. 1996; Pringle 1997). At Pavlov I (a palimpsest of occupations dated to the range ca. 24,870–26,980 BP) there are four impressions of open simple twining, representing a semi- or fully-flexible mesh (Figure 2.7b) and another fragment with an impression of open diagonal twining representing a semi-flexible fabric (Figure 2.7a). These impressions indicate knowledge of cordage techniques. Pollen analysis identifies two possible bark fibres that could have been used as cordage materials on the site, that of yew (Taxus spp.) and alder (Alnus glutinosa). Charred cordage or netting from Mezhirich, Ukraine and from Kosovtsy, Moldova have been found in contexts not older than ca. 17,000 BP. Twisted fibres thought to be the remains of cordage were found at Ohalo II, Israel in contexts dated to ca. 19,000 BP (Nadel 1995). These impressions on ceramics and cordage fragments indicate that the manufacture of nets and traps for fishing would have been within the technological capabilities of Upper Palaeolithic groups. It is not certain, however, that such gears were used at this early date. Le Gall (1984) interprets the dominance of autumn caught chub (Leuciscus cephalus) at Le Gisement de Pont d’Ambon, Dordogne, France, as possible evidence for trap fishing as the chub (Leuciscus cephalus) migrate to deeper water to over-winter. Balme (1983) argues for the existence of a riverine trap fishery and a lacustrine gillnet fishery dating to ca. 25,000 BP from the size distribution of fish remains at four single deposition sites on the Darling River, New South Wales. The use of nets in Upper Palaeolithic Europe has been inferred from engravings of mesh designs, e.g. the hexagonal mesh design on a mammoth tusk from Eliseevichi, Desna Basin, Russia (Figure 2.8). However caution should be taken in attributing these mesh designs to fishing even if they could be
definitely identified as representations of nets; nets are used in terrestrial hunting. The gillnet has a hexagonal mesh — if these designs do in fact represent fishing nets, the depiction of a hexagonal mesh at Eliseevichi goes some way to support Balme’s (1983) findings on the early use of sophisticated nets. This type of inference based on the size selectivity of fish gear is somewhat tenuous; on the basis of behaviour, the fish could have been taken by a number of methods but it is possible (see Chapters 4 & 5) that nets and traps were used long before the Holocene.

2.1.4: Fish Remains from the Upper Palaeolithic

In Western Europe long sequences of cave deposits of the Iberian Peninsula contain faunal assemblages and possible fishing implements that indicate increasing exploitation of both marine and freshwater resources from the Solutrean period ca. 20,000 BP (Straus 1979; Deith & Shackleton 1986; Menéndez de la Hoz et al. 1986; Straus & Clark 1986; González-Morales 1996; Straus 1996b; Pokines & Krupa 1997). Relying only on data from inland sites may be misleading: any apparent increase in marine fishing activities may relate to increasing sea levels bringing sites closer to the coast and therefore making fish processing at such shelters increasingly likely rather than reflecting increased exploitation of aquatic resources. Increasing dependence on freshwater fish is suggestive of intensification. However, differential preservation cannot be excluded as a possible cause of increased recovery of fish remains from the late Pleistocene and Holocene. Among the earliest studies of European prehistoric fishing practices, Sauvage (1875) and Rau (1885) concluded that the scheduled exploitation of anadromous species would have been important in the subsistence practices of Upper Palaeolithic groups, based on faunal remains recovered from cave sites across the Dordogne, France. J G D Clark (1965) echoes this view by attributing the lack of cranial bones of salmon (Salmo spp.) at these sites to the capture of salmon (Salmo spp.) further downstream and transport to the site. In doing so, he implies processing and seasonal scheduling of activities — both phenomena generally ascribed to post-Holocene subsistence activities. A more sophisticated fishery than in previous periods and possible scheduled exploitation of anadromous resources for storage is supported by the growth ring analysis of salmonid (Salmonidae) remains from La Grotte Des Eglises, Ariège River (Le Gall 1984). Of the ca. 50 individual salmonids (Salmonidae) identified at Eglises, most were taken in October to December, coinciding with autumn fish runs. A lack of cranial elements among the salmonid remains in Lower Magdalenian deposits at the site of El Juyo, Santander, has also been suggested as evidence for processing prior to transport to the site by Pokines & Krupa (1997).

Mellars states that although fish remains have been recovered at many of the Late Palaeolithic sites of France and northern Spain, the number of finds indicate that fishing would have been a secondary resource (1985). In support of this view Mellars gives the opinion,

"in the case of adult salmon, the bones are certainly both sufficiently large and robust to ensure recovery with any reasonable degree of care and
diligence during excavation...if chemical and physical conditions...were adequate to allow some fish bones to survive, it is difficult to see why salmon bones should not have survived – in at least certain contexts...the generally sparse occurrence of salmon bones in the caves and rockshelters of southwestern France must be accepted as a genuine feature of the faunal assemblages in these sites” (Mellars1985:281).

As detailed in Chapter 6 there are many reasons for differential preservation on sites. Many of the Upper Palaeolithic sites of south-west Europe were excavated before fine recovery techniques were widely practised and it is very possible that much data concerning the Upper Palaeolithic exploitation of aquatic resources has been irretrievably lost.

Assessing the importance of fish in the Upper Palaeolithic and Late Glacial of the more northern areas of Europe is hampered by the lack of faunal assemblages. Of 100 known Late Glacial sites of Northwest Europe only 12 have produced faunal remains (Eriksen 1996). The accepted view of Ahrensburgians and Hamburgians as specialised reindeer/elk hunters may not be fully representative of Late Glacial subsistence activities. Scales of lemon sole (Microstomus kitt) have been identified in Late Upper Palaeolithic contexts at Creswell Crags, England, pike (Esox lucius) and rudd (Scardinius erythrophthalmus) have been identified at Stellmoor and pike (Esox lucius) at Meiendorf (J G D Clark 1948a, 1965; Johnstone 1980). Sediments recovered from both Stellmoor and Meiendorf, Germany, were not sieved and may have contained additional fish remains.

2.1.5: Fishing Related Artefacts from the Upper Palaeolithic

Although there are finds of boat remains in the Mesolithic, there are no remains of watercraft, associated artefacts or depictions in the palaeoart of preceding periods (Johnstone 1980; Bednarik 1999). Bednarik (1999) proposes that the lack of Pleistocene remains of watercraft is the result of sea level rise. This does not explain the lack of finds in inland waterways. J G D Clark (1948a) attributed the rarity of marine fish at Upper Palaeolithic sites to the lack of watercraft. However, the colonisation of certain islands implies the use of some form of watercraft in the Palaeolithic, such as the Mousterian occupation of Kefallinia, Middle Pleistocene activity on Crete, Sardinia and Cyprus (Vita-Finzi 1973; Bednarik 1999). The colonisation of the Pacific Islands and Australia ca. 60,000–50,000 BP provides clear evidence for the use of watercraft for long-distance travel in open waters. The idea of accidentally being blown off course is not consistent with the scale of the colonisation of the Pacific and Australia at this time. It is possible that watercraft were employed hundreds of thousands of years before this. Modified lithics from Flores Island, (19km from mainland Indonesia) associated with the bones of a Stegodon (that lived ca. 750,000 BP) suggest that H. erectus crossed water, possibly using simple rafts (Verhoeven 1952; Gibbons 1998; Morwood et al. 1998). Palaeomagnetic and fission track dating of the deposits containing the lithics were found provided a date of ca. 800,000 BP. It has been questioned whether the lithics show traces of modification by
hominids, this criticism mainly stems from adherents of the traditional view of the inception of the use of watercraft no earlier than 50,000 BP.

The use of watercraft for fishing in the Upper Palaeolithic is suggested by the finds of offshore fish species: tuna (*Thunnus thynnus*) at Grimaldi, Italy, and in Upper Palaeolithic levels at Franchthi, Greece (Cleyet-Merle & Madelaine 1995, Vigne & Desse-Berset 1995).

Upper Palaeolithic parietal and mobiliary art is also suggestive of pre-Holocene fishing. Pokines & Krupa (1997) have pointed out the association of fish representations in both forms of art at sites located near major rivers. They also note that salmonids are most commonly depicted; other species identified in art works include dab (*Limanda limanda*)/sole (*Solea solea*), pike (*Esox lucius*) and eel (*Anguilla anguilla*). This corresponds to the species recovered and their relative abundance at Upper Palaeolithic sites.

Definite representations of fish in rock art have been found at a number of Upper Palaeolithic sites in Cantabria, e.g. Altexerri, Coimbra, Cueva d’Ekain, Pindal, El Pendo, Micolon and possible depictions at Altamira, El Castille, La Pastega, El Pendo, Las Mouedas, Chusfin, Tito Bustillo, La Paloma, Cueto de la Mina, and La Lluberia I (Pokines & Krupa 1997). Some of these depictions, which are at sites some distance from the sea, clearly portray marine species. Flatfish (Pleuronectidae) are represented on cave walls or bone engravings at the inland sites of Altexerri, La Pileta, Pindal, all Spain, and Mas d’Azil, Ariège, France (Cleyet-Merle & Madelaine 1995). One example of a fish (probably a sole [*Solea solea*]) in mobiliary art comes from Lespugue, Haute-Garonne, France, (Figure 2.9) this is similar to the engraving of a sole (*Solea solea*) at Lespugue (Bahn 1982). A flatfish interpreted as a flounder (*Platichthys flesus*) was engraved at Grotte des Boeufs, Alpes-Maritimes (Feustel 1985).

Depictions of fish occur on a category of artefact known as ‘baton de commandement’, on boar’s tusk, and on fragments of reindeer antler or sea mammal bone from sites across south-west Europe, e.g. Montgaudier, Charentes; Mas d’Azil, Ariège; La Madeleine, Ardèches; Laugerie Basse, Dordogne; all France, and Goyet Cave, Belgium, (Figure 2.10) (Lartet & Christy 1875; Rau 1885; Sollas 1911; Cornwall 1968; Johnstone 1988). The example from La Grotte Cosquer, Marseille, France, has been dated in the range ca. 27,000–19,000 BP. Four salmon (*Salmo spp.*) are represented on an antler fragment from Lorthet Cave, Hautes-Pyrénées, France (Figure 2.10.1). The examples shown in Figure 2.10.2 and Figure 2.10.3 have the form of Cyprinidae (also identified at Laugerie Basse, Dordogne). An example from Laugerie Basse, Dordogne, is thought to represent a Squalidae (Figure 2.10.8). A boar’s tusk from Duruthy Grotto, Landes, France (Figure 2.10.6) depicts a pike (*Esox lucius*). As mentioned above, these are species recovered in the art at these sites. At Niaux Cave, Ariège, France, the outlines of two trout (*Salmo trutta*) traced in sand on the floor are thought to date to the Aurignacian (Figure 2.10.7). Dated to the Proto-Solutrean period is a representation,
engraved on a piece of bone, of a salmonid being taken on a line with a lure (Desse & Desse 1976). The dating and interpretation of the piece is uncertain.

Pálsson (1991) suggests that these representations of fish may have a utilitarian function — as teaching aids, cognitive maps for the navigation of seascapes and folk accounts of fishing. Among many groups, fish serve as a metaphor — for example, in the rock art of Aboriginal Australians the fish is used as a symbol for fertility. Fish were viewed as good for artwork because of their variety in form and colour.

It is clear from the above that the technology required for the range of fishing gear apparent in the Mesolithic record was available from the Middle to Upper Palaeolithic. It is also apparent that at least some of these implement types were being used for the exploitation of aquatic resources from the Middle Stone Age. It seems likely, therefore, that many of the fishing practices of the Mesolithic period had a long history and were well developed by Holocene times. Such finds have led Cleyet-Merle & Madelaine to the conclusion,

"Palaeolithic man's exploitation of the sea coast in France and South-West Europe seems very underestimated. The few inland traces seem to indicate a very active exploitation, which became a real tradition in the Mesolithic period in France. It is of course too early to imagine Palaeolithic subsistence strategies essentially based on sea coast resources. However we are sure that during what was called 'the reindeer age' (implying an exclusive idea) an important part of the diet, as well as of the intellectual and religious cares was based on the sea, a situation that could not be imagined a few years ago" (1995:307).

2.1.6: Stable Isotope Analysis and Diet Determination in Upper Palaeolithic Populations

A further line of evidence for the exploitation of aquatic resources in the Palaeolithic is the stable isotope analysis of carbon and nitrogen. A study of Upper Palaeolithic human remains by Richards et al. (2001) documents an increased dependence of freshwater resources in the mid-Upper Palaeolithic (see Table 2.1 for values). The sample from Dolní Věstonice 35 has produced the clearest evidence for significant dietary intake of freshwater resources comparable to the results obtained for the Mesolithic inhabitants of the Iron Gates region (Richards et al. 2001). Interestingly, it is from this site that the earliest evidence for woven textiles (thereby implying the technological capability for net or trap manufacture) originates. Demographic expansion is proposed as the cause of a general increase in dietary breadth from the mid-Upper Palaeolithic period.

Exploitation of marine resources is suggested by stable isotope analysis of three individuals from Gough’s Cave (Richards et al. 2000). It is argued that the unexpectedly positive values are a consequence of changes in atmospheric δ¹³C values because there is no corresponding change in δ¹⁵N,
expected if there had been a marine component to diet. However, Richards et al. then contradict this with the statement that the $\delta^{15}\text{N}$ values obtained are higher than predicted for a diet consisting primarily of terrestrial herbivores. In fact, both the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values are consistent with a marine component in diet.

The exploitation of fish and the manufacture of specialised fishing gear are apparent in the Upper Palaeolithic in Europe. Stable isotope analyses attest to fish and other aquatic resources comprising a major part of dietary protein, for some individuals at least. These data suggest that certain groups from the Upper Palaeolithic and perhaps, earlier periods, were dependent on the exploitation of aquatic resources from coastal, riverine or lacustrine environments.

2.1.7: Holocene Intensification in Fish Exploitation

It is generally proposed that the change from a predominantly tundra environment to boreal forest at the Pleistocene-Holocene transition resulted in a reduction in primary productivity of terrestrial environments. This combined with rising sea levels and rapid contraction of hunting grounds and changes to the faunal inhabitants of regions may explain the increased focus on aquatic resources in certain regions of Europe. Coastal and estuarine areas have the highest biomass and generally a more uniform annual climate than interior zones (Bailey & Parkington 1988; Andersen 1995). The rapidly emerging dense forest would have concentrated mammals along the edges of rivers, lakes and bogs, further encouraging occupation of large waterways and coasts (Newell 1973; C Smith 1992). In certain areas this reduction of the terrestrial biomass would have been exacerbated by the decline in terrestrial species, possibly through over exploitation by human groups as suggested for Zealand in the Later Mesolithic (Aaris-Şørensen 1980b). It should be noted, however, that Newell (1990) argues that there is no evidence for this impoverishment of terrestrial game on Zealand. However, there is no definitive proof for intensified exploitation of aquatic resources at the Pleistocene-Holocene transition. The rise in sea level has destroyed any coastal sites pre-dating the Holocene that could provide irrefutable evidence of any intensification. The effects of deglaciation would certainly have resulted in instability in the hydrological conditions of the seas and inland waters of Europe and would have affected the exploitation of aquatic resources. It has been suggested that it is the stabilisation of hydrological conditions on the North Pacific coast in the early-mid Holocene, and the predictability of resource availability that resulted from this, that permitted dependence on anadromous resources (Fladmark 1975; Cannon 1996). However, maritime adaptations and the significant exploitation of anadromous species are evident for some time prior to this: ca. 8000 BP (6950 cal BC) on the North West Pacific coast and ca. 9500 BP (8900 cal BC) on the East Pacific coast (Lazenby & MacCormack 1985; Matsui 1995, 1996).
Cannon (1996) proposes that, 

"a global shift in fishing strategies and settlement patterns, if present, may be due to independent cultural factors coincident with, but unrelated to, environmental change" (1996:32).

Cannon does not state which independent cultural factors could explain this intensification. If there were intensification, it is most easily explicable in environmental terms. However, the resources exploited and the range of technology available to the Upper Palaeolithic groups indicate that in areas where fish was not already a staple, the shift to aquatic adaptations would have been a gradual process.

The changing salinity of the Baltic zone climaxed in the high biomass of the Littorina Sea in the Late Mesolithic that would have led to the availability of a greater range and abundance of aquatic resources. At this time, the observed intensification and technological innovation may have been permitted by environmental change rather than stimulated by the increasing needs of Mesolithic groups. The development of the Baltic affected the species available to groups and may in part explain the apparent increasing dependence on aquatic resources through time. Löugas (1996) argues that there was a shift from inland to coastal fishing activities in Estonia with the transgression of the Ancylus Lake that increased the biomass of the Baltic and permitted cod (Gadus morhua), herring (Clupea harengus), trout (Salmo trutta), flounder (Platichthys flesus), sturgeon (Acipenser sturio), sprat (Sprattus sprattus) and eel (Anguilla anguilla) to colonise the Baltic Sea. The highly sophisticated fishing gear, which has been recovered from the earliest Mesolithic contexts, is suggestive of a long developmental history extending back before the Holocene. Such investment, both in terms of time and raw materials, would be unlikely in communities exploiting fish on an expedient basis.

2.1.8: Intensification in Fish Exploitation: common archaeological misconceptions

The absence of a recoverable coastal aspect to any pre-Holocene cultures and recent historical attitudes to fish has led to misconceptions concerning the status of aquatic resources in human subsistence: e.g.

"marine resources generally and molluscs in particular are low in the scale of preferred foods, because of high risks or costs of exploitation, and would have been avoided until more attractive resource options had been fully taken up or exhausted" (Bailey & Parkington 1988:6).

Fishing has been viewed by many as a "poor man's" subsistence strategy due to the recent use of aquatic resources as starvation foods and ethnographic observations drawn from groups inhabiting marginal areas: e.g.
“a little tribe [Elmomo] fast becoming extinct, who have a few poor villages on the south-east shore of that lake. These people spend most of their time in the water in pursuit of fish which form their only food. As a result probably of this insufficient diet their physique is very poor; they have stunted bodies with markedly bowed legs and suffer terribly from sores” (Worthington & Worthington 1933:141).

This is clearly not the case for many groups, both prehistoric and present day, subsisting on aquatic resources: a prime example being the Native American groups of the Northwest Coast. Aquatic resources can be abundant and nutritious and have provided the dietary staple of many ethnographically recorded groups (Geiger & Borgstrom 1962:30).

Aquatic resources would have provided a suitable alternative to terrestrial resources. To ignore the seas, rivers and lakes would be to ignore one of the largest and richest environments on earth. Oceans and seas cover 71% of the earth’s surface and approximately half the land surface is covered by inland water bodies (Nikolsky 1963). Fish inhabit all these waters except for the very saline regions of the Red Sea (Pinkas 1969). There are over 20,000 species of fish, 8,000 of which inhabit freshwater. This constitutes 60% of all vertebrates (Bone & Marshall 1982).

A further criticism levelled against the exploitation of fish in preference to terrestrial resources is the accusation that fishing with ‘primitive’ technologies would be labour intensive and limited to small bodies of water (Limp & Reidhead 1979; Bailey & Parkington 1988):

“many species of fish and sea mammals...require a degree of technological ingenuity and social organisation which could well have been beyond the intellectual capacity of earlier human populations; or else demand a cost in terms of physical danger or investment in skills which might have been a chronic disincentive until a very late period in prehistory” (Bailey & Parkington 1988:6).

This criticism is simply not valid in any discussion of Mesolithic fishing practices. It is clear from the preserved artefacts that Mesolithic fishermen were using sophisticated technology analogous to that employed in traditional fisheries across Europe until the early-mid 20th century. It may be that fisheries of preceding periods were more limited by technological inadequacies but it is simply not possible, in the absence of evidence, to conclude that relatively advanced fisheries could not have existed.

2.2: Nutritional Value of Fish

Yesner compared the calorific yield of terrestrial mammals, marine mammals, fish and shellfish to the energy expended in procurement of the specified resource and concluded from this study that,
"marine foods do offer some distinct nutritional advantages in comparison with other subsistence regimes" (1980:733).

However, such yield-to-expenditure models are based on too many assumptions to provide meaningful results. Moreover, this model failed to account for the other nutritional requirements of humans. It is considered more relevant here to assess the possible benefits and deficiencies of diets consisting predominantly of aquatic resources in comparison to diets composed of terrestrial resources. The energy value of commercially exploited fish species are given in Table 2.2 and their vitamin and mineral constituents in Table 2.3. It should be noted that studies of the nutritive value of foodstuffs give the value of fish flesh only. Sikorski et al. (1990) point out that the skin, eyes, liver, milt, roe, fins and the intestines may also be consumed. Ethnographic observations suggest that all parts of the fish would be used. An additional problem for this study is the restriction of food composition analyses to species that are of commercial importance today. Data of the nutritive value of several of the species recovered at Mesolithic sites are not available. Generally, however, these species were of minor importance to Mesolithic economies. Comparative values for the main terrestrial resources available to Mesolithic groups are given in Tables 2.4 and 2.5. The data indicate that aquatic resources can provide diets, equivalent and in certain cases, superior to diets derived entirely from terrestrial resources.

2.2.1: Variation in Nutritive Value of Fish

Fish and sea mammals are high in protein, vitamins and minerals (Rostlund 1952; Jaquot 1961; Geiger & Borgstrom 1962; Higashi 1961; Nikolsky 1963; Stansby 1969; M H Thomson 1969; Wilkinson 1981; Sikorski et al. 1990; Scherz & Senser 1994). However, fish cannot be considered as a single resource in nutritive terms. The nutritive value of fish varies among and within species and on a geographic and temporal scale. Fat content is most variable, ranging from a minimum of 0.2% in haddock (*Melanogrammus aeglefinus*) and a maximum of 23% in anchovies (*Engraulidae*). In general, primary freshwater species have a lower fat content than marine species. Intra-species variation is dependent on quality of food and stage in the breeding cycle; both vary seasonally. For example, the fat content of salmon (*Oncorhynchus* spp.) varies from 0.35–14.00% depending on season of capture — the maximum content attained immediately prior to spawning migrations and the minimum immediately after spawning. In species that do not undertake such large-scale migrations, fat content generally varies with seasonal availability of food. The nutritive value of fish also varies with body part consumed. The largest fat content of Chinook salmon (*Oncorhynchus tshawytscha*) is to be found in the head. In lean species (those with fat content not exceeding 5% by weight at any point in the annual cycle), fats are concentrated in the liver (up to 80% by weight) and a subcutaneous fatty deposit. In fatty species, fats are deposited throughout the body, including the flesh. The types of fats (and therefore their nutritive value) varies amongst species according to genetic differences, diet, temperature (species occupying waters with low temperatures, including species of temperate waters,
generally have higher percentages of non-saturated fatty acids), distribution of fats around the body and salinity of water inhabited. Saturated fatty acids are found in large quantities in the livers of elasmobranchs. The health benefits of fish oils are now widely recognised: fish rich diets are known to protect against ischaemic heart diseases, thromboses and cancer. The unsaturated fats that make fish flesh and oils healthy also make fish highly susceptible to oxidation and therefore more likely to decay prior to disposal and during deposition.

The variation in fat content is responsible for the significant variations in calorie and fat-soluble vitamins by weight of different species. Water content and therefore water soluble vitamin content is less variable between species. In the leanest species, such as flounder, the average calorific value per pound cited in archaeological/ethnographic studies of edible weight is 250 kcal up to 1000 kcal in very fatty species such as salmon (Salmo spp./Oncorhynchus spp.), eel (Anguillidae) and catfish (Siluridae) (cf. Rostlund 1952; Olsen & Hubbard 1984). The quoted calorie content per pound for beef is 300 kcal per pound. Clearly, if these data are accepted, fish (even lean species) provide a suitable alternative to terrestrial resources. However, food composition and nutrition tables (Scherz & Senser 1994) record significantly different values for the calorie, vitamin and mineral content of these species (Table 2.2 and 2.3). The oils of fish and sea mammals are detailed as having the highest calorie content of foodstuffs ranging from ca. 895–900 kcal per 100g edible weight. Various cuts of beef are recorded to have energy values in the range ca. 107-852 kcal/100g. Fish rank well below this with fatty species in the range ca. 182–280 kcal/100g and lean fish significantly below this at ca. 72–100 kcal/100g. It is possible that fish exploited by ethnographically observed groups (and perhaps prehistoric fishermen) were taken at different points in the seasonal cycle from modern commercial fisheries. As such, the calorific values recorded for commercially captured fish may be somewhat reduced compared to fish taken in traditional fisheries. It is clear, however, that fish cannot be considered a ‘superior’ resource in terms of energy content to terrestrial game. On the whole, fish do contain at least equivalent and in many cases significantly higher quantities of vitamins and minerals than terrestrial resources. The exceptions to this generalisation are iron, copper and zinc, which are present in greater amounts in beef. Significantly, in terms of its ubiquity across European Mesolithic sites, the hazelnut provides ca. 644 kcal/100g and contains much larger amounts of vitamins and minerals than the other aquatic and terrestrial resources listed.

Fish are good sources of vitamins A, B, D, E and K (Borgstrom 1962; Geiger & Borgstrom 1962; Sikorski 1990; Sikorski et al. 1989). Fatty species generally have higher quantities of vitamins, due to the concentration of vitamins in fats. Fat-soluble vitamin A is concentrated in liver oils and in the flesh of older, spawning females. It is present in very high quantities in conger eel (Conger conger) and spurdog (Squalus acanthias). It occurs in only small quantities in lean species. Vitamin D is also concentrated in fatty fish, especially freshwater species, but is entirely absent in cartilaginous species. Liver, skin, eyes, milt and roe are good sources of vitamins B2 and K; this varies considerably between species. The B2 content of Atlantic cod (Gadus morhua), haddock (Melanogrammus
The protein content of certain species of fish and shellfish is equivalent to that of terrestrial mammals, containing the same quantity of essential amino acids by weight. Fish proteins may be of better nutritional value to humans because they are more easily digested. Fish and shellfish also contain the essential amino acids, lysine, methionine and tryptophan, that are not available in plant proteins. Crude protein content is less variable than fat or vitamin content, ranging from 11–24% depending on species, maturity and season. Although crude protein content can decrease by up to 10% during migration or periods of poor feeding, amino acid content (6–8% by weight) does not vary either among or within species and individuals (Rostlund 1952; Jaquot 1961; Geiger & Borgstrom 1962; Higashi 1961; Nikolsky 1963; Stansby 1969; M H Thomson 1969; Wilkinson 1981; Sikorski et al. 1990).

The mineral content of fish is constant (0.6–1.5% by weight). Marine resources are good sources of iodine: it is particularly concentrated in anadromous species and fish roe (Sikorski et al. 1990).

2.3: Nutritional Limitations to Dependence on Fish in Human Diet

There are several nutritional limits to the contribution of fish in human diet, comprising dietary deficiencies, hypervitaminosis, protein poisoning and the toxic effects of high concentrations of certain minerals. Biotoxins, allergies and parasites also pose a threat to humans subsisting largely on aquatic resources.

Human dietary requirements of vitamins and minerals essential to health are detailed in Table 2.6. Many of these vitamins are available in recommended daily amounts from the consumption of fish. However, several are more readily obtained from other aquatic or terrestrial resources. Amongst these are chromium, magnesium and vitamins E and K. (The effects of long-term dietary deficiencies of these vitamins and minerals are detailed in Table 2.6.) However, the main deficiency in diets heavily reliant on aquatic resources is a lack of vitamin C (Jaquot 1961; Huelsbeck 1988). Only trace amounts of vitamin C are found in fish flesh but larger quantities may be present in fish roe (Olsen & Hubbard 1984; Rostlund 1952). Vitamin F, an essential fatty acid, is not found in many species of fish (Higashi 1961). Essential fatty acids can be stored within the body and as a result deficiencies are rare in adults, but can prove lethal to infants subsisting on low fat diets (Noli & Avery 1988).
Excess consumption of certain vitamins and minerals present in fish may also have deleterious effects on human health. Hypervitaminosis D is a potential consequence of high dietary intake of fatty species (Lazenby & MacCormack 1985). Chisholm et al. (1983) propose that the native groups would have been aware of the potential dangers of hypervitaminosis D. Symptoms readily dissipate with change of diet: cause and effect could be easily established. This is supported by the stable isotope studies of Lazenby & MacCormack (1985) which indicate that children, who are more susceptible to the effects of hypervitaminosis, were less dependent on fish than adults. Shark (Elasmobranchii) livers generally contain high concentrations of vitamin D, consumption of shark liver can prove fatal to humans (Jaquot 1961; Higashi 1961). Salmon (Oncorhynchus spp.) contains such large quantities of vitamin A that Isaac (1988) recommends limited intake in children. Though hypervitaminosis A may be a problem in infants, it is of more danger to an unborn foetus. Several naturally occurring minerals found in certain fish species may be toxic if consumed in large quantities, e.g. mercury, cadmium, arsenic and fluorine (Higashi 1961; Jaquot 1961; Nakamura 1985; Sikorski et al. 1990).

Fish provide little or no carbohydrate, which must obtained from other components of diet (Speth & Spielmann 1983; Noli & Avery 1988). Up to 50% of required glycogen can be derived from dietary protein. However, there are no known human diets where greater than 30% of energy requirements are met by dietary protein. Additional requirements must be met by carbohydrate or fat intake. Protein poisoning is a problem only for fishing groups subsisting heavily on non-fatty species. Many marine resources, particularly sea mammals, have high fat content that can compensate for reduced carbohydrate intake (Noli & Avery 1988). High protein diets also inhibit the uptake of calcium.

Biotoxins affect the exploitation of certain species, predominantly marine species, and may reduce the availability of resources in specific seasons. Most biotoxins are water-soluble and are not destroyed in cooking processes. Fish roe may be poisonous (Halstead 1962). Raw eel (Anguillidae) blood can produce severe inflammation on contact with skin and tongue; cooking or digestive acids destroy this toxin. In rare cases the consumption of raw eel blood may cause death. The tail spines of spurdog (Squalus acanthias) and stingray (Dasyatis spp.) do not cause severe wounds but the venom released causes swelling, pains, discolouration, necrosis of tissue and may affect the cardiovascular system occasionally resulting in human death (Endean 1969).

Certain freshwater species act as hosts for helminths (Halstead 1962). Infections result from consumption of improperly cooked, raw, and dried fish.

Allergic reactions to a phylogenetic group of fish or shellfish is relatively common (Halstead 1962). Salmon (Salmonidae) and sardine (Sardina spp.) are frequent triggers. A number of species (see Table 5.4) can be responsible for ciguatera — bacteria produce a histamine like substance in the muscle of the fish when kept at room temperature. Symptoms are like extreme allergic reaction. Death due to suffocation and shock has been reported. Fish oils are a common cause of skin irritations.
2.4: The Exploitation of Aquatic Resources by Mesolithic Groups

It is clear from the above discussion that, taking only dietary factors into account, Mesolithic groups are not likely to have subsisted solely on fish. A number of essential vitamins are more readily obtained from terrestrial animal sources or plants (see Table 2.6). However, it is possible to maintain a healthy diet based entirely on the exploitation of a full range of aquatic resources (fish, waterfowl, invertebrates, mammals and plants). This raises the question, to what extent was Mesolithic diet derived from aquatic resources?

2.4.1: Site Location as an Indicator of Subsistence

Many of the sites that have faunal and/or artefactual remains indicating a dependence on aquatic resources are ideally located for this adaptation; on coasts, islands, rivers and lakeshores: specifically in areas where natural features would have concentrated fish (Forsten & Blomqvist 1974; Broadbent 1978; Andersen 1981, 1995; Fischer & Aaris-Sørensen 1983; Larssen 1983b; Forsberg 1984; Trolle-Lassen 1984; Enghoff 1991, 1994a, b; Boaz 1994; Skaarup 1995a). On the basis of this distribution, dependence on aquatic resources has been inferred for Mesolithic populations in the absence of other sources of data (e.g. Sulimirski 1970; Rozoy 1973; J G D Clark 1975; Sakellaridis 1979; Price & Brown 1985; Price 1987; Zagorska & Larsson 1994; Bjerck 1995). However, there are many possible explanations for the concentration of Mesolithic settlements at coastal and inland bodies of water, other than dependence on aquatic resources. The simplest explanation is the need for supplies of freshwater: other possible explanations include defence, more equable climate, communication, transport and concentration of mammals. A more reliable method of determining dependence on aquatic resources is through dietary reconstruction.

2.4.2: Reconstruction of Diet

"Past human subsistence is one of the most important aspects of archaeological research. The quest for food directs and conditions many aspects of prehistoric human society, including group size and social organisation, residence patterns and settlement location, tool manufacture and technology, and transportation. Information on past diet is essential to characterise the trophic position of prehistoric populations, the utilization of the environment, the determinants of site placement, the nature of subsistence activities, status differentiation, and the like." (Price 1989b:49).

Subsistence studies are of paramount importance to archaeological explanation because they impact on every other aspect of hunter-gatherer lifestyle. All other activities are secondary and relate directly or indirectly to subsistence activities. This does not advocate the 1970s and 1980s views of ecological
determinism to the exclusion of all social and cultural factors influencing behaviour. However, inattention to subsistence activities would cause group failure. Subsistence must be viewed as a primary motivator.

Meta-analysis of the fish remains and fishing associated artefacts at a site does not in itself provide evidence for the importance of fish in Mesolithic economies. The range of gear found at sites across Europe would suggest the importance of aquatic resources to many Mesolithic groups. However, the discussion given in Chapter 6 indicates that the actual number of gear finds that can definitely be attributed to use in fishing is relatively small.

Traditional dietary reconstruction based on species representation in hand-collected faunal assemblages suggested that though aquatic resources were exploited by Mesolithic groups these were of secondary importance to terrestrial resources (e.g. J G D Clark 1975). Dietary reconstruction, until recently, was based on inference from the faunal, floral and artefactual remains from archaeological contexts. This had the effect of producing a one-dimensional view of diet and economy, often reflecting short-term dietary intake or subsistence activities. Faunal remains, and in particular fish remains are subject to differential taphonomy, preservation, recovery and identification.

"The highly visible remains of certain foods - particularly animal bones, mollusc shells, and nut shells - bias archaeological interpretations in favour of these more durable categories" (Price 1989b:49).

Faunal assemblages indicate potential contributors to diet and economy,

"In the best circumstances, these remnants are a small and disproportionate reflection of prehistoric subsistence" (Wing & Brown 1979:5).

The use of animals for raw materials, food-storage, waste and trade distort site subsistence remains and subsequent dietary reconstruction.

"Although data on the range of potential resources available to a prehistoric community have improved considerably as a result of new sieving and flotation devices, it is doubtful whether we have improved our ability to identify the actual range of resources eaten by a group" (Dennell 1979:128).

Palaeopathology has two main uses in the reconstruction of diet. Skeletal development can be used to identify dietary deficiencies. This informs on dietary lack rather than dietary contributors and can be very difficult to separate from the effects of disease or the large nutrient requirements of certain individuals (Dennell 1979). Inferences based on palaeopathology can often seem very tenuous. For example, L Jonsson (1988) interprets observed thickening of the skull vault in human skeletons from the Skateholm (Sweden) sites, as the result of chronic anaemia resulting from the consumption of fish
infected with tapeworm. Though it is not doubted that fish contain parasites, there are many other causes of chronic anaemia and of cranial vault thickening that should be considered.

Another important line of palaeopathological evidence is dentition. The occurrence of dental caries and calculus has been used to infer the proportion of protein and carbohydrate consumed. This is based on the knowledge that the bacterial metabolism of proteins produces alkali waste products and that of carbohydrates produces acidic waste products (Hillson 1979).

“Dental caries and dental calculus tend to be mutually exclusive because of this relationship with plaque pH. For this reason, when their frequency is recorded in ancient teeth, they should make particularly good indicators of the protein versus carbohydrate content of diet... periodontal disease requires thick plaque deposits and is independent of pH, however when accompanied by dental calculus indicates high protein diet” (Hillson 1979:150).

The high incidence of dental calculus and periodontal disease combined with no caries observed in individuals from the site of Vlasac (Serbia), Schela Cladovei (Romania) and Padina (Serbia), all in the Iron Gates region, was used to support hypotheses of diets high in protein (y’Edynak 1978; y’Edynak & Fleisch 1983, Bonsall et al. 1997). This, combined with the fauna recovered from the site, suggested a diet comprised predominantly of fish. The low incidence of caries among the Skateholm populations may have a similar interpretation of high protein intake (Alexandersen 1988). The heavy dental attrition and chipping observed among the Henriksholm-Bøgebakken (Denmark) population has been linked to the consumption of fish and fish bones (Albrethsen & Brinch Petersen 1976). This is a feature of the dentition of ethnographic groups subsisting heavily on aquatic resources such as the Eskimo.

Although dental attrition and the occurrence of caries may indicate the proportion of protein consumed relative to carbohydrate intake and suggest the role of plants in diet, the use of circumstantial evidence (from faunal assemblages) to imply the primary role of fish in diet is tenuous to say the least. Dental attrition, for example, is common among groups using teeth as a tool, such as the Eskimo groups, as well as in those with high consumption of fish. The dental wear evident in the Grotta dell’Uzzo (Italy) population implies use in power grasping and the pulling of fibres. This has been tentatively explained as grasping fishing lines, cordage or vegetable fibres for basketry (Tarli 1989). It is important to note also that heavy dental attrition, which is recorded at Vlasac, Schela Cladovei, Henriksholm-Bøgebakken and Skateholm, may reduce the identification of caries in individuals with relatively carbohydrate rich diets.

Human populations at the Muge sites in Portugal display high incidences of dental caries. Lubell et al. (1994) proposed that this was the result of the consumption of large quantities of sticky dried fruits. Tarli & Repetto (1985) give a similar explanation for the high incidence of caries in populations from Uzzo Cave and Molara Cave, both on Sicily. However, a recent study casts doubt on these
interpretations by showing that in addition to diet, mortality rates, excavation, recording techniques and curation methods influence the observed occurrence of dental caries in a complex and (as yet) unpredictable manner (Jackes & Lubell 1995). This study indicated that the caries observed in the Muge populations was not consistent with fruit consumption.

It is only with the analysis of the stable isotope component of bone that sources of dietary protein can be reliably distinguished. In the reconstruction of subsistence in the Iron Gates Mesolithic by Radovanović & Voytek (1997) through the more traditional methods of artefact and faunal remain analysis. Radovanović & Voytek concluded that, “fish were not a vital resource in the diet” (1997: 29).

However, stable isotope analysis of these populations indicates that fish, in fact, constituted a dietary staple at the Iron Gates sites of Lepenski Vir (Serbia), Vlasac and Schela Cladovei (see Section 2.5.1 below). The Iron Gates project presents a case study where stable isotope analysis settled the debate on dietary constituents.

2.5: Stable Isotope Analysis

The analysis of stable isotopes for prehistoric dietary reconstruction has been conducted since 1977 (Vogel & van der Merwe 1977). This technique gives direct evidence of human dietary intake of protein and, in many instances, the relative proportions of specific categories of food that contribute to diet (by linear isotope modelling [Schwarcz 1991]). The 10 to 30 year turnover rate for bone collagen allows a long-term picture of diet to be obtained (Chisholm et al. 1982; Tieszen et al. 1983; Lovell et al. 1986; Sealy et al. 1995; Robins & New 1997). Moreover, it indicates diet at the level of the individual (a rare concept in archaeology), and therefore can provide information on differential availability of specific resources within groups and suggest individual dietary preferences.

There have been three main applications of this technique: determining the spread of maize agriculture through the Americas (e.g. Bender et al. 1981; van der Merwe et al. 1981; Farnsworth et al. 1985; Schwarcz et al. 1985; Sealy et al. 1986; Ericson et al. 1989); distinguishing aquatic from terrestrial diets (e.g. Schoeninger & Peebles 1981; Tauber 1981; Chisholm et al. 1982, Chisholm et al. 1983, Schoeninger et al. 1983, Hobson & Collier 1984; Chisholm 1989; Bonsall et al. 1997, 2000); and the analysis of dietary change at the Mesolithic-Neolithic boundary in Europe (e.g. Lubell et al. 1994; Bonsall et al. 1997, 2000). More recent applications include attempts to establish population migration (Dupras & Schwarcz 2001). Of relevance here is the ability of stable isotope analysis to discern the proportion of marine, freshwater and terrestrial protein in human diet.

The dietary intake of terrestrial and marine foodstuffs can be distinguished through the 7‰ enrichment of the 813C:12C ratio in sea water in comparison to atmospheric CO2 (the result of oceanic absorption of atmospheric CO2 and subsequent fractionation in evaporation events). This is reflected
in the δ¹³C:¹²C ratios of marine and terrestrial organism protein and human consumers of these resources. It increases (up to 1% at each level) at each trophic level (Tauber 1981; Schoeninger 1989; Bonsall et al. 2000). Analyses of δ¹⁵N:¹⁴N ratios provide further resolution to dietary reconstruction, indicating the trophic level of the consumed foodstuff. The δ¹⁵N:¹⁴N ratio increases by ca. 2-4% at each trophic level, higher organisms at the top of the food web can thus be distinguished from lower organisms in human diet (Bonsall et al. 2000, Richards et al. 2001). As the food-chains of aquatic environments are considerably longer than those of the terrestrial environment, the δ¹⁵N:¹⁴N ratios of higher organisms from aquatic environments are heavier than those of terrestrial resources, thereby permitting diets comprising freshwater fish to be distinguished from those comprising terrestrial plants and animals — illustrated in Figure 2.11 (Schoeninger 1989; Schoeller 1999). The proportion of marine, terrestrial and freshwater resources in diet is determined from the expected signals of individuals subsisting entirely on one of these three categories (a technique known as Linear Isotope Modelling [Schwarcz 1991]).

Human bone collagen is synthesised using essential amino acids derived from dietary protein, but may derive from carbohydrate sources if there is a protein deficiency. In a low protein diet only essential amino acids are derived from dietary protein — 1/5 of amino acids in bone collagen (Sealy 1986). It is assumed that most of the groups in this study would have obtained sufficient protein in the diet for the amino acids to be mainly protein derived (Table 2.7).

As stable isotope analyses only reflect intake of dietary protein, diets should not be inferred in isolation from other forms of evidence.

“For maximum effectiveness, any isotopic palaeodiet study should be preceded by an archaeological, archaeo-botanical and archaeozoological study to define lists of foods that were actually consumed” (Schwarcz 1991:273).

As mentioned above (Section 2.2), even where stable isotope analyses indicate significant intake of fish proteins, Mesolithic diets must have consisted of a number of other resources to maintain health.

2.5.1: Stable Isotope Studies Applied to the Mesolithic

In the context of Mesolithic studies, the results of stable isotope analyses have been used to determine the importance of aquatic resources in diet and the movement of groups or individuals (Noe-Nyggaard 1983; Meiklejohn 1986b; Andersen 1987a; Fischer 1987; Brinch Petersen 1988; Price 1989b; Lubell et al. 1994; Zagorska & Larsson 1994; Nordqvist 1995; Rowley-Conwy 1995; Skarrup 1995b; Wigforss 1995; Day 1996; Løugas 1996; Bonsall et al. 1997, 2000; Richards & Mellars 1998; Lynch et al. 2000; Schulting & Richards 2001). The results obtained from Mesolithic populations across
Europe indicate a wide range of diets and therefore a wide range of subsistence activities (Table 2.8 and Figure 2.12 and 2.13). On a regional scale there is more evidence for homogeneity in diet along the Atlantic seaboard of Europe and in the Iron Gates region. Greater variability in diet is evident from analyses of Scandinavian populations.

2.5.2: Fish as a Dietary Staple

One of the most comprehensive studies undertaken analysed the carbon and nitrogen isotope values from both Mesolithic and Neolithic individuals from the sites of Lepenski Vir, Schela Cladovei and Vlasac on the River Danube (Bonsall et al. 1997, 2000). The homogeneity of the results, both carbon and nitrogen isotopes, from Mesolithic populations at the Iron Gates sites implies a uniform diet consistent with protein obtained predominantly (>67%) from freshwater fish. The heavy nitrogen ratio values observed in the Iron Gates populations are consistent with the consumption of fish species at the top end of the food web. The stable isotope results are in agreement with the locations of the sites and the faunal and artefactual remains recovered.

Stable isotope analyses of Danish skeletal remains led Enghoff to state that,

"one may safely conclude that the Mesolithic was really a golden age for fishing in Denmark." (Enghoff 1995).

Though, to some extent, isotope results combined with the faunal and artefactual record imply that fishing was of extreme importance to the economies of certain groups, it is clear from the isotope results that a varied range of resources were exploited by Danish Mesolithic groups. This reflects the local availability of resources or lifestyle choices.

At the Danish sites of Holmegaard, Argus, Småland Bight, Norsminde, Vænge Sø, and Møllegabet II, which span the period from Late Maglemose to the Late Ertebølle³, heavy human carbon isotope ratios indicate a significant intake of marine resources (Meiklejohn 1986b; Fischer 1987; Skaarup 1995b). The signals at Møllegabet II are as heavy and those from Holmegaard and Vænge Sø are in fact heavier still than the Greenland Eskimo who have a 75% marine input and Alaskan Eskimos who obtain up to 85% of whole diet from marine resources (Chisholm et al. 1982; Schoeninger et al. 1983; Brinch Petersen 1987). The marine signals obtained from Danish human remains suggest the sedentism, or at least semi-sedentism, of coastal Mesolithic groups in this region. For example, Andersen states of the Tybrind Vig (Zealand) analysis,

"That the girl's food was mainly of marine origin indicates that she belonged to a group of Ertebølle people which either lived permanently at the coast or at least stayed there sufficiently long for the marine component of the food to make a change in the chemical composition of her bones" (1987a:265).
Supporting evidence for this marine emphasis in the Danish Mesolithic comes from the stable isotope analysis of dog bone collagen from coastal sites (see Table 2.9 and Figure 2.14). It is assumed that the dogs obtained food from the site's inhabitants or scavenged from the refuse on the site and thus would reflect human diet (Noe-Nygaard 1983). This is certainly the case amongst Native Americans groups, subsisting primarily on fished resources, where it is common practice to feed dogs on otherwise useless fish bones/remains (La Gorce 1924). This ethnographic observation is upheld by analyses conducted on prehistoric dog and human remains excavated at Namu, British Columbia (Cannon 1999). Human and dog populations dated to be contemporaneous at this site produced almost identical stable isotope signals and, by inference, it can be concluded that dogs and humans at this site had a similar dietary intake. Dog bones from Vedbæk, Denmark, have produced marine signals similar to human inhabitants. Clearly Enghoff's (1995) statement holds true for some sites at least.

The isotope signals of human and dog bones from inland sites gives a more complex picture of subsistence and settlement in Mesolithic Denmark. There is, as mentioned above, the marine signal obtained for two individuals from the inland site of Holmegaard. Of four dog bones examined from Ringkloster, Denmark, three gave terrestrial signals. A single isotope result from dog bone from Praestelyngen, Denmark, gives a terrestrial or freshwater signal (Noe-Nygaard 1983). If these results do, in fact, represent a terrestrial signal then the economic emphasis on fishing observed by Enghoff (1995) is confined to coastal regions. However, it may be that the signals result from a diet based on freshwater resources, particularly in light of the artefactual and faunal inventories at Åmosen. It would be interesting, therefore, to determine the nitrogen isotope signals of the dog remains from the inland sites in Denmark to assess freshwater resource intake. The fourth dog bone analysed at Ringkloster gave a very heavy carbon isotope signal implying a dominance of marine resources in diet. The two dogs analysed from Kongemose both had a significant marine intake. This implies some form of contact or movement between inland and coastal regions. Other indicators of this include the finds of a bottle-nosed dolphin (Tursiops truncata) rib, Gadidae and flatfish (Pleuronectidae) at Ringkloster and worked spurdog (Squalus acanthias) spines at Åmosen (see Tables 2.12 and 6.2) (Enghoff 1994a, b, 1995).

It should be noted here that Noe-Nygaard states,

"only one Maglemose human skeleton from the Holmegaard bog, Sjælland, has been analysed, it shows a clear terrestrial $^{13}$C content"

and concludes that,

"though few in number, these data suggest that the coastal Mesolithic people were highly dependent on marine food, whilst the inland Mesolithic people appear to have exploited terrestrial resources" (1983:139).
This is clearly contradictory to the finding of Meiklejohn et al. (1986). If the contemporaneity of the human remains from Holmegaard could be established, direct contact between coastal and interior groups would be implied. Movement of, and contact between, coastal and interior groups may result from trade, exogamy or the agreed exploitation of resources in neighbouring areas.

The stable isotope results obtained for Portuguese sites have varying interpretations, all of which indicate the importance of aquatic resources in diet. Results from Moita do Sebastião have been interpreted by Meiklejohn et al. (1986) as a combination of terrestrial and marine resources. Lubell et al. (1994) states that there was a predominantly marine diet evident from analyses of the human remains at this site. In addition, Meiklejohn et al. (1986) propose a greater marine intake at Samouquiera (based on one result) than at Moita do Sebastião despite the overlap of isotope values. This illustrates the need for some form of standardisation in the interpretation of the stable isotope results. In fact, the results from Moita do Sebastião, Cabeço da Arruda and Samouquiera are relatively light in comparison to such groups as the Greenland or Alaskan Eskimo with very high marine intake (Table 2.10). This may reflect a mixed diet of marine and terrestrial resources but an explanation more consistent with the faunal remains from the midden sites is the significant consumption of a number of euryhaline species and secondary freshwater species taken from the estuarine waters in the immediate locality of the sites (Table 6.2). The large intra-site variation in isotope values, which is not related to age or sex, is attributed by Lubell et al. (1992) to a varied marine diet or differing terrestrial plant intakes combined with one or more marine foods. Temporal variations in resource availability or hydrological conditions were not considered as possible explanations.

Isotope studies of remains from Scottish sites again suggest a significant marine intake. Six human bones from the ‘Obanian’ midden sites of Cnoc Coig and Casteal nan Gillean II (CNG II) on Oronsay have been subject to analysis — see table across (Richards & Mellars 1998). The five human bones from Cnoc Coig give marine carbon signals similar to those obtained for the Scandinavian coastal sites implying a dominance of marine resources in protein intake. Richards & Mellars (1998) propose a mixed diet of shellfish, fish and sea mammals to account for the relatively heavy nitrogen isotope signals. Caution should be taken in the interpretation of the results from this site as the bones could have originated from as few as two individuals. The Casteal nan Gillean II result has a somewhat lighter carbon isotope content but again a heavy nitrogen content. This has been explained in terms of a protein intake derived from terrestrial herbivores and marine mammals (Richards & Mellars 1998). Richards & Mellars (1998) used the results (with the proviso that the Casteal nan Gillean II sample may not be representative of the whole population) to argue for at least two different groups with

<table>
<thead>
<tr>
<th>Site</th>
<th>δ¹³C</th>
<th>δ¹⁵N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cnoc Coig</td>
<td>-13.6</td>
<td>+15.2</td>
</tr>
<tr>
<td>Cnoc Coig</td>
<td>-13.2</td>
<td>+14.5</td>
</tr>
<tr>
<td>Cnoc Coig</td>
<td>-12.3</td>
<td>+16.0</td>
</tr>
<tr>
<td>Cnoc Coig</td>
<td>-12.0</td>
<td>+14.7</td>
</tr>
<tr>
<td>Cnoc Coig</td>
<td>-12.0</td>
<td>+17.0</td>
</tr>
<tr>
<td>CNG II</td>
<td>-15.8</td>
<td>+14.6</td>
</tr>
</tbody>
</table>
different economies visiting the island with one permanently inhabiting Oronsay or a similar coastal environment and the other intermittently visiting the island (or exogamy).

"The humans in the Cnoc Coig midden did consume mainly marine food, and so could well have lived on Oronsay year-round. The single individual from Casteal nan Gillean II consumed a combination of marine and terrestrial food, and so probably did not live on the island year-round" (Richards & Mellars 1998:183).

The Casteal nan Gillean II result does not suggest a large role for terrestrial protein sources — Alaskan Eskimos obtaining up to 85% of their diet from marine resources have carbon signals within 1.5‰ of this result. It should be noted that the sample from Oronsay is very small (possibly as few as three individuals) and differences in isotope signal of the scale observed between the two sites could be attributable to personal dietary preferences or differential access to foodstuffs. It could also be the result of variations in metabolism. Schoeninger (1989) quotes a coefficient of variation of 20% for mink fed on monotonous diets in laboratory conditions. The natural range in wild species has been reported to be even greater with a coefficient of variation up to 35% (Price 1989a). At both sites the signals would suggest a primary role for marine derived protein. It is very unlikely that any group permanently inhabiting an island the size of Oronsay would permit a second group to exploit coastal resources from their territory. The role of freshwater fish has been ignored in these studies. Ethnographic observations of Native American groups indicate that coastal groups very commonly exploit freshwater resources on a seasonal basis.

Intra-regional differences in diet are evident in Wales in the Late Mesolithic, similar to the differences observed in Mesolithic Scandinavia. Marine signals are evident in human remains from Potter’s Cave, Daylight Rock and Ogof-yr-Ychen all on Caldey, dated to ca. 8600–7800 BP (7600-6650 cal BC) (Lynch et al. 2000). Results of isotope analyses from Pontnywedd Cave and Foxhole on the Gower Peninsula indicate a terrestrial-based diet (Aldhouse-Green et al. 1996). Lynch et al. (2000) link the variation of diet in Wales to increased territoriality in the Late Mesolithic (see Chapter 8).

The isotope signals of dog bones from Seamer Carr in the Vale of Pickering, England (some 5km from Star Carr) also imply a significant marine intake (Noe-Nygaard 1983). The dog vertebrae recovered from Seamer Carr possibly come from the same individual as examples found at Star Carr. Day (1996) argues that the signal is erroneous; the result of a terrestrial diet combined with a hard water error from the carbonate rich lake passed through the food chain. Day (1996) cites in support of this the findings from Scandinavian dog remains, which indicate that those from inland sites have terrestrial signals and those from coastal sites have marine signals. The majority of the dog and human remains analysed come from Later Mesolithic contexts when there is increasing evidence for sedentism and territoriality and with possible restrictions to movement not in place in the Early Mesolithic of Britain. A dog bone from the inland site of Ringkloster (Late Mesolithic) and human remains from Holmegaard (Early Mesolithic) have produced marine signals indicating that movement
between the coast and interior in Scandinavia did occur. Day further supports her case with the statement,

"Study of the Mesolithic inland site of Præstelyngen in Denmark showed that birds, fish and freshwater mussels (Unio and Anodonta) were all exploited, and it seems likely that a similar situation existed at Star Carr" (Day 1996:785).

However Præstelyngen and Star Carr (England) are fundamentally different types of occupation. Faunal remains indicate that Præstelyngen was a summer fishing camp whereas Star Carr probably acted as a hunting station (Andresen et al. 1981). The deer (which, it is assumed by Day, obtained water from the lake and browsed on lakeside vegetation, from Seamer Carr) produced a δ¹³C value of −22.65‰: within the expected range for a terrestrial herbivore. Even if the relatively positive δ¹³C results from Seamer Carr are the product of hard water error this would imply a heavy dependence on freshwater aquatic resources, which is not supported by the faunal remains from the site. A more reasonable explanation of the result from Seamer Carr is some form of seasonal movement between the coast and the Vale of Pickering with marine resources playing a dominant role in diet. The absence of freshwater fish at Star Carr is explained by Noe-Nygaard (1983) as a preference for marine fish, eaten when at the coastal settlements. Perhaps dried marine fish were taken with groups travelling to the interior on terrestrial hunting expeditions so that all attention could be given over to the monitoring of herd movements and pursuit of game that would have been as important as a source of raw materials as for meat.

The δ¹³C signals from Hoedic, Morbihan, France (average −14.3‰) indicate a dietary intake comprising up to 80% marine protein. Those from Téviec, Morbihan, France, are less heavy (average −15.3‰) suggesting a balance between marine and terrestrial protein sources (Schulting & Richards 2001). Hoedic was further from the coast than Téviec at the time of occupation. The increased reliance on marine resources is attributed to the greater isolation of the Hoedic site from the mainland interior or to varying use of inshore resources. There is no statistically significant difference in the δ¹⁵N values obtained from the sites. On this basis it is here suggested that the δ¹³C differences were not the result of varied terrestrial component to diet but to greater reliance on estuarine resources at Téviec. This corresponds to the species identified at the two sites. Admittedly, however, only a fraction of the fish remains from these sites were identified to species (Péquart et al. 1937, Péquart & Péquart 1954). The results from Hoedic and Téviec are similar to those obtained from the Oronsay middens and the Danish coastal sites and imply a marine emphasis to diet, which is suggested to vary from 50–90% for populations inhabiting the Atlantic coastal region (Richards & Mellars 1999).
2.5.3: Problems Associated with Dietary Reconstruction based solely on δ13C Isotope Analysis

Unfortunately, a large number of isotope studies have examined carbon isotopes only. These permit predominantly terrestrial diets to be distinguished from predominantly marine ones but do not allow the trophic level of foodstuffs to be established. A direct consequence of this is the inability to distinguish the contribution of sea mammals from marine fish in a predominantly marine diet. It also makes it difficult, if not impossible, to determine the exploitation of aquatic resources in areas where freshwater foodstuffs may have been expected to play a role in diet. The carbon signal of an individual subsisting largely on freshwater resources may be very similar to that of an individual consuming mainly terrestrial resources, however δ15N is enriched in freshwater resources (Schoeninger et al. 1983; Hobson & Collier 1984; Katzenburg 1993). It is essential that nitrogen isotopes, in addition to carbon isotopes, become the subjects of all future analyses so that the role of sea mammals and freshwater fish in the diet of Mesolithic individuals can be assessed.

A case in point is Oleni ostrov, Russia: samples OX–2124 and OX–2125 gave δ13C values of –20.1‰ for skeletal remains from the cemetery site, which Price & Jacobs (1989) attribute to either a terrestrial diet or the freshwater aspect of the Baltic. The location of the site would suggest that freshwater resources might have been significant to the Oleni population. The contribution of terrestrial versus freshwater resources might have been clarified if nitrogen isotopes had been analysed. Similarly, the location of the cemetery of Zvejnieki, near Lake Burtneiks (Latvia) and the outlet to River Ruja would suggest a focus on aquatic resources. δ13C results from skeletons recovered from the cemetery range from –20.07‰ to –23.33‰ (Table 2.8). Zagorska & Larsson (1994) state that this is lighter than normally associated with the intake of freshwater resources and argue that the isotope values imply a terrestrial focus despite the site’s location. They employed the value of –19.0‰ as the benchmark for dependence on freshwater resources. However, this is described in the literature as a ‘typical’ value (cf. Bonsall et al. 2000) implying that it is merely the average of a distribution with ‘tails’ that may extend in either direction. It is possible, therefore, that a value of –20.07‰ could result from a diet deriving a considerable proportion of protein from freshwater fish. Groups subsisting on freshwater fish and C3 plant resources exhibit δ13C values of –18.7‰ to –20.5‰ (Chisholm et al. 1982). The δ13C values of freshwater fish vary within and between ecosystems — see Table 2.11 (Hecky & Hesslein 1995; Dufour et al. 1999; Katzenburg & Weber 1999). For example, the δ13C values of modern fish from Lake Baikal range from –12.9‰ to –24.6‰ (Katzenburg & Weber 1999). Similar ranges in isotope values have been observed in fish from Lake Geneva, Lake Constance, and Lake Aiguebelette in Switzerland and Lake Malawi, Malawi. This variation is thought to reflect the different habitat of the species analysed and several sources of carbon (Hecky & Hesslein 1995; Dufour et al. 1999; Katzenburg & Weber 1999). Dufour et al. (1999: fig 5) have published a graph of the natural variation in the δ13C and δ15N content of the major foodstuffs of Eurasia, which demonstrates the overlap of freshwater resources with certain terrestrial and marine...
resources. The $\delta^{13}$C value of an individual is the lifetime product of varying dietary forces: an increase in the proportion of terrestrial foodstuffs will make the value more negative (i.e. lighter) whereas marine sources will make it more positive (i.e. heavier). With the values attributable to terrestrial and freshwater foodstuffs lying so close to each other together and with the $\pm 0.9\%$ variation in isotope ratios of animals consuming identical diets (Chisholm et al. 1982), and the natural variation in foodstuff values, it can be seen that there will be instances where precise elucidation of an individual’s diet would be impossible with carbon information alone. Analysis of nitrogen isotopes would, in such cases, indicate the role played by resources from complex food webs (i.e. freshwater and marine).

The Skateholm results show a wide variation at the level of individual diet: carbon signals ranging from $-16.8\%$ to $-25.5\%$ (Meiklejohn 1986b). Experimental studies indicate that isotope signals do vary between individuals consuming identical diets due to differences in individual metabolism (Tauber 1981; Chisholm et al. 1982; Schoeninger 1989; Price 1989a). However, variations of at least $\pm 0.9\%$ between individuals can be taken as good evidence for differences in intake (Chisholm et al. 1982). This is clearly the case for the Skateholm individuals. Despite the location of Skateholm, the majority of the results suggest a terrestrial focus. Two signals ($-16.8\%$ and $-18.6\%$) are interpreted by Price (1989b) as implying a reasonable intake of marine resources.

There has been speculation concerning the implications of the varying salinity of the Baltic through the Mesolithic and its impact on isotope signals obtained from populations subsisting largely on fish. For example, Meiklejohn (1986b) interprets the carbon stable isotope result of $-18.0\%$, obtained for a female from the island site of Kams, Sweden, as indicative of a dietary ‘balance’ of marine and terrestrial resources. Zagorska & Larsson (1994) argue that the reduced salinity of the Baltic (Ancylus Lake) in the Boreal period implies a significant (i.e. dominant in diet) intake of aquatic resources by this individual. Groups subsisting on estuarine resources exhibit signals with values between terrestrial and marine dietary endpoints (Thornton & McManus 1994). Price (1989b) has explained the ‘unexpected’ results of the Skateholm human remains, given the coastal location of the site, as resulting from decreased salinity of the Baltic or increased use of terrestrial resources. It would be desirable, therefore, to evaluate the conditions in the Baltic coincident with the dates obtained for the Skateholm individuals, to assess whether heavy $\delta^{13}$C results correspond to periods of increased salinity. Unfortunately, the samples range over a relatively short time span, 6270±70 BP to 5850±90 BP (5300 - 4600 cal BC) and with the error margins it is not possible to obtain a fine enough resolution for significant results. It is important to note, however, that the range of species identified at Skateholm, which are predominantly freshwater species, are consistent with the relatively light carbon isotope results (Table 6.2). The ‘unexpected’ isotope signals may be a consequence of significant dependence on freshwater resources. Moreover, in areas with significant freshwater drainage, such as Skateholm, euryhaline marine species, such as the various species of flatfish recovered at Skateholm, will produce light isotope signals. The carbon isotope signals of all groups
practising inshore subsistence fishing in coastal areas will be lighter than expected in regions with large freshwater drainage. Any large-scale exploitation of catadromous eel (Anguilla anguilla) on its migration to the Sargasso Sea (implied at Bjørnsholm and Ertebolle, Denmark) would also have implications for the interpretation of any isotope analysis of humans from these sites. This would be expected to result in lighter carbon isotope signals whilst heavy nitrogen signals would be maintained. The Skateholm case illustrates the importance of interpreting results in light of additional archaeological evidence, the range of fish species identified and the necessity of nitrogen isotope analysis.

Certainly a reduction in salinity resulting from increased freshwater drainage and separation from the North Sea would result in a change to the carbon isotope signals of organisms inhabiting the Baltic, which would be passed on through the food chain. Stable isotope results obtained from human remains dating to Early Mesolithic sites in Estonia (Narva and Kunda) are consistent with the freshwater aspect of the Baltic (or Ancylus Lake) at this time (Löugas 1996). There is a clear shift in isotope results obtained from the Late Mesolithic/Early Neolithic seal hunting station reflecting the shift in subsistence from freshwater and terrestrial resources to the significant exploitation of sea mammals and the salinity of the Baltic in the Atlantic period. However, the variations in salinity would not alter the observed differences in nitrogen isotope signals between aquatic and terrestrial organisms. A programme of research, investigating the nitrogen isotope signals of Mesolithic populations, would go some way to resolving the problem regarding the contribution of aquatic resources to diet in the Mesolithic in the circum-Baltic zone.

2.5.4: The Role of Fish in Mesolithic Diet based on Isotope Analyses

Price (1989b) emphasises the role of stable isotope data in the reconstruction of Mesolithic diet because of the generally poor organic preservation and differential site preservation at sites of this period. It has been used to demonstrate that Mesolithic groups were consuming large quantities of fish at many sites, some of these have an overwhelming dominance of fish remains in their faunal assemblages but also at many sites, such as Viste, Norway, and Årgus, Denmark (Huffhammer & Meiklejohn 1986; Fischer 1987), where faunal remains suggest a terrestrial emphasis in diet and at others where there is no direct evidence for fishing. It has confirmed the overwhelming importance, to certain Mesolithic populations, of fish as a dietary resource, e.g. groups inhabiting the Atlantic seaboard of Europe, the Iron Gates region, the south-west coast of Sweden and coastal Norway, and specific groups in Denmark. In certain cases, stable isotope results indicate that aquatic resources other than fish may also have been important to diet: this is supported by the wide range of aquatic resources identified at the Mesolithic sites incorporated in this study (see Table 2.12 for species lists). Although stable isotopes indicate that up to 80% of dietary protein was obtained from aquatic resources by certain Mesolithic groups, Mesolithic hunter-gatherer-fishers may have had a significant
intake of carbohydrates or fats to provide for energy and vitamin and mineral requirements. This facet of diet may have been derived from terrestrial sources.

Importantly, stable isotope analyses have demonstrated a terrestrial emphasis at a small number of coastal sites where fishing technology has been recovered and fish are considered to be, at the very least, an important contributor to diet. This may reflect the existence, in coastal locations, of distinct groups with different subsistence practices, the movement of populations between the coast and interior or individual differences in diet (relating to general social factors or personal preference). This has important implications for the reconstruction of fishing practice and its role in economy and society: the recovery of fish remains and fishing implements does not necessarily indicate significance in terms of dietary consumption.

There is a drawback to the use of stable isotope analysis — the lack of suitable anthropological samples. The majority of the data (Tables 6.1 and 2.8) derive from human remains recovered from coasts, major rivers and lakes. This may bias reconstruction of Mesolithic subsistence over Europe as a whole, placing too heavy an emphasis on the role of aquatic resources. However, there is as yet, no clear evidence for large-scale settlement of interior regions. With the exception of the Iron Gates study, the interpretation of results is limited due to the small number of samples for any one site. There is also some evidence to suggest movement between the coast and interior on the basis of isotope results supported by finds of sea mammals and saltwater fish at certain inland locations. However, the lack of human remains at inland sites (possibly due to preservation conditions or the cultural preference for cemetery location at the coast) to assess whether there was large scale movement between coastal and inland locations or the existence of separate groups with smaller scale movement between the two areas. It is also difficult to assess the role of freshwater fishing at inland locations in Scandinavia. It may be that inland locations with significant finds of fish remains and fishing gear were the remains of inland groups subsisting to a greater or lesser extent on aquatic resources living alongside inland groups subsisting primarily on terrestrial resources. It is possible that coastal groups moved inland to exploit seasonally available or concentrated resources.

2.6: The Advantages of Fish Exploitation over Terrestrial Resources

Generally, the exploitation of fish is less seasonally restricted than the exploitation of terrestrial resources. In all regions, certain species of fish are available year round and the migratory patterns of many different species extend over large parts of the year. Naturally the food value obtainable from fish will vary seasonally, relating to species availability and quality of food available to the fish. Fish distribution is limited only by temperature gradients, while terrestrial resources are often restricted by geographical features.
The regularity of the fish’s life cycle, its fecundity and rapid growth makes it a predictable and reliable resource (Schalk 1977; Wilkinson 1981; Wheeler & Jones 1989; Walker 1988). The spatial and temporal regularity of fish migration patterns minimises search/pursuit times. Rivers concentrate fish spatially, allowing mass-capture techniques to be efficiently used for the capture of anadromous species. Coincident with this spatial concentration of anadromous species is the greatest nutritive value of these species. Fat content (and therefore calorific value and fat-soluble vitamin content) is highest immediately prior to spawning. The temporal predictability of migrations allows the scheduling of group activities to permit large quantities of fish to be processed for storage or trade in a short period of time.

2.6.1: Storage, Processing and use of Fish

The relative ease of large-scale capture of fish provides a storable resource to provide for predictable seasonal variation in resource availability. Storage is a consistent feature of temperate and sub-Arctic groups (Murdock 1967). Most fish intended for human consumption, whether fresh or preserved, will undergo some form of processing. It is likely that all but the smallest of fish consumed by Mesolithic groups underwent some form of processing and probably cooking; this has implications for the preservation of fish bones in archaeological contexts, as discussed in Chapter 6. It is difficult to discern the effects of processing and cooking in archaeological assemblages. This becomes an impossible task if fish have been processed off-site, at sea or at landing areas — a practice frequently observed ethnographically. Historical records indicate that the fish remains of medieval date recovered from riverside sites in Newcastle would have been processed. However, few show evidence of this processing (Nicholson 1999). Nicholson suggests that this may be in part due to the preferential decay of bones with cut marks. Only 4% of the fish remains recovered from abandoned fishing sites at Lake Turkana bore cut marks, though it is assumed that all the fish had been processed for consumption (K M Stewart 1991). Many species of fish can be processed by cutting between bones or by hand without the use of implements. Analysis of skeletal element representation has been used as a method of determining the processing of fish. Caudal vertebrae would be under-represented on processing sites where the fish were beheaded and the trunks transported elsewhere (Nicholson 1999). Nicholson adds the proviso that caudal vertebrae appear to be less durable than precaudal vertebrae and that overall site preservation must be assessed before methods of this sort can be applied. It is considered here that such methods are inappropriate in light of the effects of differential preservation detailed above. For sites of Mesolithic age, in the absence of cut marks or archaeological features/artefacts that would imply processing, speculation on processing methods should be avoided.

The presence of small fish, unlikely to have been constituents of diet, may indicate the gutting of larger fish (Nicholson 1999). Such interpretations should be made cautiously; they are influenced by
cultural definitions of foodstuffs, moreover, small fish may be accidentally taken in the pursuit of larger prey and discarded on site or may represent the remains of small bait-fish.

The small number of finds of burned bones in Mesolithic contexts leads Andersen & Malmros (1984) to suggest that boiling or steaming (both cooking methods are commonly observed ethnographically) would have been the predominant method of cooking. It would be possible to assess this by investigating whether Mesolithic fish bones show evidence of thermal denaturation (cf. Richter 1986a). It should be noted that cooking fish results in the loss of significant quantities of vitamins and amino acids/proteins (Bramstedt & Auerbach 1961; Burgess et al. 1965).

2.6.2: Fish Spoilage

The rapid rate of fish spoilage from the moment of death has important implications for the processing of fish intended for long-term storage, both in terms of required speed of processing and in terms of social organisation, where there is large-scale storage of seasonally available species.

Decay rates vary among species with the most noticeable differences between freshwater and marine species and cartilaginous and bony species. A certain amount of decomposition is today considered desirable to obtain the best flavour from fish (Sikorski et al. 1990). This is obviously entirely subjective and will be influenced by cultural preferences. However, it is generally held that cartilaginous species tend to have an improved flavour if left for a few days prior to consumption (Holden 1979). Initial spoilage is the result of autolysis (the internal breakdown of cells/tissue). Clearly this is more relevant to fatty species. Herring (Clupea harengus), for example, can become inedible within 1–2 hours after death in normal summer temperatures. However, it is reported that herring are not gutted at sea because the pheromones released will result in herring avoiding the area for some time afterwards (Samuel 1918). Decomposition due to surface bacterial action does not occur until after rigor has passed (lactic acid produced during rigor inhibits bacterial action). Bacterial action producing trimethylamine results in unpleasant odours. Cartilaginous fish produce large amounts of ammonia resulting in a strong, undesirable taste/odour (Bramstedt & Auerbach 1961; Tsuchiya 1961; Cutting 1961; Burgess et al. 1965; Sikorski et al. 1990).

Immediate gutting reduces the rate of spoilage (Bramstedt & Auerbach 1961; Cutting 1961; Tsuchiya 1961; Burgess et al. 1965; Sikorski et al. 1990). This is imperative if the fish are to be preserved for storage and is usually done at landing sites on the shore or at sea if the boat is any distance from the shore.

Physical exertion prior to death increases the rate of spoilage (due to the production of high-energy phosphates, glycogen and lactic acid), reduces the strength and duration of rigor and affects the
flavour of the fish (Sikorski et al. 1990; Thomas et al. 1999). This has important implications for the processing of fish for long-term storage. If physical exertion has been very strenuous, the flesh turns brown and has an unpleasant taste. Handling of fish also affects rates of spoilage through microbial action (Sikorski et al. 1990). Tearing rather than cutting fish greatly increases the rate of decay. Roughly handled or physically exhausted fish will not store well irrespective of the form of preservation employed (Cutting 1955, 1965; Burgess et al. 1965).

The nutritional content of fish is only significantly altered if spoilage is very advanced. In highly decomposed fish, denaturation reduces the solubility of proteins and vitamins are destroyed (Geiger & Borgstrom 1962; Doe & Olley 1990; Sikorski et al. 1990). Long-term storage reduces the digestibility of fish proteins and the vitamin content of liver oils (Geiger & Borgstrom 1962; Tsuchiya 1961).

Decomposition of fish oils occurs spontaneously in the presence of atmospheric oxygen, much more rapidly than in fish flesh, making it less suited to long-term storage (Sikorski et al. 1990). However, the extent of decomposition considered still palatable depends on individual and cultural food preferences.

2.6.3: Preservation

Fish cannot be preserved for long-term storage before rigor has set in or after it has passed (Bramstedt & Auerbach 1961). Groups storing large quantities of fish for future consumption must be organised to process and preserve the fish during rigor. Given that rigor sets in less strongly if the fish are badly handled or exhausted at death it may be that passive gears as well as mass capture techniques were required before fish could be efficiently stored in large quantities for long-term use. Rigor occurs 1–7 hours after death and continues for 32–98 hours depending on the size of the fish. Onset is faster and rigor lasts longer in smaller fish compared to larger ones and in teleosts compared to cartilaginous species. Spiking the brain of the fish delays the onset of rigor (Sikorski et al. 1990) — a method that could be employed if large catches are being preserved. Fish with acidic tissues have better storage qualities due to reduced microbial action (Amlacher 1961).

It is the reduction in water content and in turn the inhibition of bacterial action that permits long-term storage of foodstuffs. Moisture levels must be reduced from ca. 80% of total weight to <25% in order to stop bacterial and microbial action. Where the water content of fish is reduced to ca. 15% of total body weight, they can be stored for several years. Cutting (1955) suggests that in prehistoric times, drying in the sun would have been the most common method of preservation. However, the action of wind, not sun alone is essential to reduce moisture levels sufficiently for storage (O’Leary 1996). Large quantities of stockfish (dried cod [Gadus morhua], still widely consumed in Scandinavia) were traditionally preserved by sun and wind drying in Norway and Iceland. This takes from two to six
weeks depending on the fish species and size and prevailing weather conditions. Dried fish must be soaked for many hours before use. Fish were preserved in the spring rather than the summer to avoid fly larvae infestations that could result in considerable losses. This is only possible where there is low atmospheric humidity and mild temperatures. The drying fish would also have to be protected from the action of scavengers. In conditions with high atmospheric humidity, rainfall or hot temperatures, the fish would putrefy before it could dry out sufficiently for storage; under such conditions smoking would be required for storage (Cutting 1955; Burgess et al. 1965; Jason 1965; Doe & Olley 1990). Shingle beaches offer ideal conditions for the sun or wind drying of fish as water is naturally drained from the surface (Gray 1978; Coull 1996). In the more maritime regions of Europe, smoking would have been a necessary prerequisite for long-term storage of fish. Doe & Olley (1990) note that dried fish is commonly used as flavouring rather than as a food in itself. However, it was common practise among Native Americans to store dried fish, which provided a primary staple through winter.

2.6.4: Smoking

Smoking can be used to accelerate the drying process; it can be done in inclement weather and the smoke repels flies. It is essential for long-term storage in humid environments (McKervill 1967; Sanger 1995). Rotten wood is preferable as a fuel to fresh wood as it produces more smoke (Suttles 1990b). In addition to reducing moisture content in flesh, the smoking of fish reduces bacterial action and autolysis through the action of phenols released in the burning of wood. The anti-bacterial and anti-oxidant properties of phenols are enhanced by the presence of citric acid, phosphoric acid, ascorbic acid, isopropyl citrate and various organic hydroxy acids. It is necessary to smoke fatty species very heavily if the flesh is to be stored. The Norfolk ‘bloater’, for example, which is one of the most heavily smoked modern herring (Clupeidae) products will spoil within five days (Samuel 1918). High fat content results in putrefaction before dehydration in sun/wind drying, leading to spoilage (due to the detrimental effects of fats on water diffusion through flesh). Smoking and sun drying were the traditional methods of fish preservation for storage across the African continent at the time of first European contact. Smoked fish products today are smoked much less heavily than stored products detailed in ethnohistoric/ethnographic records and presumably less so than in prehistory. Today, smoking is mainly for flavour rather than preservation and is also used to tenderise fish flesh by thermal denaturation of proteins. In prehistory, smoking fish to preserve it for storage would have to be sufficiently heavy to inhibit bacterial and microbial action for periods of months if not years. If the fish are stored before they have fully cooled after smoking there may be mould growth (spores are picked up from the wood used for smoking) during storage. Strong smoking of the type that must have been practised for long-term preservation makes the flesh very hard (Cutting 1955, 1965; Kroeber & Barrett 1960–62; Tsuchiya 1961; McKervill 1967; Burgess et al. 1965; Doe & Olley 1990; Miller & Sikorski 1990; O’Leary 1996).
Fish need to be processed to differing extents prior to smoking. Small fish can generally be smoked whole but gutting prior to smoking will increase storage life (Cutting 1955, 1965; Burgess et al. 1965). All large fish will be gutted and may be cut into strips prior to smoking to ensure uniform preservation. Eel (Anguillidae) must be gutted because the tough skins prevent smoke penetrating to the flesh. Paxman (1994) states that Native Americans do not consider fish that has been speared as suitable for smoke preservation. However, it has not been possible to confirm this from other sources.

Dependence on smoked foods as a dietary staple has implications for the general health and life-expectancy of Mesolithic populations. Phenolic compounds are carcinogens. Cancers would therefore be expected to be particularly prevalent among groups for whom smoked fish are a dietary staple. This is supported by the frequent occurrence of primary and secondary cancers in prehistoric populations of the British Columbia Coast (Cybulski 1990).

2.6.5: Salting and Freezing

Meat/fish preservation using salt was not a common practice in the past owing to its limited geographical distribution, but ethnographically it has been observed that salt was used for preservation where available. Cold temperatures inhibit microbial action. Storing foods in frozen ground is a natural method of preserving meat/fish that has been historically practised in arctic latitudes (Cutting 1955). It seems unlikely that either form of preserving foods would have been practised on any significant scale in Mesolithic Europe. It is possible that frozen storage was practised in the most northerly reaches of Europe such as the Varanger Fjord (see Chapter 8).

2.6.6: Fermentation

Long-term storage of fermented fish products is widespread, however consumption of these products is culturally determined. For example, Tsuychiya states that,

"The flavour of oxidised fish oils is different from that of fresh fish oils, and is unacceptable" (1961:238).

Fish flesh and oils fermented for up to 18 months are considered delicacies in certain parts of Asia (Saisithic 1994). Though there is nutritional loss in fermented products they are very easily absorbed and digested and provide large quantities of nitrogen, vitamin B<sub>12</sub>, phosphorous, calcium, magnesium, sulphur, and iron. Another benefit is the destruction of the bacteria responsible for gastrointestinal illness during fermentation.

1 Noli & Avery 1988 state that terrestrial meat is the best source of high quality protein.

2 Corresponds to the mid to late Mesolithic period ca. 7000-5000BP.
Chapter 3

The Use of Ethnographic Analogy

3.1: Aims

One method of elucidating prehistoric fishing techniques is the application of ethnographic analogy. Ethnographic analogy has been applied in the reconstruction of all aspects of Mesolithic society and economy on the basis of formal or relational analogy (exemplified by J G D Clark [1975]; C Smith [1992]; Pedersen [1995]; Zaliznyak [1997, 1998]). The fishing strategies of non-industrial and ethnographically observed fishing groups, herein termed traditional fisheries, will be assessed in order to provide further insight into the fishing activities of Mesolithic groups. The information regarding fishing strategy *i.e.* intended prey species, gear choice, modes of operation and location of fisheries, which is derived from groups depending heavily on fish in diet has been collated. Steane & Forman (1991) state that in the study of prehistoric fishing activities, the early development of many fishing technologies, which remain essentially unchanged throughout prehistory and into recent historic times, is a major problem. Though this may be problematic to the dating of finds on the basis of typological comparison, it can be argued that this technological continuity validates the use of ethnographic analogy for elucidating modes of operation of fishing gear.

3.2: Criticisms of the use of Ethnographic Analogy

The reliance on ethnographic accounts is the subject of debate (Trigger 1982). Four main criticisms have been levelled against the use of ethnographic analogy for archaeological explanation:

1. the dissimilarity of the early Holocene environment and that inhabited by modern and recent hunter-gatherers,
2. the influence of inter-group contacts (social and economic) on the structure of modern and historic hunter-gatherers,
3. the inevitable bias introduced to ethnographic studies by the act of observation,

On the basis of such criticisms it has been suggested that the use of ethnographic analogy in archaeological interpretation should be abandoned (Gould 1980).
The first of the criticisms concerns the role of environment in analogy. Awareness of the variability of the social and economic structure of hunter-gatherer groups has resulted in more rigorous application of analogy. Analogies can only be considered appropriate (but not necessarily predictive) if drawn between ethnographic and archaeological groups living in similar environments and having access to similar resources (Bicchieri 1972). The validity of any analogy is given more weight if continuity can be demonstrated between the ethnographically observed group and the archaeologically known group (Trigger 1982; Møbjerg & Robert-Lambin 1989). Cultural continuity is evident for only a small number of European hunter-gatherer groups inhabiting the sub-Arctic regions of Northern Europe. Zaliznyak (1997) considers these groups to constitute suitable analogies for Preboreal Europe. The Inuits and Aleuts of sub-Arctic regions are also used as analogies for this period. For the later Boreal and Atlantic periods, Native American groups of temperate latitudes with similar resource availability, particularly those of the North West Coast culture, have been considered most appropriate for analogy (Price 1973; Bender 1985; Price & Brown 1985; C Smith 1992; Finlayson 1998). It has been argued that modern and historic hunter-gatherer groups have not been subjected to the changes in climate experienced by Late Glacial and Preboreal Mesolithic groups. As a consequence, no exact environmental analogies for this period exist or have existed in recent history (C Smith 1992).

Ethnographic studies generally document groups as isolated entities, i.e. in evolutionary ecological terms (Wobst 1978; Yoffee & Sherratt 1995). This paradigm, though the subject of much controversy in anthropological circles, is still used by archaeologists to provide analogies upon which adaptive models of prehistoric hunter-gatherer behaviour are based — for example, the economic-cultural type (ECT) model of Zaliznyak, which assumes that,

"at a particular level of development under given environmental conditions, the society, inevitably works out quite a definite model of behaviour...The way of life of a particular ancient society may be reconstructed in general terms on the basis of an analysis of the way of life of any other (including ethnographic) society of the same ECT" (1997:61).

The revisionist debate (or 'historical particularism') was a consequence of the realisation that hunter-gatherers did not conform to a single stereotype but actually exhibited a wide range of social and economic structures. This argues for caution in the use of analogy or models (such as Zaliznyak's ECT) based on the behaviour of modern hunter-gatherers to reconstruct or predict prehistoric economic and social structures (Yellen 1977; Wobst 1978; Bird-David 1988; Foley 1988; Barnard 1992; Burch & Ellana 1994). Historical particularism argues that it cannot be assumed that prehistoric groups have modern correlates; many prehistoric groups may have no modern counterpart (Gould 1980). The contact of modern and historic hunter-gatherer groups with agriculturalists for considerable periods of time (and in some areas for millennia), may produce a different range of behaviours from prehistoric groups (Stiles 1992). Specifically, the existence of 'commercial' hunter-gatherers is considered a recent phenomenon that has no prehistoric counterpart (Foley 1988). Modern hunter-gatherer groups have incorporated social and economic ties with neighbouring groups whilst
maintaining traditional lifestyles but this contact, it is argued, must influence social and economic organisation (Bird-David 1988). Generally, any observed behaviours that deviate from the traditional view of hunter-gatherers is attributed to inter-group contact. Anthropological models tend to see trade as a recent development that has changed hunter-gatherer social systems. All modern and historic hunter-gatherer groups have had contact at some scale with non-foraging groups. It is generally accepted that such exchange relationships are essential to the existence and persistence of hunter-gatherer groups (Stiles 1992). The only role for ecological determinism in the explanation of change within this paradigm is to delineate constraints to human behaviour (Ellen 1982; Foley 1988; Lourandos 1997).

The criticisms of the revisionist debate can be countered. Supporting arguments reveal a fundamental lack of knowledge of the archaeological data when applied to prehistoric hunter-gatherers of the Holocene era. To claim that prehistoric hunter-gatherer groups are fundamentally different from modern hunter-gatherers (often quoted as invalidating analogies between Mesolithic groups and Native American groups) because of contacts with agro-pastoralists simply does not apply to groups inhabiting Mesolithic Europe. With the possible exception of Pleistocene hunter-gatherers, e.g. Foley (1988), archaeologically observed Holocene hunter-gatherers did not exist in a social or economic void. The inception of agriculture was temporally transgressive across Europe. Many European Mesolithic groups were in contact with agro-pastoral groups for significant periods prior to the transition to agriculture (Zvelebil & Rowley-Connor 1984; Radovanović & Voytek 1997; Zvelebil 1998a, 1998b; Binder 2000; Price 2000). In the Northeast of Europe, conservative economies are apparent down to the Early Iron Age ca. 3000–2000 BP (1250–0 cal BC) (Zvelebil 1995a; Zaliznyak 1997, 1998). Trade and exchange on a significant scale is not a recent or even a Holocene development. There is evidence for long-distance contacts and trade/exchange of exotic goods in Upper Palaeolithic contexts (e.g. Stiner 1999). The presence of exotic goods implies exchange between hunter-gatherers and agricultural groups in mid-Holocene Europe and suggests the presence of ‘commercial’ hunter-gatherers at least in Northwest Europe.

Wobst (1978) reiterating the Kuhnian paradigm argues that the very act of observation may alter behaviour, rendering all empirical research meaningless. If this is assumed and if, in addition, it is accepted that historical particularism precludes the use of ethnographic analogy and modelling to elucidate the behaviour of archaeologically known hunter-gatherers then archaeological research of the Mesolithic would be reduced to the reporting of finds with no attempts made at explanation or generalisation. It is essential to the understanding of human development, given that over 99% of the period of human existence has been as hunter-gatherer (Bicchieri 1972), that some attempt at explanation is made. To avoid archaeology of the Mesolithic and preceding periods becoming purely descriptive in nature (back to the days of culture history and the recording of finds and establishing chronologies), it is necessary to accept that the context of all observations and interpretations will be influenced by the subjectivity of the observer. Both ethnographic and archaeological explanation is
necessarily dependent on prevailing paradigms and, as such, is subject to reinterpretation with subsequent paradigm shifts. To exclude the use of analogy or any hypotheses/models based at any stage on ethnographic observation would be to reject all previous interpretation or explanation of the Mesolithic period.

Johnson (1999) indicates that analogy is used implicitly in all archaeological explanation. All interpretation of artefacts such as fishing gear is based on analogy with modern and historic fisheries. It is impossible to discuss the lifestyle or subsistence activities of Mesolithic groups without drawing on ethnographic analogy or drawing on hypotheses or models based on analogy. The similarity of Stone Age and Native American artefacts (and in particular fishing and hunting implements) has been noted from the mid-19th century. Lartet & Christy (1875) in *Relique Aquitaine* and Sauvage (1875) in the same volume discuss the similarity of artefacts from Palaeolithic contexts to those of Native Americans and, in particular, those groups inhabiting the Pacific Coast. From the earliest studies of the Mesolithic, authors have used analogy with native American groups to interpret and explain the archaeological record. Subsequent explanations or interpretations have been based upon or involve counter-arguments to these hypotheses or models.

The shortcomings of ethnographic research and the problems of applying modern analogues to prehistoric hunter-gatherers are fully acknowledged. It should be remembered that any hypothesis, which is supported by the bulk of ethnographic data, is not necessarily correct (Wobst 1978). Testing of hypotheses to validate archaeological explanations is not possible in the Popperian sense (Popper 1995) within the discipline of archaeology, despite the widespread belief that the use of scientific techniques within archaeology lends objectivity to interpretation and explanation. In opposition to the statements of Gould (1980) and Møbjerg & Robert-Lambin (1989), ethnoarchaeological investigations do not remove assumption from archaeological explanation and are not a valid test for archaeological data in empirical terms. Gould states that general propositions should be formed that are subject to validation but not given the status of a law and as such are not open to scientific testing (1980). Surely the act of validation is subjecting these ‘general propositions’ to testing? In this sense, Gould’s argument is self-contradictory. Gould proposes that anomaly is more revealing than analogy and that this method of discovery is well established in the natural and physical sciences. This, however, invokes the scientific disciplines and testability he previously rebukes.

A more fundamental problem in the use of modern or historic groups for the elucidation of past societies is the difference in the temporal and geographic scales of ethnographic and archaeological studies (Wobst 1978). This is a problem that has no resolution. Even if it were possible to organise ethnographic studies of hunter-gatherers over generations and over wide regions, groups subsisting predominantly by traditional hunting and gathering are rapidly disappearing.
It is essential to understand the biases of the available data (Hammersley 1992, 1998). The focus of ethnographic studies varies according to the subjectivity (conscious or not) of the observer. The major problem encountered in evaluating ethnographic or ethnohistoric literature for analogies to Mesolithic fishing practices is the relative lack of detailed discussion of fishing and the incorrect or biased reporting of observations. The first accounts by explorers (or traders) tended to document behaviour that deviated from that of agro-pastoralists, relating only unusual or spectacular fishing activities (Leach & Boocock 1993). The lack of detailed reporting of fishing activities in subsequent studies is attributed by Landberg (1975) to the similarity of ethnographically observed fishing practices with those of non-industrial European fisheries, making discussion of these practices redundant. More recent social anthropological studies fail to document material culture per se because it is not considered a profitable line of enquiry (Trigger 1982). The activities of women are often not reported, partly due to cultural perceptions of the role of women, both socially and economically, but also because the ethnographer may have had restricted access to women (Attenbrow & Steele 1995). Inaccurate or incomplete recording of fishing activities is further compounded by cultural restraints on the divulging of information concerning subsistence activities — the Polynesians, for example, believe that informing on practices gives away power and are reluctant to discuss fishing techniques.

Reliance on ethnographic accounts is complicated by contradictory reports on behaviour, e.g. Kvause (1956) states that the Tlingit held whale meat in disdain while de Laguna (1990b) states that they regularly exploited strandings for flesh. The Ethnographic Atlas (Murdock 1967) reports the Ainu exploitation of fish contributing up to 45% of diet, however other sources on Ainu economy indicate a far higher dependence on fish (Watanabe 1972, 1973, 1977a, 1977b; Ohnuki-Tierney 1974). Underestimation of the role of fish in diet is widespread in ethnographic accounts. Isotopic analyses of human skeletal remains from Northwest Coast sites indicate that the adult diet was composed of 85-90% marine foodstuffs. Ethnohistoric records suggest an input of 45-55% to 90%, depending on the author (Lazenby & MacCormack 1985).

Groups subsisting primarily on aquatic resources have been the focus of much research (particularly the so-called ‘complex’ groups inhabiting regions of the Pacific Coast). This research tends to focus on the issue of social organisation and complexity — its causes and correlates. More than a cursory description of fishing practices is seldom given. Generally, any such discussions detail only the main techniques used and species exploited, with particular emphasis placed on the techniques employed in the riverine fishing of anadromous species and the pursuit of large or voracious species at sea. Mundane activities are little documented.

There are exceptions: the fieldwork of Gifford, Kroeber and Hewes in the 1900s and 1930s-40s was conducted with the specific intention of recording the fishing practices of the Yurok, Karok, Hupa,
Wiyot and Klamath Valley groups of the Northwest Pacific Coast (Gifford 1939; Kroeber & Barrett 1960–62). A total of 72 different fishing implements and methods of operation were recorded. The works of Kvause (1956) and H Stewart (1975) detail the fishing technology of North West Coast groups of North America and the works of Watanabe (1972, 1973, 1977a, b) detail traditional Ainu fishing practices. Similar works cover the fishing practices of groups in tropical zones (Hornell 1929a, b; Hickling 1961).

There are two problems with these studies. The remit of each study was to detail traditional fishing practices. However, it is not certain that the studies, conducted long after European contact, accurately reflect pre-contact fishing activities. Many of the observed fishing practices may be post-contact introductions. Relying on informants to verify the relationship between present and prehistoric practices (as in the case of Watanabe) is affected by the problem of ‘read-back’, informants repeating the works of ethnographers or hearsay rather than recounting personal experience (Suttles & Jonaitis 1990). Inevitably the difference between what people say they do and their actual behaviour is incorporated into records based on the word of informants rather than observed behaviour (Leach & Boocock 1993; Burch 1994).

“Fishing is one of the most important domains of the apocryphal story” (Leach & Boocock 1993:7).

Any practices that are thought or known to be late introductions are excluded from this study. Archaeological investigations of palaeo-Indian groups across North America indicate that certain types of fishing gear may be post-contact introductions within certain regions, however, all types of gear used by modern or recent groups are known from prehistoric contexts across the continent (Moorehead 1911; Bennyhoff 1950; Rostlund 1952; Johnston & Cassavoy 1978; Ames 1981, 1985; Cleland 1982; Kirk 1986; Croes & Hackenberger 1988; Huelsbeck 1988; Wigen & Stucki 1988; Croes 1989, 1992, 1997; Hobler 1990; Mitchell 1990; Pettigrew 1990; Ross 1990; Wessen 1990; Lutins 1992; Cannon 1996). It is therefore assumed for the purposes of this study that all the gear documented by Kroeber & Barrett (1960–62) and Gifford (1939) would have been available to certain if not all groups in the pre-contact period.

The second problem with ethnographic studies of fishing activities is the limited discussion of the species fished with the different types of gear documented. Details of method of manufacture and mode of operation of fishing may be given but the species captured with the gear is cursorily discussed if mentioned at all. This constrains discussion of methods of capture of many species.

Despite these problems, ethnographic and ethnohistoric accounts of fishing practices may reveal practices not apparent in the archaeological record. Comparison of the written records and excavated material at two medieval sites; a Dutch monastery in Greenland and Eindhoven Castle in Amsterdam
showed that taphonomic loss had been huge (Rosenlund 1984; de Jong 1994). The number of identified species and their relative abundance was found to be greatly divergent from records detailing the consumption of fish at both sites. Ethnographic accounts are not necessarily fully comprehensive — in many instances it is archaeological data that provides evidence for unrecorded activities. The inadequacies and biases inherent in early ethnographic documents are amply demonstrated by the comparison of the archaeological record with documentary evidence of fishing practice. Historical records detailing fishing practices in 16th century Mexico with archaeological remains indicated that the ethnographic records only minimally reflected pre-Hispanic knowledge of fish diversity (Polaco & Guzman 1994). Attenbrow & Steele (1995) compared the archaeological remains at Port Jackson, New South Wales with historical records of fishing practices. The earliest documents on Aboriginal groups of the area detail angling and spearing as the most important subsistence activities. However, the range of the size and species of fish recovered from shell midden deposits was more consistent with the use of traps or nets.

Given that ethnographic accounts are not fully comprehensive and that normal fishing practice may differ from observed behaviour, it is accepted that the range of gear and modes of operation collated in Table 3.1 may not reflect the total range of traditional fishing practices. The use of an 'incomplete' data-set mitigates in favour of the use of the grab-bag approach to ethnographic analogy rather than the production of models of fishing practice.

3.4: The Structure of Fish as a Resource and Implications for Ethnographic Analogy

In terms of terrestrial environment and resource base, it is generally accepted that Native American groups and sub-Arctic groups constitute the most appropriate analogies for Mesolithic Europe. This is evident from an evaluation of the ethnographically studied groups listed in Ethnographic Atlas (Murdock 1967). This acceptance of parallels drawn only between groups with similar environments is a relic of cultural evolutionism, prevalent in anthropological studies of the 1950's and 1960's and based on the premise that if the environment inhabited by a society and the technology employed by that society is known, then all other aspects of society can be deduced by analogy. Rigid categorisation of groups is avoided today.

Perhaps it is more relevant, particularly for the purposes of this study, to consider aquatic environment. Though caution must be taken in the choice of analogy for the reconstruction of hunter-gatherer societies using general models, the application of 'buckshot' or 'grab-bag' parallels for the reconstruction of past fishing practice — i.e. the use of specific case analogies to suggest suitable fishing areas, modes of gear operation, raw materials used in gear manufacture and knowledge of prey species — is less restricted. The type of gear used for the capture of fish under specific hydrological conditions is remarkably uniform in all non-industrial fisheries. This is because fish biology,
behaviour and habitat (see Chapter 5) largely determine methods of fish capture. The same types of fish species are taken with the same types of gear in similar aquatic environments. The constraints to gear use are intended prey species, hydrological conditions and raw material availability. There are few limitations to raw material choice/use in temperate regions. The hydrological conditions fished are determined by the species sought and seasonal vulnerability to capture. Once the presence of a certain type of fishing gear and range of fish species have been archaeologically established there are certain generalisations that can be made on the method of operation based on ethnohistoric and ethnographic observation of groups (from a wide range of terrestrial environments), which fish the same types of species in similar aquatic environments.

Of 220 hunter-gatherer groups documented in Murdock (1967), only 89 are groups that exploit fish on a significant scale (>35% of annual dietary intake). The majority are North American groups of temperate and sub-Arctic regions, namely Aleuts, Inuit and Northwest Coast groups. Additional groups that traditionally have been excluded from analogy with Mesolithic groups, on the basis of terrestrial resources, are the Ainu and Maori. The fishing practice of the small number of hunter-gatherer groups exploiting fish as a dietary staple out-with these regions are little documented.

The anadromous resources that provide the dietary staple of the Northwest Coast groups are thought to influence or, in the cultural ecological paradigm, determine, the social organisation of these groups (Ames 1981, 1985; Leland & Mitchell 1994; Gould & Plew 1996; O'Leary 1996). This resource has a different structure from the anadromous resources available on the Atlantic coast of Europe particularly in the context of the size and duration of spawning runs. Five species of salmon are available on the North Pacific coast of North America: Chinook (Oncorhynchus tshawytscha), sockeye (O. nerka), coho (O. kisutch), pink (O. gorbuscha) and chum (O. keta) (Scott & Crossman 1974; Magnuson 1996). These five species enter freshwater for a period of a few weeks to, at most, a few months (Scott & Crossman 1974; Hoffman et al. 2000). The duration of freshwater occupation is proportional to the distance from the river mouth to the spawning ground (up to 1200 miles). At any point within a single river the runs may last no more than a few days. The temporal concentration of the Pacific salmon (Oncorhynchus spp.) runs has been linked to the necessity of storage for efficient exploitation of this resource and consequent development of social complexity in Northwest Coast groups. It has been observed that variations in the abundance of the salmon (Oncorhynchus spp.) runs between rivers influences the extent of dependence on fish in diet and to some extent alters social organisation and complexity (Schalk 1977; Cannon 1996). In direct contrast, there is only one species of Atlantic salmon (Salmo salar), which enters freshwater throughout the year with significant runs of fish occurring on some rivers each month of the year (Mills & Graesser 1981; Mills 1989). The protracted runs and reduced overall numbers of salmon (Salmo salar) entering Atlantic Coast rivers would not require the same level of storage (and potentially social organisation) of this resource. Atlantic salmon (Salmo salar) can be taken in sufficient quantities for subsistence fisheries throughout the year.
This difference in aquatic resource structure between the Atlantic coast of Europe and the Northwest Coast groups makes other ethnographically observed groups equally, if not more, valid as analogies for European Mesolithic fishing practices. For example, the freshwater fisheries of the Maoris, which focus on the exploitation of eel (Anguillidae), are relevant to explanations of Mesolithic fishing (Best 1929; Murdock 1967; Watanabe 1972, 1973, 1977a, b; Metge 1976; Leach & Boocock 1993). For the purpose of this study, analogy is drawn from groups fishing a similar range of species as those identified at European Mesolithic sites, irrespective of terrestrial environment or social organisation. Analogy is therefore based on the behaviour and habitat of the fish and the most appropriate method of capture given these variables. Groups that subsist primarily on fish on the Atlantic coast of North America would provide more suitable analogies than those of the Pacific Coast in terms of the range of available aquatic resources (Johnston & Cassavoy 1978). Unfortunately, there is simply insufficient literature available concerning fishing gear for any analogy to be drawn from these groups (Marquandt 1988; Sanger 1995).

3.5: Overview of Ethnographically Observed Fishing Practices

Recent anthropological studies of fishing groups still take the attitude that fishing is adopted by groups only where there is a deficiency in the terrestrial environment (Acheson 1981; Pålsson 1991). This perception has filtered through to archaeological interpretations with aquatic resources often seen as a buffer against starvation (e.g. G A Clark 1983). The social and economic organisation of groups constituting particularly pertinent analogies for Mesolithic Europe — hunter-gatherer groups inhabiting temperate regions — do not conform to this perspective. The analysis of the practices of traditional fisheries in such regions allows a number of generalisations to be made. (It is acknowledged that such generalisations will not apply universally and may be negated by specific cases.)

The data (and references from which this data is drawn) relating to ethnographically observed fishing practices are collated in Table 3.1 and 3.2. The former details the range of fishing gear and raw materials used for construction, documented for ethnographically observed groups (including the recent, non-industrial fisheries of Europe) subsisting to a significant extent on fish (>35% according to Murdock [1967]). The latter (Table 3.2) assesses the ethnographically observed capture of fish species, the gear used and the hydrological conditions under which a gear type was used. The species list is limited: it does not include all the species recovered from Mesolithic sites, a consequence of the limitations of the ethnographic record. Most ethnographic studies limit discussion of fish species captured to dietary staples or the primary species caught.
The fishing practices of these groups demonstrate considerable homogeneity and are found to correspond closely to the expected capture techniques determined from fish biology (Table 5.4). The close correspondence of observed fishing practice to that predicted by fish biology, behaviour and habitat validates the use of biological data to suggest the most suitable fishing techniques for species not recorded in the literature of traditional fisheries (Chapter 5).

The following constitutes a summary of generalisations drawn from the databases of traditional fisheries practice constructed for this study (Tables 3.1, 3.2 and 3.3). The fishermen demonstrate a sophisticated knowledge of prey species and methods of capture. Gear choice and raw materials used in construction of fishing gear are adapted to fish biology and behaviour (and to short- and long-term variations in behaviour that relate to the physiology of the fish) and to prevailing weather and hydrological conditions. Preferred subsistence-fishing methods are mass capture techniques and/or techniques that facilitate continuous fish capture or capture without moving station. These methods generally involve group co-operation. Small groups or single fishermen conduct smaller-scale fisheries, often when weather conditions or fish dispersal precludes the use of mass capture techniques. Frequently, fishing activities are conducted at night. This increases the effectiveness of fishing gear — it is less visible — and also frees the daytime for other activities. The majority of groups exploiting fish as a staple use boats to increase the efficiency of fishing activities, i.e. the use of watercraft is a consistent feature of temperate region fisheries. Anadromous species are the focus of riverine fisheries. Dependence on fish as a dietary staple is found to reduce with distance from river-mouths, except on major rivers and large lakes (Kroeber & Barrett 1960–62; Pilling 1978; Zaliznyak 1997, 1998). In addition, there is a corresponding reduction in the number and technological sophistication of fishing implements manufactured by groups. The majority of coastal groups fish marine and freshwater, moving residence or establishing fishing camps on a seasonal basis. Marine fishing is generally conducted in the warmer months with riverine fisheries scheduled according to the seasonality of spawning runs. There are large intra-regional variations on dependence on aquatic resources relating to abundance and seasonal availability of fish, which may vary along small stretches of coasts, along individual rivers and between lakes. All groups subsisting to a large extent on fish employ four main gear types, i.e. nets, traps, hook and line and spears or harpoons, and also use poisons to capture fish. Culturally determined taboos that limit the use of certain types of gear for specific fish, or prevent the consumption of certain fish species, are widespread. On the whole, however, observed variability in fisheries practice primarily reflects local differences in species and hydrology. The seasonal capture of anadromous species or the manufacture of large, communally owned fishing nets and weirs is attended by ceremony. Distinct differences in emphasis on gear are apparent between marine and freshwater fisheries. Traps and nets are used in the middle and lower reaches of rivers, estuaries and inshore marine fishing. Open water fishing with nets is a recent development in most areas. Weirs are predominantly employed for the exploitation of anadromous or migratory species in the lower stretches of rivers and tidal zones. They are also used in lakes with ground baits. Most open water or offshore fishing for large and voracious species is conducted with
hooks, often using troll-lines. A smaller number of groups practice open sea fishing for shoaling groups using nets. Leisters and harpoons (including toggle head harpoons) are predominantly used in freshwater fisheries for anadromous species — often in conjunction with barriers and weirs but in certain instances constitute the primary method of capture of anadromous species. Gear construction and use in traditional fisheries and implications for the reconstruction of Mesolithic fishing practice are discussed in further detail in Chapter 4.

3.6: Ethnographically Observed Uses of Fish

It is generally assumed in Mesolithic discussions of fishing practice that fish were captured solely for consumption. Ethnographic observations indicate that fish and fish products serve a number of additional uses (Table 3.3). It should not be assumed that Mesolithic groups procured fish purely for consumption, although it seems very probable that this was their primary function (unlike certain terrestrial animals, which may have had a primary function as raw material for tool production). Fish products have been used for a wide range of products and implements and for trade and exchange. These products/implements and evidence for trade and exchange would only survive in the archaeological record under very exceptional circumstances.

Glues are rendered from the heads, bones and skins of various species of fish particularly sturgeon (Acipenseridae) heads and cod (Gadidae) skins (Kroeber & Barrett 1960–62; Norland 1969; Jangaard 1969). Fish glues are protein based and are therefore extremely susceptible to bacterial attack and as such are unlikely to be preserved in archaeological contexts. Fish glues have good adhesive properties for wood and leather but are water-soluble, thereby limiting use (particularly in implements intended for the pursuit of aquatic animals).

A number of groups use the skins of various species of fish for the manufacture of storage vessels and clothing (Green 1948; Kroeber & Barrett 1960–62; de Rohan-Csermak 1963; Berg 1984). Leather was produced from the skin of the Danube sturgeon (Acipenser sturio) on a commercial scale up to the early 20th century (de Rohan-Csermak 1963). The air bladder of the sturgeon was used for the manufacture of 'isinglass'. The skins of larger marine species such as porbeagle (Lamna nasus) and rays (Rajidae) have been used for clothing in the Faroe Islands (Berg 1984). Catfish (Silurus glanis) skins were used for the manufacture of shoes by groups in Norway and Iceland. Once tanned, eel skins become an extremely tough and pliable leather and have been used in recent times in the commercial manufacture of belts, shoelaces, binding cords, rope and sacks, throughout Scandinavia and in England (Green 1948; Berg 1984). The skins of freshwater eel (Anguillidae) are preferred, as those from marine waters tend to become brittle when tanned. The Ainu of Sakhalin Island prefer to use the skins of sea mammals and fish for the manufacture of clothing and shoes rather than the hides of terrestrial mammals: large ceremonial garments required up to 50 fish skins; shoes required one
large and up to 12 small skins (Ohnuki-Tierney 1974). The Hezhe of China manufactured fishing trousers from the skins of large fish, exploiting the waterproof nature of the fish skins.

In Europe the rough skins (the scales have sharp tips) of the spotted dogfish (Scyliorhinus caniculus) and other shark species (Elasmobranchii) were used as sandpaper, known as ‘rubskin’ or ‘shagreen’. The Polynesians, Micronesians and Melanesians have taken sharks for their flesh but also to obtain teeth for use in weapons and tools and the skin for use as drum skins (Tricas et al. 1997). The Inuit, Gilbert Islanders, Hawaiians and South American groups make knives and weapons with shark teeth inserts (Curwen 1941; Tricas et al. 1997). Australian Aborigines have taken the stingray (Dasyatis spp.) for their spines, which are mounted in weapons (Tricas et al. 1997). The venomous serrated spines of the stingray are employed to ward off predatory sharks. If, in the process of capture, the spine stings an individual, the venom can be lethal within six hours, depending on the location of the wound and the species inflicting the injury. In addition, if the venom is not lethal, the wound often turns septic and without treatment this results in fatal blood poisoning. Ray (Rajidae) skins have been treated to produce leather and were used in sword handle grips in Japan.

Oils rendered from livers and blubber were widely used by groups subsisting largely on aquatic resources (Table 3.3). Recently cod liver oil has been used for its medicinal properties, however, in traditional fisheries, cod liver oil was obtained for fuel for lamps and for dressing leather (Cutting 1955; Jangaard 1969; Walker 1988; E Martin 1995). Pre-industrial methods of rendering oil from cod livers involved exposure to the sun and/or slow heating in large vats. The supposed medicinal properties of other fish species have also been exploited.

Polynesian groups are agriculturalists, however, the Maori of South Island subsisted primarily on aquatic resources due to the limited range of terrestrial resources and poor arable soils (Metge 1976)
Chapter 4

Fishing Technology

4.1: Introduction

Fishing technology is defined as raw materials used in gear construction, gear operation, fishing tactics and fishing vessels (von Brandt 1984a). A description of the various types of fishing gear and the mode of operation observed in use in traditional fisheries, draws upon ethnographic and ethnohistoric observation, and historical and contemporary practices. The expected archaeological remains of the fishing gear employed in traditional fisheries are used to assess the range of gear used in Mesolithic fisheries. The artefacts recovered from Mesolithic sites and reconstruction of fishing activities, which are in part based on these finds, are discussed in Chapters 6 and 7.

4.2: Fishing Gear, Raw Materials Used in Gear Construction and Gear Operation

Four main categories of fishing gear are used in traditional fisheries; (i) fish spears and harpoons, (ii) hooks and lines, (iii) weirs and traps, and (iv) nets. It should be noted here that many types of implement can be used for a variety of activities in addition to fishing and that this must be accounted for when interpreting isolated finds or multifunctional implements, particularly on archaeological sites where there is no supporting evidence in the form of fish remains (see Chapter 6).

There are a huge number of methods of classifying fishing gear, almost as many methods as authors on the subject, (e.g. Hornell 1929a, b; Rostlund 1952; Kroeber & Barrett 1960–62; Hickling 1961; Bullis & Captiva 1969; Brinkhuizen 1983; von Brandt 1984a; Sikorski & Karnicki 1990; Bune 2000).

"There have been many attempts to classify and categorize fishing gears and methods. It can be done in very general terms, but individual variations and the mixtures of various components of the gears do not provide the basis for sound and rational organisational patterns" (Bullis & Captiva 1969:237).

It is considered most useful here to use two distinct attributes of fishing gear:
1. Method of capture.
2. Active/Passive nature of gear.

Table 4.1 summarises this data.
Many of the fishing implements detailed in Table 4.1 are used in conjunction with each other. For example, scoop nets and spears are often used to remove fish from weirs or encircling nets. It is also considered useful here to divide these methods of capture into further categories according to potential yield (Table 4.2).

The use of passive gears such as weirs, traps, set nets and multiple hooks and long-lines all extend the scale of a fishery in spatial and/or temporal terms. Passive mass capture techniques that have traditionally been used to exploit migrations or concentrations of fish generally give the biggest yield relative to labour input (Lindstrom 1996) despite requiring considerable organisation and labour input in their manufacture/construction.

4.3: Components of Fishing Gear

4.3.1: Hand Fishing and Drives

Not all methods of fishing require the use of fishing implements (Pálsson 1991); fish drives and hand fishing would leave no artefactual correlate in the archaeological record.

Fish can be caught with bare hands (sometimes smeared in bait) by a technique known as ‘tickling’. The hands are placed under the water to wait for a fish to pass over them. The belly of the fish is then tickled and the fish is then grabbed by the gills. Strips of cloth may be used to wrap around the body of the fish to facilitate capture. Many species are too fast and sensitive to touch to be caught in this manner but sessile and thigmotaxic species may be taken this way. Von Brandt states, “Most fish, even when trapped in small pools, are too quick and sensitive to be caught by hand” (1984a:11).

In coastal regions, the best waters for hand fishing are those with significant changes in tide (Hickling 1961; von Brandt 1984a; Paxman 1994). Fish may be stunned by clubbing or hitting with stones (known as mechanical narcosis) to facilitate hand capture (von Brandt 1984a).

Native American fishermen have been reported as capturing large sturgeon (Acipenser spp.) by hand. The fishermen dive into the water, approach the sturgeon from behind and take the sturgeon by the gills, the fish is then directed to shore with the fisherman ‘riding’ the sturgeon. This is only practical in slow moving or still waters and is occasionally practised for the capture of other large freshwater fish such as catfish and is generally considered to be a prestige activity (Rau 1885; Kroeber & Barrett 1960–62; Paxman 1994).
Fish drives involve the encircling of shoals of fish, which are then directed to the shore by portable fish barriers or, more simply, by groups of people (and even dogs) making a lot of noise and splashing the water (von Brandt 1984a). Clearly, this technique can only be used on shorelines with a very specific topography, i.e. shallow sloping shores. Hickling (1961) notes that this method is commonly used in waters that have taboos regarding the use of fishing gear. Most types of gear can be used in conjunction with fish drives.

4.3.2: Artificial Hiding Places

These have been commonly used among ethnographically observed groups such as the Native Americans. Brush, branches or hollow tubes are placed in the water and rely on thigmotaxis to capture certain species of fish and octopus. When the intended prey concentrate in the ‘hiding place’ the gear is lifted from the water and the fish captured. These ‘artificial shelters’ are submerged from a few minutes to several weeks depending on the method utilised. Artificial hiding places of brushwood, used for fish capture, have been tentatively identified at the Swiss Lake dwellings of the Neolithic period (von Brandt 1984a).

4.3.3: Bow and Arrow

A bow is defined as a two armed spring, spanned and placed under tension by a string; when an arrow is placed on the string and drawn, the bow stores potential energy, which is imparted to the arrow when the string is released (Bergman & McEwen 1997). For bowyer terminology see Figure 4.1. Important in the choice of raw material for bow manufacture is the ability to adapt to compressive forces. Four main types of bow are known from traditional industries: self-bow, sinew-reinforced bow, composite bow and laminate bow. Self-bows are constructed from a single material, usually wood, and have long limbs up to 200cm to allow a long draw and to decrease the tensile force along the back of the bow, lessening the risk of breakage. This is consistent with the types found in the Mesolithic period (see Chapter 6). All recovered bows of this period are self-bows made from a single stave of wood (Bergman 1993). Other traditional forms of bow have the addition of one or more materials to increase the compressive forces that can be withstood. This increases the amount of energy that can be imparted to the arrow at the same time as permitting a reduction in limb length (making the bow more portable). Sinew-reinforced and composite bows are generally reflexed and are not apparent in the archaeological record of the Early Holocene though possible knowledge of the reflexed bow in the Mesolithic period is suggested by rock carvings at Cueva Saltadora, Spain (Figure 4.2).
It is generally assumed that the bow and arrow were used exclusively in the hunting of terrestrial game (J G D Clark 1975). However, arrows with single or multi-barbed points, without flights and with retrieval lines, have been used for the capture of fish and sea mammals in traditional fisheries, and for sport (von Brandt 1984a). The use of the bow and arrow in water media and the necessity to correct for refraction requires even more skill than when used in the pursuit of terrestrial prey (Rau 1885). It is possible that the bow and arrow was used for fishing in Mesolithic times though in the majority of instances its primary function would have been the capture of terrestrial game.

4.3.4: Hook and Line

There is a huge body of literature concerning the use of the hook and line, a result of the modern leisure pursuit of angling and the immediately identifiable form of the hook. Today, angling is practised primarily as a sport. It is known that ethnographically observed groups also angled for sport rather than for subsistence, especially groups dependent on anadromous species (Spier 1930). During spawning migrations, anadromous fish generally do not feed and do not respond to bait, making the use of the single hook and line inefficient. However it was common practice among certain Native American groups for the first fish of the spawning run to be taken by hook and line as a part of the first fish ceremony (Kroeber & Barrett 1960–62).

The simplest forms of line fishing do not require hooks, bait is tied directly onto the line, colloquially known as ‘bobbing’. The line may be made of moss, wool, hemp or hair, all material that will tangle in fish teeth increasing the chances of landing a fish. This method is commonly used for the small-scale capture of eel (Anguillidae), crustaceans and shellfish. This form of fishing is unlikely to leave a recognisable trace in the archaeological record. Hooks are required to take many species as they will release the bait if they encounter the tension of a line.

There are two main forms of fishing with the hook and line, hand-fishing and long-line fishing. The hand-line consists of a hook and possibly a float and/or sinker. Poles may be used in conjunction with lines to increase the reach of the fisherman and to remove the fisherman from the line of sight of the fish. There are disadvantages to the use of poles: where reels are not utilised the line cannot be too much longer than the pole if the fish is to be easily retrieved and they reduce the ability of the fisherman to ‘feel’ a bite and may allow the fish to escape if any tension is detected before the fish is securely on the hook. The long-line (used in traditional fisheries across the globe) consists of many hooks, which may be attached directly to the main line or via secondary lines, known as snoods, each short enough to prevent snagging of hooks. Floats and sinkers are used to position the line at the appropriate depth for the fish sought and to ensure the line remains clear of the bottom on rough substrates. Long-lines are particularly effective for predatory species, larger individuals, which are found in deeper waters, and for inaccessible fishing grounds. The use of hand lines is generally small-
scale and long-lines is large-scale. Both hand-lines and long-lines can be used in either a passive (set and left unmonitored) or active (from the shore or trolled from a boat) manner. Animal sinews, baleen, plant fibres and hair have all been used as raw materials for lines in non-industrial fisheries (Kroeber & Barrett 1960-62; Hickling 1961; Lagler 1968; von Bandt 1984a; Steane & Foreman 1991; Lokkeborg 1995). The use of kelp lines in marine fishing observed among Northwest Coast groups (Table 3.1) may act as a natural camouflage making the fish less suspicious of bait.

"Line strength is often a question of compromise. Strong, thick line allows you to apply more pressure to a hooked fish, but its greater visibility naturally tends to reduce the number of bites" (Clifford 1989:104).

It is at the point of attachment that the line is most likely to break; secure attachment is essential. The most effective lines are made from materials that have the least contrast to the background and do not reflect light.

Weights used with lines must be accurately determined, the weight must be heavy enough to sink the line but not so heavy that it drags the hook and line into the substrate. The action of tides and currents make the use of weights more prevalent in marine and estuarine fishing than in freshwater fishing. Prevailing currents and weather conditions will influence the choice of weight. Weights can act to secure the hook in the fish if the sinker holds the line taut (Holden 1979).

Hooks are a variation of the barbed point dedicated to the capture of fish. The hook is one of the few implements that can be immediately associated to the capture of fish or other aquatic resources. For this reason it is very unfortunate that these are rare finds in archaeological contexts. The lack of finds may relate to three factors: the use of composite hooks, the components of which, as H Stewart (1975) points out, may be mistakenly identified as, or functionally indistinguishable from, awls; the observation of Steane & Forman (1991) that the points of hooks are frequently broken during deposition and thus may not be recognised; or the discard of hooks only after breakage, resulting in only accidental losses being recovered complete.

It is usual to categorise hooks according to type: single-piece and composite. Rostlund (1952) includes a third category — the gorge — however many authors consider this a separate type of fishing implement (possibly because its use for the capture of terrestrial and avian resources is known and in part due to the view that in many areas it was a precursor to the true fish hook). The gorge is considered separately below.

Fish hook terminology is given in Figure 4.3. A fish hook is comprised of three main parts: the shank to which the line is attached, the bend and the point. Barbs are introduced to the point to reduce the chance of the fish pulling free from the hook and to secure bait, but they can prevent the hook penetrating the flesh if the fish does not bite with force. Rau (1885) states that barbs are essential for
the capture of fish that nibble at bait. In the composite hook, the point and the shank are joined at the bend. The hook being swallowed or becoming embedded in the mouth catches fish. Larger hooks are generally used for the capture of larger fish and may have eyes to facilitate secure line attachment. Long shanks on small hooks and hooks without barbs are used where rapid unhooking of fish is required. It is held that small hooks (and in particular offset hooks) and small baits are most effective in inshore fisheries where small fish species and small individuals of larger species predominate. Large fish can be landed on small hooks but small fish are unlikely to take a large bait on a large hook (Darling 1982).

Hooks are made from a wide range of materials such as wood, bone (including human bone and often sea mammal or bird bone), fish or dog teeth, ivory, shell, stone and various plants with natural barbs (Figure 4.4) (Best 1929; Feustel 1985). Generally, the shank is made from one of the heavier raw materials such as bone, shell or stone to ensure that the hook does not float (von Brandt 1984a). However, certain fisheries require floating hooks and in such cases the entire hook may be made from light woods. The use of shell for hooks is commonplace in traditional fisheries. The lamellar structure of the shell imparts resistance to stress; the nacre acts as an in-built lure (Best 1929b; Kroeber & Barrett 1960–62, de Rohan-Csermak 1963; von Brandt 1984a).

Hook efficiency is a compromise between the visibility of the line and the thickness required to prevent the line snapping and the angle of the bend, which when large, permits the fish to be hooked more deeply but makes escape easier. The addition of a barb will reduce the chance of escape (Brinkhuizen 1983; Clifford 1989).

The mechanical and structural qualities and morphology of bone, which Knecht (1997) states limit the form and dimensions of bone points, would be expected to impinge on the manufacture of single-piece bone hooks. As bone is more likely to crack longitudinally, the hook would have to be cut from the bone so that the grain runs longitudinally across the bend, which experiences the greatest stress (Allen 1996), if the risk of fracture is to be minimised. This would increase the risk of fracture at other parts of the hook. The avoidance of this weakness of bone may have led to the use of the composite or shell hook. Decreasing the length of the shank and/or point of the hook can reduce the stress experienced at the bend (Allen 1996).

4.3.5 Gorge

The gorge comprises a single- or double-ended point, possibly with a groove to facilitate line attachment at the centre of the point. The point is covered with bait (often a small fish), which the intended prey swallows whole. When the line is taut the point is pulled horizontal, snagging the fish. Gorges are made from a variety of natural materials such as bone, wood, horn, stiff grass and flint and
are still in widespread use in South America for fishing (Hickling 1961). Von Brandt (1984a) and Rostlund (1952) both suggest that the gorge is the precursor to the hook. Archaeologically, it is difficult to interpret finds of double ended bone points as gorges, let alone distinguish those used for fishing rather than some other subsistence activity. Gorges were used for fowling by the Eskimo and until the last century in areas of Western Europe (J G D Clark 1965, Feustel 1985). Lartet & Christy 1875 interpret small bi-points as components of composite hooks (Figure 4.5).

4.3.6: Fishing Lures

Lures are all visual, chemical, acoustic or tactile phenomena that attract and concentrate fish (Hickling 1961; von Brandt 1984a). Response to lures varies with fish species, age and sexual maturity. Bait attracts fish through chemical and visual stimuli. Natural chemical stimuli include anise, musk, castor, civet and shrimp oil, which can be rubbed on gear. Fish can be lured to gear by the presence of captured sexual partners or rivals — along the Rhine, female salmon (Salmo salar) are placed in traps to lure males. Noise can be used to attract or frighten fish to gear.

4.3.7: Nets

The simplest nets are knotless. Twisting or knotting the mesh before looping gives the net more stability and consistent mesh size (von Brandt 1984a). Nets are costly to manufacture and maintain but can last for many seasons if cleaned, dried and tanned regularly (Lindstrom 1996). Rounded stones are preferred for net sinkers to prevent damage to the net in setting, hauling and storage (Steane & Foreman 1991). The best tension on set nets such as gillnets is achieved by the use of sinkers of the same size and weight spaced uniformly across the net. Ethnographically, a wide range of materials are known to have been employed in net manufacture including plant fibres, horse hair, animal sinews and leather strips (Rau 1885; Spiers 1930; Rostlund 1952; Netboy 1958; Feustel 1985; Codere 1990; Silverstein 1990). Availability generally determines choice of raw materials.

Nets of traditional fisheries consist of a mesh of plant or animal fibre. Floats and sinkers or a framework may be used to obtain the required form during fishing. The net is often perceived as the most efficient type of fishing gear and its manufacture as evidence for a significant fishing industry (Rostlund 1952; J G D Clark 1965). Whether nets are in fact the most efficient of gears is open to debate. Netting is the most efficient method of taking shoaling species in open waters (Coull 1996) but many authors propose that traps and weirs are equally, if not more, effective under certain hydrological conditions (Enghoff 1994a, b, 1995; Andersen 1995). However, the use of nets does require skill, investment of time, both in terms of manufacture and maintenance, considerable raw materials and implies a certain level of organisation (Rostlund 1952). It has been calculated that the
Manufacture of cord (approximately 6½ miles of cord would be required) and the netting of an average sized gillnet ca. 100’ x 4½’ of mesh size ¼” to 4” would take up to 12 months, based on a six hour working day (Lindstrom 1996).

There is a huge range of different types of nets with many hundreds of local variations, dependent on hydrological conditions and traditions of manufacture (H Stewart 1975). The main categories of net used in non-industrial fisheries are described below.

Encircling nets are an active gear drawn around the intended prey and include:

a) Dip (or scoop) nets are small nets fixed to a round or triangular framework usually operated by one man and are frequently used to land fish at weirs and barriers in freshwater fisheries (Figure 4.6) (Kroeber & Barrett 1960–62; Bullis & Captiva 1969; von Brandt 1984a).

b) Lift nets differ from dip nets only in the method of capture, the nets are set in the water and lifted when fish pass over them (Figure 4.8). Often operated from a platform built out over rivers, these nets can be considerably larger than dip nets.

c) Seines are long, shallow nets with floats and sinkers placed along head- and foot-ropes (Figure 4.7). These nets are set around shoals of fish from shore or in open water from boats and also used under ice in northern latitudes. Two to hundreds of men are required to operate seines of varying size. Open water seines are set out vertically between two canoes and then pulled horizontal, the fish are then caught in a central bag.

d) It is unlikely that Mesolithic groups employed purse seines, for this reason, this gear will not be discussed.

e) Trawls are similar to seines but consist of a conical bag of netting, dragged through the water, around shoals of fish and are generally used for demersal species (Bullis & Captiva 1969). Although H Stewart (1977) documents the use of trawls in the traditional fisheries of Northwest Coast groups (Figure 4.9), this gear is thought to be a relatively late, post-contact, introduction. Similarly, it has only come into widespread use in European fisheries since the development of large-scale commercial fisheries from the mid-19th century. For this reason, it is not thought likely that Mesolithic groups used trawls.

Entangling nets that trap fish in the mesh of the net, are generally (though not always) passive in operation and can be left unmonitored. Fish exhibit a remarkable ability to avoid nets, visual stimuli alerting the fish of their presence. The efficiency of set nets is most affected by visibility, e.g. colour, knot size and net thickness, mesh size and shape. The strength of a net is always compromised by the need to reduce the width of the net cordage. The efficiency of this type of net is greater with increasing mesh size, which is thought to be a consequence of the increased swimming speed of larger fish that have less time to respond when visually alerted to the presence of the net. However, catches of certain species such as trout (Salmo trutta) are always greater (regardless of size of individuals) when small meshes are used (Jensen 1990). This type of gear is most effective when used at night in
slow moving water and can be set at any depth. These types of nets exploit the fact that fish swim backwards very poorly and cannot escape once caught in the mesh (Engås & Lokkeborg 1995). The nets become saturated at the point when the number of fish trapped alerts other fish to the presence of the obstruction. This varies according to species and the amount of net entangled in trying to escape.

Hake (*Merluccius merluccius*), for example, tangle large amounts of net around them, herring (*Clupea harengus*) take up only one mesh per individual. Experimental studies indicate that to use gillnets at their greatest efficiency it should be hauled each day or after two days. It is common practice for fishermen to drive fish toward set nets to increase catches. The main types of set-net used in traditional fisheries are:

**a)** Gillnets are set vertically with the use of floats and sinkers (Figure 4.10). Diamond-shaped meshes (nets set 1/3) are most efficient at trapping fish by the gills but this limits capture to species with oval bodies and as a result square meshes are also used. Experiments with various sizes of mesh indicate that the efficiency of gillnets varies with species sought and their body shape (Jensen 1986). The net traps fish by the gills or by their girth as they try to pass through the mesh and as such are considered the most size selective of all types of fishing net, *i.e.* the size of the mesh determines the size of the fish caught. Fish smaller than the width of the mesh pass through the net. Fish with a width at the gills larger than the mesh will turn away from the net (Kroeber & Barrett 1960-62; Garner 1968; Lagler 1968; Bullis & Captiva 1969; Alexander 1980; von Brandt 1984a; Steane & Foreman 1991; Engås & Lokkeborg 1995).

**b)** Tangle nets take a wider range of sizes of fish than gillnets but preferentially capture fish with rough or spiny bodies, *e.g.* tangle nets are more likely to take perch (*Perca fluviatilis*) than roach (*Rutilus rutilus*) (Engås & Lokkeborg 1995). Tangle nets are very loosely hung meshes that trap fish entangling any part of their body in the mesh (Figure 4.11). Attempts to escape the mesh entangle the fish further. Tangle nets are commonly employed for fishing under ice.

**c)** Trammel nets are comprised of two or three layers of netting (of decreasing mesh size) used in the same manner as tangle nets, the layers of nets reduce the chance of escape (Bullis & Captiva 1969; von Brandt 1984a).

Entrapment nets capture fish in netting in the same manner as basketry traps:

**a)** Cast nets are circular meshes with a cord running its diameter that is drawn taut when the net is cast over a shoal of fish. They are traditionally used for the capture of fish, crayfish (*Astacidea*), squid (*Cephalopoda*), crab (*Brachyura*) and shrimp (*Natantia*). It is an effective method, one of the few operated by one man that can produce large-scale catches (Figure 4.12).

**b)** Somewhat similar, cover nets are set on a conical frame and are released from the frame over passing fish.
4.3.8: Poisons and Suffocants

Fish poisoning and suffocation has been widely practised throughout the world and has been documented since the time of Aristotle. The use of poisons has even been documented in the pursuit of seal (Phocidae) and octopus (Octopus spp.) (Heizer 1953). It is a technique that leaves no direct trace in the archaeological record. Béarez (1998) claims that the size and species structure of an archaeological assemblage from the Indo-Pacific region implies the use of poisons in coastal tidal pools. The use of poisons for marine fishing has only been ethnographically observed in the Indo-Pacific region and could be responsible for the assemblage. However, the conclusions drawn by Béarez ignore other methods of fishing that could have produced the assemblage, such as hand collection or the use of small meshed nets in tidal pools. As yet there is no method for definitively identifying the use of poisons in prehistoric contexts.

Though the use of poisons in coastal fishing has only been recorded in the Indo-Pacific region, it should not be dismissed (as in Bowdler & McGann [1996]) as a technique used in prehistoric fisheries in coastal regions.

Poisons are generally used in slow moving or still freshwater, which restricts dilution of the poison and reduces escape of fish (Hornell 1941; Rostlund 1952; Heizer 1953; Lagler 1968; Brinkhuizen 1983; Gunda 1984; von Brandt 1984a). Larger bodies of water may be artificially dammed to facilitate the use of poisons. The poisons used must be harmless to the consumer or removable by processing and cooking and also must dissipate rapidly to permit stock replenishment (Hornell 1941, Gunda 1984). For this reason, most poisons used traditionally are suffocants rather than stomach poisons. Poisons are most effectively used by mobile groups or groups exploiting fish as a minor resource to prevent depletion of stocks. It is not practised in water used for human consumption. The poisons vary in efficacy, ranging from a few minutes to several hours before the effects are observed; tanins, for example, are very slow-acting poisons and it may take several days for fish to suffocate.

The five main poisoning and suffocating methods are given below:

1. Poisonous plants that are crushed and placed in the water are most commonly used in traditional fisheries. Their efficiency can vary seasonally. The main plant families used are — amaryllis (Amaryllidaceae), morning glory (Convolvulaceae), Chinese yam (Dioscoreae), Rosemary (Laminaceae), Brazil nut (Lecythidaceae), lily (Lilaceae), legumes (Papilionaceae), soapberry (Sapindaceae), snapdragon (Scrophulariceae), solanales (Solanaceae) and vervain (Verbenaceae). Three main chemicals are responsible: rotenones (found in leguminous plants), saponins (widely distributed) and cyanides (this includes their presence in Euphorbia sp. and Phyllanthus sp.)

2. Highly toxic plants may not be placed directly into the water but instead are diluted in water and only the dilution is placed in the body of water to be fished.

3. Poisoned ground or hook baits are effective stomach poisons, but this method usually requires the removal of the gut or extensive cooking to remove all traces of the poison.

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4. Stirring up bottom sediments can reduce available oxygen causing fish to suffocate.
5. Inorganic substances such as lime can be placed in the water, this acts to suffocate the fish. Such practices have been observed in India, Malaysia, Italy, France and Palestine.

An additional method, the use of smoke to suffocate fish, has been observed only amongst Paiute groups of North America. The fire was set onshore and the smoke fanned out over the river. Exactly how this worked is uncertain and was not documented ethnographically.

4.3.9: Snares

Snares traditionally used in fishing consist of a loop of plant or animal fibres that can be placed around a fish and then pulled tight around the fish, which is then quickly lifted out of the water. Figure 4.13 illustrates a number of different types of fish snare. Again, this is a method that leaves little trace in the archaeological record and is a technology ethnographically observed to be widely used for hunting small mammals and waterfowl in addition to fishing for fish, crab (Brachyura), octopus (Octopus spp.) and shark (Elasmobranchii) (J G D Clark 1948b; von Brandt 1984a).

4.3.10: Spears and Harpoons

This study will not assess the role of specific lithic types in the role of Mesolithic fishing technology. The multifunctional use of microliths, ubiquitous on Mesolithic sites across Europe, employed in a wide range of composite implements makes such an analysis impossible and meaningless. Points that may have served a function in fishing will be described.

The raw material of production affects the morphology, manufacture, performance, durability and maintainability of a projectile point (MacGregor 1985; Knecht 1997). Shea (1997) states that stone-tipped spears are a milestone in terms of investment of labour and functional specialisation. The manufacture of stone-tipped spears involves knapping of the point, collection of mastic and binding materials and manufacture of a shaft to allow secure hafting of the point. Reconstruction experiments suggest that the manufacture of stone tipped spears could take nearly twice as long as a simple wooden spear. It is clear from both the ethnographic and archaeological record that points of organic materials were preferred for certain activities.

Points of organic materials have been shown to be more durable and more easily reworked than lithic points (MacGregor 1985; Knecht 1994, 1997). It is for this reason that organic materials may have been preferred for the manufacture of spears and harpoons in prehistory. Though stone points can be more speedily produced than those of bone, the isotropic nature of high quality stone that allows
shaping also makes the stone point highly susceptible to fracture on impact. The morphology and anisotropic nature of bone and antler limits the form and dimensions of points produced. Bone/antler points are made in two stages: production of the blank and reduction to a point by longitudinal scraping and grinding. The structure of bone tends to result in longitudinal fracture under pressure. Antler has a lower mineral content than bone and consequently is 30% more flexible across the grain than bone, which reduces the chance of breakage on impact. The high collagen content of antler permits it to be easily worked and shaped after soaking. Antler points are more robust than bone points and generally antler points break transversely at the tip so can be reworked whereas bone points tend to break at the mid-section and have to be discarded. Antler, where available, would be expected to be the preferred raw material for point manufacture (particularly as bone may be required for fuel or food).

"antler is a significantly tougher material than bone, with a markedly better capacity to absorb shocks and sudden impact loads" (MacGregor 1985:29).

However, the choice of raw material is to some extent culturally determined. For example, the Thule Inuit only use points made from sea mammal bone/ivory for marine hunting. The cross-sectional area of the point base must be less that that of the mid-shaft for efficient penetration. This is generally achieved with the manufacture of a tapered, bevelled or tanged base. Elastic resilience is maximised (i.e. minimal chance of breakage) if the cross-sectional shape is uniform across the implement. The shape of the base determines hafting methods (Knecht 1997). Experiments indicate that points secured by resin only will dislodge on impact, which may be advantageous in certain situations.

The spear is defined as at least one point of bone or stone permanently hafted to a wooden shaft (Bennyhoff 1950). Harpoons are defined as implements with at least one point of bone or stone that detaches from the shaft on impact. The point is provided with a retrieval line, which may also pass through the shaft (or it may have a separate line) acting to impede prey. This design makes them particularly suited to the capture of aquatic animals. The points of harpoons may be designed to toggle in the flesh to secure the prey when the line is pulled taut. Harpoon shafts are generally shorter than those of spears. Leisters are a form of spear particularly associated with fishing: comprised of at least two points fixed on a single haft so that fish are trapped between the points. The points are usually, but not always, barbed to help retain the fish. Increasing the number of points increases the chance of a strike and reduces escape. The points of harpoons and spears are morphologically similar; the distinction lies in the method and permanence of hafting. Points made from organic materials have a wide variety of forms (Hornell 1929b; Curwen 1941; Bennyhoff 1950; Rostlund 1952; Kroeber & Barrett 1960–62; H Stewart 1975; von Brandt 1984a). Figure 4.14 illustrates a number of fishing spears and harpoon used in traditional fisheries of the Northwest Coast groups. Self-barbed points are curved, pointed at both ends, laterally flattened and scored to facilitate hafting — the basal point acts as the barb (Figure 2.5).
It is usual to classify projectiles in terms of morphology: function is generally ignored (Friis-Hansen 1990). J G D Clark states that harpoons and spears can be easily distinguished on the basis of morphology.

"On a priori grounds no great difficulty should exist in distinguishing between two major functional groups, namely harpoon-heads and spear- (or arrow-) heads, since the tasks for which they were designed ought clearly to be reflected in their morphology. In the former the tang would only need to be sufficiently developed to hold the head while the shaft was being propelled and the emphasis would rest on devices needed to secure the line, whether these took the form of perforations, grooves, protuberances or any combination of these. Again, since the barbs of harpoon-heads were designed to hold the victim while it struggled at the end of the line they would have to protect the stem sufficiently to present a hook-like profile, to be stoutly made and therefore to be widely spaced. Spearheads (or for that matter arrowheads) on the other hand were designed to be permanently fixed to shafts while in use. The tangs would in this case be the prominent feature: in the case of arrowheads they might be pointed so as to fit into the head of the shaft without impairing the flight, but in spearheads one might expect to find the tangs longer and broader to give purchase to binding. Again, the barbs, being intended only to hold the weapon in place and so impede the victim, could be finer, more closely set and less prominent" (1975:130).

However, ethnographic and archaeological studies suggest that there is no a priori distinction between spears/arrows and harpoons on morphological grounds (Brinch Petersen 1973; von Brandt 1984a) — for discussion see Chapter 6. It is possibly the difficulty of attributing function to implements that has resulted in morphological classification of points. However, the projectile points produced for use in terrestrial hunting perform a different function from those used for fishing (Friis-Hansen 1990; M C Nelson 1997). Points used in terrestrial hunting are designed to open a large wound to allow the point to penetrate deeply into the flesh and result in wounds that bleed profusely causing the animal to fall at a minimal distance from the hunter. For this reason stone tipped points that penetrate deeply and fracture on impact are preferentially used (M C Nelson 1997). Projectile points used in aquatic media are intended to retain the target prey without necessarily dispatching the prey prior to landing (Friis-Hansen 1990). An assessment of function is essential to determine the use of a wide range of implements in Mesolithic fishing practice (Chapter 6).

In archaeological contexts the method of hafting of some points is suggested by the recovery of binding materials and working of the base for permanent hafting. However, harpoons take a range of forms and only those with perforations can be identified as such. Spear heads and harpoons used for fishing are intended to retain prey while it struggles, so may have equally defined barbs.

Spear fishing is considered a small-scale capture technique. Bennyhoff (1950) found fish spears and harpoons to be the commonest implement used in traditional fisheries in North America. Rostlund (1952) states that the widespread spearing of fish by Native American Indians was culturally conditioned and often used where fishing was economically unimportant. Where fishing was more
important, harpoons or leisters were more frequently used. These implements are frequently used in conjunction with other fishing techniques, such as poisons, lures, ground baits, weirs and barriers (Rostlund 1952; Hickling 1961; Kroeber & Barrett 1960–62; K M Stewart 1989).

Spear throwers (or ‘atlatls’) may be used in conjunction with the spear to increase hunting range and speed (Feustel 1985). S E Churchill (1993) argues that problems of accuracy and velocity make the spear thrower inefficient in the pursuit of terrestrial game, suggesting, with the use of ethnographic observations of the Aleut and Koniag, that the spear thrower was used exclusively in the pursuit of marine resources. Whether this was the case in prehistory where the advent of the bow and arrow may have occurred some time after the development of the spear thrower is uncertain. Both technologies would have been available to Mesolithic groups.

Gaffs, which are amongst the most commonly employed gear in ethnographically observed freshwater fisheries, consist of a point or hook secured on the end of a pole (Figure 4.15). The gaff is used to scoop fish from shallow or surface waters onto land or into boats and is commonly used in conjunction with weirs and lines.

4.3.11: Traps and Pots

The terms trap and weir are used interchangeably by some authors (e.g. Enghoff 1994a, b, 1995; Andersen 1995). In the following study the terms are used to describe distinct types of gear, which may be used in combination. Traps from non-industrial fisheries take a huge range of forms, vary greatly in dimensions and are made from a variety of raw materials, which has resulted in a number of classification schemes (Best 1929; Rostlund 1952; Hickling 1961; Brill 1964; Bullis & Captiva 1969; Brinkhuizen 1983; von Brandt 1984a; Furevik 1995). These variations relate to local availability of raw materials, behaviour of intended prey, hydrological conditions, substrate type and cultural influences. They are defined as any framework structure with a chamber that captures and retains fish. Placing a bend in the entrance to the chamber greatly reduces escape rates. The main types of pots and traps are described below:

1. Tubular traps: traps with a small, funnel-shaped entrance: the size of the entrance impedes escape (Figure 4.16). Two forms of tubular trap are known — closed- or open-weave — which determines the minimum size of the fish retained by the trap. In Europe they are made of hazel (*Corylus* spp.), linden (*Tilia* spp.) and spruce (*Picea* spp.).

2. Non-return devices: these traps have a variety of forms, they are easy to enter but difficult to leave (Figure 4.17). As with tubular traps there are two forms of this device based on the weave of the outer casing; open and close woven.

3. Funnel or trumpet traps: these are wide mouthed traps that taper to the end (Figure 4.18). This type of trap is commonly used with barriers and weirs.
4. Pots/Creels: these are widely used today for crustaceans and eel. They are varied in form (Figure 4.19). Their size is restricted only by weight.

5. Nets: traps may be manufactured from nets set on a wooden framework. The fyke net falls into this category (Figure 4.20).

6. Salmon boxes: set up along salmon migration routes to take fish as they fail to clear any natural obstacle (Figure 4.21).

7. Cover pots: used in turbid, shallow waters (Figure 4.22). The pot is placed over the fish and the fish removed from the hole at the top. Women usually conduct this type of fishing. It was very commonly used in Southeast Europe. (Rostlund 1952; Hickling 1961; Brinkhuizen 1983; von Brandt 1984a)

Traps may be baited to improve catches. Baited traps must be set according to currents and topography to ensure that the chemical stimuli is dispersed and that the fish can enter the trap from downstream. Unbaited traps are most effective if small meshes or close woven baskets are used: fish attracted to them will be thigmotaxic or shelter-seeking species.

Most species of fish will remain alive in a trap for several days, giving the trap a considerable advantage over the use of set nets that must be hauled daily to obtain a fresh catch. Weather conditions may affect the ability of the fisherman to lift catches on a daily basis (Furevik 1995).

4.3.12: Weirs and Barriers

The weir is a passive gear, defined as a structure designed to obstruct the path of or hold fish to facilitate capture (Rostlund 1952). Weirs vary hugely in design. A fisherman from Maine stated,

"all weirs are alike but no two are the same" (Lutins 1992:7).

All perform the same function but are adapted to specific environments and prey. Most frequently, they are constructed on rivers to exploit the temporally and spatially concentrated runs of anadromous and catadromous species but are also set along coasts and lakes to take a wide range of migratory and sessile species. The raw materials used for manufacture depend on local availability, substrate type and strength of current (Rostlund 1952, Brinkhuizen 1983, von Brandt 1984a). Hydrological conditions limit the areas in which weirs can be constructed. Requirements include gently sloping shores, suitable substrates and current/flow of a certain strength or significant tidal change. Weirs constructed in strong tidal currents may be made of stone and exploit the tidal action to trap fish on the ebb flow. Their use requires a significant change in water level with tidal action (Rostlund 1952). Unfortunately, most preserved prehistoric weirs are of stone and consequently cannot be dated. Riverine and lacustrine weirs are generally constructed from wooden posts supporting wattle fencing and may incorporate traps to hold fish, allowing the weir to be left unattended (Kroeber & Barrett
1960-62). Using piles, fences or traps made from plant species poisonous to fish may increase gear efficiency (Gunda 1984). They may be fixed or portable and are very varied in design (Figure 4.23).

Weir construction would have been a co-operative task implying organisation and leadership and is ethnographically observed to be a male pursuit (von Brandt 1984a).

"Both in recent times and in prehistoric times the quantity of materials used to build the stationary fishing structures was enormous" (Pedersen 1995:83).

The large V-shaped weirs constructed by the Yurok to exploit salmon runs required the co-operation of several hundred men, all of whom brought raw materials for construction to the temporary fishing camp set on the shore next to the weir (Kroeber & Barrett 1960-62). Even the simplest of barriers such as the wattle fences used by the Karok and Yurok were reported to have taken up to two weeks to construct. Over soft substrates continual erosion both underneath and around the weir would require frequent repair or reconstruction, adding to the workload (Hickling 1961). Lutins (1992) suggests that the need for maintenance and repair may have influenced settlement location.

"There are many advantages with stationary fishing equipment: it is labour saving, efficient and members of the population not normally involved in subsistence activities (children, older people) could participate." (Andersen 1995:54).

Weirs used to exploit anadromous/catadromous species may have gratings to permit small fish to pass or may be left open at specific times. However, the use of weirs is beneficial to stocks, acting to prevent overcrowding at spawning grounds (Swezey & Heizer 1984).

The weave of the screens had to be smooth to prevent vegetation becoming entangled in the fence and scaring the fish or making the screen too heavy (Pedersen 1995). Great care is taken to remove accumulating vegetation from the weir walls at regular intervals to prevent collapse (Foster 1995). Once abandoned, water action rapidly destroys weirs, which may explain their relative scarcity in the archaeological record. Another possible factor in the limited number of finds is the recent exploitation of coastal gravel and alluvial sediments. Lutins (1992) attributes the lack of finds of fishing gear at sites with abundant fish remains to the use of weirs that are not preserved or are not sought.

4.3.13: Watercraft

Some fishing activities require the use of a form of watercraft. Bjerck (1995) states that a seaworthy boat is the most important technological development for marine hunting. This is one of the most difficult areas of fishing gear to be discussed in the context of prehistoric usage due to the limited number of finds (see Chapter 6). All of the different types of fishing gear detailed above can be operated more than adequately without the use of watercraft. The use of watercraft for fishing
activities increases the spatial range of the fisherman and allows inhabitants of offshore waters to be exploited. The distribution of finds, the examples of watercraft shown on Stone Age rock engravings and the watercraft recovered from Mesolithic contexts has led to the conclusion that two main forms of craft were probably in use: the dugout and the coracle. There is no direct evidence for more complex vessels. Ethnographically, dugouts have a wide distribution in temperate areas. Johnstone (1980) attributes this to the availability of suitable trees rather than to hydrological conditions. Narrow dugouts have limited lateral stability. They can be easily overturned, i.e. their operation requires considerable skill, particularly in rough waters.

"For lakes, slow running rivers or even short coastal journeys, dugouts would have been usable. But when it came to open-sea voyages in northern Europe, especially in the cold conditions which lasted for a time after the passing of the last glaciation dug-outs would hardly have been satisfactory" (Johnstone 1980:27).

He argues for the use of bark canoes in seacoast situations stating that in the manufacture of watercraft, bark,

"was one of the most obvious materials for prehistoric man to use...it leaves very little trace in the archaeological record" (1980:17).

However, Johnstone, himself, points out that though bark canoes have a wide ethnographic distribution, they were used primarily in lakes and rivers. For the open sea he argues for the use of skin coracles. These are ethnographically the most widespread form of skin boats. Sealskins have long been prized as coverings for coracles and kayaks as they are waterproof and resistant to floating ice (J G D Clark 1975). They are frequently recovered among the faunal remains of coastal Mesolithic sites.

4.4: Baited Gear

4.4.1: Natural Baits

A wide range of insects, molluscs, fish, crustaceans, plants and other foodstuffs can be used as bait. Fish respond to different baits depending on species, individual food preference and temporal variations in behavioural patterns. Almost all natural food sources can be used as bait. However, Holden (1979) states that there are two baits that are almost universally effective; worms and fish. Effective insect baits for freshwater fishing with hook and line include spiders, ants, casters, maggots, wasps and flies (Hickling 1961). Most freshwater species will respond to maggots and worms. Maggots are useful for the capture of surface feeding fish with hook and line. When immersed maggots absorb water and will float naturally, making the use of artificial floats unnecessary. Lugworm (Arenicolodae), ragworm (Nereidae), shellfish and fish are good natural baits for most species of sea fish (Holden 1979). Fish with high oil content such as herring (Clupea harengus), mackerel (Scomber scombrus), smelt (Osmerus eperlanus), sprat (Sprattus sprattus), eel (Anguilla
Breeding and feeding cycles. Studies indicate demersal species with limited visual acuity. Seasonal variation in fishery responses is also evident. For example, torsk (Bosme brosme) feed on copepods during the summer making them more attractive for torsk (Bosme brosme) and haddock (Melanogrammus aeglefinus) than at other times of the year. Response to bait varies between species due to biology. Predatory species that hunt by sight are more likely to react to visual rather than chemical stimuli (Løkkeborg 1995). This is reversed for demersal species with limited visual acuity. Seasonal variation in response to bait is caused by breeding and feeding cycles. Studies indicate that in migratory species where appetite is suppressed,
(e.g. cod [Gadus morhua]) there is no response to chemical stimuli, but there may be a reaction to visual stimuli — the size, shape, movement and colour of the bait become important.

This seasonal and species variability in bait preference is further complicated by the individual preference of fishermen. Among the traditional fisheries of Japan choice of bait was found to vary according to the age and skill of the fishermen with younger or less skilled fishermen preferring to use live baits in all instances influencing the size and species obtained (Akimichi 1977).

All the above factors that influence bait use and preference obscure any understanding of gear selectivity (see Section 4.8) determined from gear morphology, operation of the gear and fish biology, thus blurring any resolution that could be obtained.

Lures are often more effective than bait but tend to catch smaller individuals. Bird feathers have been commonly used as lures but today are used mainly for angling mackerel (Scomber scombrus). A string of feathers is thought to resemble a shoal of small fish. Feathers of vivid colours appeal to cod (Gadus morhua), pollack (Pollachius pollachius) and saithe (Pollachius virens).

4.4.2: Natural Baits Obtainable from the Shore

The lugworm (Arenicola marina), up to 30 cm in length depending on species, can be found buried in sandy beaches. It reveals its location with characteristic spiral casts and is most easily collected at low spring tides (Holden 1979; Darling 1982). Smaller specimens have higher water content and leave a stronger trail/aroma when hooked. Their length requires a hook with a long shank to prevent them slipping off the hook. Sharks (Elasmobranchii), conger (Conger conger) and mullet (Mugilidae) will not take lugworm (Arenicola marina). Ragworm (Nereidae), (which grow up to 20 cm) are common on beaches with a mix of sand, mud and gravel and can be located by squirts of water ejected from their holes and again are useful because they are a natural bait. They are considered second only to lugworm (Arenicola marina) as a marine species bait. King ragworm (Nereis virens), which grows up to 50 cm and inhabits sandy beaches, is ideal for large specimens of bass (Dicentrarchus labrax), cod (Gadus morhua), smoothhound (Mustelus mustelus), pollack (Pollachius pollachius), saithe (Pollachius virens) and rays (Rajidae). Flounder (Platichthys flesus) and mullet (Mugilidae) favour harbour ragworm (Nereis diversicolor), which is found in estuaries. Particularly favoured by flatfish (Pleuronectidae) and bass (Serranidae), peeler crabs (Brachyura) inhabit rocky shores, and are found in sheltered areas (often in vegetation or thick estuarine mud) in spring and summer (Darling 1982). Often, at the time of peeling, fish will not respond to any other type of bait. The gills are always removed from crab bait, as they are poisonous and will repel the fish. Crab flesh will start to spoil within 30 minutes of death and after this time becomes useless as bait.
Prawn (Natantia) and shrimp (Natantia) are excellent shore baits for wrasse (Labridae), pollack (Pollachius pollachius) and bass (Serranidae) and for the offshore fishing of whiting (Merlangius merlangus). Both can be taken from rock pools in nets that may be baited with mackerel (Scomber scombrus) or herring (Clupea harengus). The hooks used are as small and light as possible so that the shrimp/prawn move naturally on the hook. However for this reason they come off the hook readily.

Razor shell (Solenidae) flesh is a useful bait, retaining firmness on the hook. Darling (1982) states that it is the most effective of any type of shellfish bait. They may be brought to the surface after storms (when they are consumed by bass and flatfish) but require a considerable amount of skill to capture when buried in sand (Holden 1979). Some anglers use razor shell (Solenidae), which has been left to spoil, for cod (Gadus morhua), whiting (Merlangius merlangus) and flatfish (Pleuronectidae). The characteristic keyhole-shaped burrows of razor-shell (Solenidae) are used to locate this bait. They are more easily caught at night and are dug out or taken with a barbed spear.

Mussels (Mytilidae) are excellent natural bait, the largest specimens being the most attractive to fish. However, the soft flesh makes it of limited use in angling (Darling 1982). Extracting the meat for bait is not easy as boiling the mussel flesh reduces its appeal. It is usual to shock the mussel. Cod (Gadus morhua) are frequently taken along the rocky coasts of eastern Britain with mussel (Mytilus spp.) bait.

Single limpets (Patella spp.) threaded onto a small hook are good baits for small and medium sized fish, though not fashionable today (Holden 1979). It is the most natural and easily obtained bait for fishing rocky shores for wrasse (Labridae) and other seabed feeders and very attractive if combined with lugworm (Arenicolidae). Clumps of limpets (Patella spp.) are effective for larger fish such as whiting (Merlangius merlangus), bass (Dicentrarchus labrax) and cod (Gadus morhua). The common limpet (Patella vulgata) is a tough bait with a rubbery texture and stays on the hook well. Fish are most responsive to shellfish bait in coastal waters immediately after storms (Darling 1982).

Worms are an easily obtainable versatile bait and particularly effective in summer floods. Lobworms are large worms some 5–18cm in length; if kept in grass or sphagnum moss the skins toughen making them very desirable bait to fish (especially large tench [Tinca tinca], carp [Cyprinus carpio], chub [Leuciscus cephalus] and barbel [Barbus barbus]) and increasing the length of time they stay on the hook. Care should be taken when placing a worm on the hook as it is the wriggling of the worm that attracts fish.

Hemp (Cannabis sativa) bait is made from boiling the seeds to split them, (fish are attracted to the oily smell and taste), which is then mixed with ground bait (commonly used for roach [Rutilus rutilus], barbel [Barbus barbus], tench [Tinca tinca], carp [Cyprinus carpio], dace [Leuciscus leuciscus] and chub [Leuciscus cephalus] in the warmer months). The seeds are kept wet to prevent them from floating.
Sandeels (Ammodytidae) are good fish bait for any predatory species (Holden 1979). These are raked from the shore of sandy beaches at low tide.

4.5: Archaeological Evidence for Fishing Gear

The expected artefactual remains of fishing gear observed in use in non-industrial fisheries in various preservation conditions are detailed in Table 4.3. The table includes only gear thought to have been within the technological capabilities of Mesolithic groups. The use of the various type of fishing methods and gear, detailed in Section 4.4 above, by Mesolithic fishermen, is determined from the recovery of their expected archaeological correlates — see Chapter 6.

As indicated, outside of waterlogged conditions, fishing implements that can be definitively identified as such are expected to be rare in archaeological contexts. The archaeological excavations of Mesolithic sites confirm this. There would also be no archaeological evidence (except circumstantial such as in shell mounds) for baits. Hooks are relatively rare finds on archaeological sites of any period. This may in part be due to the fact that they are often made from very friable materials. Ethnographic and ethnohistoric records detail hooks made of wood, thorns and fish teeth (Chapter 3).

K. M. Stewart makes the statement that,

"The most notable aspects of traditional technology is its potential lack of visibility in the archaeological record. Virtually all implements are constructed of grass, fibres, reeds or wood, none of which preserve except in exceptional circumstances; only lithic or bone spear/harpoon heads or hooks have good survival potential" (1989:77).

Although this is stated of African fishing technology it is equally applicable to all traditional and prehistoric fishing technologies.

4.6: Correlating Fishing Gear and Faunal Remains

An important question for the archaeologist is whether it is possible either to predict the target fish species given a set of identified fishing gear or the reverse, whether a given fish assemblage can indicate a particular fishing strategy requiring dedicated fishing gear. This is of particular importance at sites where only one type of evidence has been preserved, i.e. either faunal remains or fishing implements. Recent developments in methods of excavation and processing have resulted in a reduction in the number of sites where only fishing implements are recovered. However, it is still common to recover fishing assemblages with no related fishing implements. The veracity of any
predictive model of expected fishing strategy reconstructed from either faunal remains or fishing implements can be tested at sites where both categories of finds have been made.

4.7: The Use of Fishing Gear to Reconstruct Fishing Strategies

Prehistoric fishing methods are usually determined from recovered artefacts in conjunction with relevant ethnographic and ethnohistoric records. In the literature on the use of traditional fishing gear it is often stated that different types of gear are intended for the capture of a range of prey species. If it can be assumed that fishing implements can be identified with certainty at Mesolithic sites, it may be possible, using this information, to suggest the target species of Mesolithic fishermen on the basis of recovered fishing gear. Clearly, this will only be representative of all the fishing practices on a Mesolithic site if a representative sample of fishing gear is preserved. There exists no way of determining if this is the case. Fishing implements are designed for use in a range of water conditions and for a wide range of target species. Some types of gear are dedicated to use in very specific water conditions. In the following section, the specific conditions of operation of fishing gear, which is expected to have some form of archaeological correlate, is detailed. The use of this information to predict the strategy (both the operation of gear and the possible target species) of Mesolithic fishermen from artefactual remains is then discussed. This section documents only fishing methods that can be expected to leave some form of recognisable archaeological correlate.

4.7.1: Bow and Arrow

The bow and arrow, more generally associated with subsistence hunting of terrestrial game, were used by modern/historic hunter-gatherer groups for the sporting pursuit of fish and occasionally to meet subsistence requirements (von Brandt 1984a). When used in fishing, a retrieval line is attached to the arrow shaft and multiple points may be used. In the context of a sport it is used only in the pursuit of large, slow moving voracious fish. A prerequisite for use is clear water and surface feeding/swimming fish. It is probable that if Mesolithic fishermen did indeed use the bow and arrow for either subsistence activities or sport it would not have been employed in the capture of smaller fish species.

4.7.2: Hook and Gorge

Today, a wide range of hook forms and sizes are used for various species, based on fish biology and behaviour. It is widely held that the hook size directly relates to fish length. This holds only for swallowed hooks. The only limit to the size of fish that can be caught by the hook becoming embedded in the mouth is the strength of the hook and the line (Owen & Merrick 1994; Allen 1996).
Though the above generalisations on hook form and fishing practices are widely accepted, assessing possible fishing strategies from the form of a hook requires an understanding of possible stylistic traits as distinct from functional morphology (Allen 1996). The major problem in prehistoric terms is the presence of traits that may be cultural indicators in certain circumstances but serve a functional purpose in others. Allen (1996) conducted an extensive analysis of the traits observed in East Polynesian fish hooks (Aitutaki, Cook Islands). The results of this study suggest that modes of line attachment are highly stylistic and therefore act as good chronological indicators. The curvature of the hook shank and bend and the raw material used are observed to be functional, determining the method of capture. The raw material for hook manufacture affects ease of production, risk of breakage and success rates. Though shell has less elasticity than bone, the cross-laminated structure makes it stronger at the bend. Pearl shell was preferred for Polynesian hooks, the lustre of the shell acting as a lure. Where pearl shell was uncommon, in East Polynesia, single-piece hooks were rare; bone was the preferred raw material for composite hooks. ‘With two-piece hooks, the weak bend region is effectively ‘broken’ and then reinforced with a flexible lashing’ (Allen 1996:109).

The morphology of the hook bend determines the type of fish species that are taken. Circular hooks are generally ingested whole, rotating in the mouth and piercing the flesh. The strongest hooks of this type have little distance between the point and the shank, these tend to be used in the deepest water for the largest fish. Rotating hooks are used in deep water or in strong currents where jerking the line is difficult or in shallower water for large prey. Hooks with more open bends and straight shanks are used in a jabbing motion to take fish through the mouth and are more effective for fish that nibble at bait (Engås & Løkkeborg 1995; Løkkeborg 1995; Allen 1996). These hooks are used in shallow water or where a taut line can be maintained, e.g. trolling. Allen (1996) also observed that wide bends catch deeply in the mouth and are more difficult for the fish to spit out but that fish with the smallest mouths should be taken on hooks with narrow bends.

An advantage to the use of the hook and line or the gorge is that they can be used in almost any water or weather conditions (Lagler 1968). The exceptions to this are waters with dense vegetation, which tend to snag lines, and very rough ground, which will blunt hooks fished near the substrate (Lagler 1968; Holden 1979).

4.7.3: Nets

All nets will only capture fish larger than the dimension of the mesh used. However, a wide range of fish species and varying sizes of fish are taken with nets with mesh size constructed accordingly. It is only the gillnet that will not capture fish larger than the size of the mesh. Gillnets are most efficient when used in water no deeper than 2/3 the height of the slack net. Tidal flow and strong currents reduce the height of the gill net thereby reducing efficiency. Seines are used in all types of waters:
lakes, estuaries, seas and rivers. Ethnographic literature concerning the use of seines nets indicates that catches are generally shared equally between participants. Seines are most commonly operated with one end secured on shore. This requires a very specific topography: a soft substrate and waters free from vegetation to prevent the net rolling up or being damaged and a flat or gently sloping shore to prevent fish escaping under the net and to permit the fish to be hauled. Seines are most efficiently used in shallow waters where the net extends from the substrate to the water surface (Kroeber & Barrett 1960–62; Lagler 1968; Bullis & Captiva 1969; Alexander 1980; von Brandt 1984a; Steane & Foreman 1991; Engås & Lokkeborg 1995).

Prevailing weather condition, currents, and underwater topography limit the operation of the various types of nets. However, it is only turbulent water that is detrimental to any type of net fishing. In strong tidal flow the fish swim in deeper, slack water and are only caught in the lower reaches of a net. The best conditions for net fishing are to be found at the mouths of large rivers.

4.7.4: Snares

Snares can only be effectively employed in clear shallow waters. They have been observed ethnographically in use for the capture of large species and individuals (von Brandt 1984a).

4.7.5: Spears and Harpoons

The use of spears, harpoons and leisters for fishing is most effective in clear waters, but all can be fished ‘blind’ in any water conditions (Rostlund 1952; Hickling 1961; Kroeber & Barrett 1960–62; K M Stewart 1989).

4.7.6: Traps

The only limitation on the size of the fish that can be taken with a trap is the dimensions of the trap entrance. This is generally quite small in traps that do not make use of prevailing tides or currents, (i.e. throated or chambered traps), to prevent the escape of fish. Traps with loose netting entrances catch fewer fish than traps with rigid entrances. As fish are wary of soft netting entrances, which could prevent the escape of fish and have large dimensions permitting large fish to enter the trap, most chambered trap entrances have some form of supporting framework. Escape is impeded by narrowing the entrance to the retaining chamber, thus limiting the size of the fish taken.
Traps can be used in isolation, set out in long-lines or placed together to form a barrier and used in any depth of water (Furevik 1995). Owen & Merrick (1994) and Morrill (1980) state that trap fishing is the most restricted technique in terms of the conditions under which they are effective, they are restricted to calm conditions and flat substrates but are the most efficient device in terms of labour input compared to yield. Ethnographically they are seldom observed in use in deeper waters. Hickling (1961) states that the trap is the most effective gear of the traditional freshwater fisheries of the African continent. Stone traps are much more durable than those made from organic materials and can be used in a much wider range of water conditions.

4.7.7: Weirs/Barriers

Weirs and barriers will capture fish of all species and sizes (Rostlund 1952; Lutins 1992). The restrictions to the use of weirs concern the local availability of appropriate construction materials, waters with sufficient current strength to retain and concentrate the fish and a suitable substrate and water-depth for construction.

4.7.8: Summary

Fishing gear remains can only be used to reconstruct prehistoric fishing strategies in the most general of terms (Table 4.4), indicating the potential range of species types and sizes (based on local availability of species) that may have been targeted with a specific gear and suggesting the types of waters that were most likely to have been exploited with the different types of gear (Table 4.4). However, it is possible to list the types of species that cannot be caught by certain types of gear. For example, filter-feeding fish such as the mullet (Mugilidae) are very unlikely to be taken with hooks or gorges. Likewise, nets and projectiles are not commonly used for the capture of small fish and chambered-traps will not take large individuals or species. Therefore, it is not possible on the basis of recovered remains of fishing gear alone to detail the exact species sought or the type of fishing grounds exploited.

4.8: The Use of Fish Remains to Reconstruct Fishing Strategies

It is commonplace for archaeologists and archaeo-ichthyologists to reconstruct fishing practices from fish remains recovered from Mesolithic sites (e.g. Tringham 1971; J G D Clark 1975; Coutts 1975a; Leach 1979; Aaris-Sørensen 1980a; Cleland 1982, 1989; Balme 1983; van Neer 1984; Fischer 1987; Rosenlund 1986; L Jonsson 1988; Hongo 1989; K M Stewart 1989; Enghoff 1991, 1993, 1994a, b, 1995; Leach & Boocock 1993; Cartwright 1994; Attenbrow & Steele 1995; Bowdler & McGann
There is no established method to achieve this. Commonly, the archaeo-ichthyologist produces hypotheses on fishing practices based on the ‘gear selection’ approach (the assumption that different types of gear will catch fish of a distinguishable species and size range) coupled with artefactual remains, local ethnography and a small contribution from information known about the behaviour and ecology of the fish present in the assemblage. The gear selection approach requires knowledge of observed patterns in the species and size structure of an assemblage and the known selectivity of certain types of fishing gear to reconstruct fishing methods.

4.8.1: Gear Selectivity

The limited number of finds of fishing gear that can readily be identified as such, the problems associated with determining implement function and the large number of recently excavated fish assemblages has led to the development of a non-artefactual approach to the reconstruction of fishing methods; analysing the structure of fish assemblages for indicators of size or species selection from which fishing gear can be inferred on the basis of gear selectivity patterns. It is therefore important to assess the selectivity of the various methods of fish capture and whether this has any applicability for reconstruction of Mesolithic fishing methods (Table 4.5).

Authors on the subject of gear operation (Rostlund 1952; Lagler 1968; Jensen 1990; Løkkeborg 1995) indicate that most types of fishing gear are selective to size, species and to sex, depending on conditions of operational and fish biology. Colley (1986a) has listed the selectivity of various types of fishing gear and discusses its potential use in reconstruction of prehistoric fishing practices. Two basic assumptions underlie this type of reconstruction: that modern populations are representative of prehistoric ones and that the archaeological assemblage is representative of the assemblage originally deposited (Colley 1986b; Bowdler & McGann 1996). A number of archaeological studies have reconstructed past fishing techniques from prehistoric faunal assemblage composition, based on gear selectivity (e.g. Balme 1983; Coutts 1975a; Owen & Merrick 1994; Bowdler & McGann 1996; Béarez 1998). This requires knowledge of the normal fish population to assess deviations from this that may be the result of gear selection (Bowdler & McGann 1996).

4.8.2: Hook and Line

It is commonly assumed in archaeological literature that hook size determines the size of individual caught (e.g. Ishiyama 1952; Koike 1986; Brinkhuizen 1983). This stems from the use, by anglers, of large hooks with suitably sized baits for large prey. This selectivity is not suitable for the reconstruction of fishing methods from faunal remains as large fish can be taken on small hooks. Moreover, a hook is only size selective if it is swallowed and only certain species ingest food (e.g. cod
[Gadus morhua], ling [Molva molva] and torsk [Brosme brosme]). Those species that nibble at bait (e.g. haddock [Melanogrammus aeglefinus], halibut [Hippoglossus hippoglossus] and hake [Merluccius merluccii]) may be embedded through the mouth and in these circumstances any size of fish can be taken on small hooks (Coutts 1975a; Owen & Merrick 1984). According to Davidson (1967, 1984) observation of fishing practices of the inhabitants of the Nukuoro atoll in the Pacific indicate that choice of hook depends not only on the species and size of the intended prey but also on prevailing hydrological conditions and personal preference.

Studies of modern fishing practices indicate that long-lines are highly selective in fish capture. Fish distribution, feeding range, competition, hook design, and type and size of bait determines size, species and sex selection. Increasing the distance between the hooks generally increases the size of the fish caught. This is a consequence of the greater home range of larger fish, the reduced risk of predators, and the ability to fend off competition. This holds also for the use of large bait that captures a greater proportion of larger fish through competition (Engås & Løkkeborg 1995, Løkkeborg 1995).

Baiting and setting a long-line immediately prior to natural feeding times in strong currents maximises the catch (Engås & Løkkeborg 1995; Løkkeborg 1995). The choice of bait influences the size and species range caught (i.e. gear selectivity), particularly in the capture of demersal species, which react to chemical rather than visual stimuli. The release of bait odour reduces over time, which, in combination with degradation through bacterial activity and up to 50% bait loss on hand baited lines, results in a reducing rate of capture. Experiments have shown that there is a huge reduction in the amino acids released by mackerel (Scombridae) bait within two hours of initial soak time. Long-lines therefore take the majority of the catch during the first few hours of immersion. Further influencing the selectivity of the long-line is the attraction of certain species to the gear by the action of the fish already caught trying to escape the line, other species will be scared away.

In Mesolithic contexts it is assumed that deep-water voracious species (such as cod [Gadus morhua], ling [Molva molva] and torsk [Brosme brosme]) were taken with hook and line. However, Clifford (1989) states that these fish can be caught by a number of other methods and the use of hook and line should not be assumed in all cases without corroborating evidence.

Long-lines will take more females than males during the spawning season, possibly related to the increased nutritional needs of the female at this time and the aggressive behaviour of the male, which suppresses appetite (Engås & Løkkeborg 1995).
4.8.3: Nets

Gillnets are highly selective to fish size and species (Jensen 1990). The size of fish caught is dependent on the mesh size of the net (Garner 1968). The fish are caught by the gills, by their girth or if the net is loosely hung, by becoming entangled in the mesh — each method producing a different selectivity both in terms of size range and species caught. Such set nets tend to capture mobile rather than sedentary species. A taut gillnet will catch only those fish small enough to pass into the mesh but too large to pass right through the net (Lagler 1968; Balme 1983; Colley 1986b; Jensen 1990; Bowdler & McGann 1996). Even small changes in mesh size will produce greatly differing size ranges (Engås & Løkkeborg 1995). Small variations in selectivity are caused by the texture of the mesh. Cod (Gadus morhua) fished with gillnets tend to be trapped by the gills or are wedged in the net by their girth if the mesh is made from firm cordage whereas those of a softer material are more often entangled.

Although the highly selective nature of the gillnet would be expected to be identifiable in the archaeological record (if the assemblage can be assumed to be representative of that originally deposited) this is complicated by the similarity of the selectivity observed with the use of hook and line for individuals of a certain size and target species. Owen & Merrick (1994) suggest that the use of gillnets may be distinguished from selective hook and line fishing by the presence of deep water species as the use of gillnets is restricted to shallow water. This provides no method for distinguishing the use of different gear types.

If fish are very abundant and the catch is very large (e.g. this sometimes occurs when gillnets are employed during spawning migrations) the mesh ‘choke’ and the selectivity of gillnets will be obscured (Engås & Løkkeborg 1995). When used over spawning grounds gillnets will take more males, which are more mobile (due to aggressive behaviour) at this time.

Other netting methods are selective only in that fish of dimensions smaller than the mesh size may (but not always) pass through the net (Lagler 1968; Colley 1986b; Bowdler & McGann 1996). Fish species with greater visual acuity may be more able to avoid stationary or set nets but this would not affect the selectivity of encircling or entrapping nets.

4.8.4: Traps

Traps are considered the least selective of the main types of fishing gear (with the exception of the barrier/weir that impedes the movement of all fish moving upstream) by many authors discussing prehistoric fishing practices (e.g. Rostlund 1952; Balme 1983; Brinkhuizen 1983; Enghoff 1994a, b, 1995a, b, c).
1995; Andersen 1995). It is often assumed that the only restriction to the range of fish captured is the dimension of the trap entrance.

Despite this apparent non-selectivity of traps, catches do exhibit certain anomalies. Torsk [Brosme brosme], for example, are frequent taken in traps (particularly smaller traps) even in waters in which they are relatively scarce whereas haddock (Melanogrammus aeglefinus) and pollack (Pollachius pollachius) are very wary of traps and are rarely taken by this method (Furevik 1995). Experimental studies conducted off the coast of western Finnmark indicate that, on average, cod (Gadus morhua) comprise 90% of the species taken in traps whereas long-lines set in the same waters will take an equal proportion of haddock (Melanogrammus aeglefinus) and cod (Gadus morhua). Certain species make more of an effort to escape a trap (e.g. cod [Gadus morhua]) and this will affect the species representation of a catch. In certain circumstances, the use of traps is actually highly selective and resulting catches are analogous to those taken with gear generally assumed to be more selective. As is the case with many other stationary gears, traps tend not to capture sessile species. Trap selectivity may be similar to that of hook and line fishing and gill netting where large traps are used to take schooling species (Merrick & Owen 1994). Moreover, large traps can be selective to larger individuals due to the larger outline of the trap (Lagler 1968, Colley 1986b, Furevik 1995). The weave of the trap also determines the range of species taken — traps with open weaves will not retain smaller fish (Brinkhuizen 1983). Closely woven traps are generally intended for the capture of small species.

Chambered traps and pots set without baits will attract thigmotaxic species only. Traps may be baited to take non-thigmotaxic species and increase capture rates. Studies indicate that traps set without baits may be completely ineffective (Furevik 1995). Baited traps must be set at some distance from each other to prevent the overlap of the active space of the bait, which will reduce capture rates (it makes the source of the bait more difficult to locate). Bright-coloured lures set at the trap entrance also increases trap efficacy. Choice of bait will affect the species selectivity of the gear. For example, traps set along the Norwegian coast in winter were found to take a greater proportion of cod (Gadus morhua) if baited with squid (Cephlopoda) and crushed crab (Brachyura) than when set with herring (Clupeidae) bait (Furevik 1995).

Another method of altering the selectivity of a trap is to place a fish in the trap when it is set. This attracts other fish of the same species through intra-specific social behaviour or by pheromones during the spawning season. At a certain threshold, saturation will be reached. At this point, the activity of the fish retained by the trap will act to scare other fish away from the device.
4.8.5: Spear and Harpoons

The use of fish spears and harpoons is highly selective for fish size and species (Colley 1986b; Owen & Merrick 1994; Bowdler & McGann 1996). This is a consequence of the personal choice of the fisherman. However, species or individuals inhabiting deep water and smaller species and individuals are less likely to be actively pursued by spear/harpoon fishermen.

Identifying the selection pattern of the spear or harpoon in the faunal record is impossible. It is very similar to that obtained from hook and line fishing and could only be distinguished from this practice by the presence of species that do not take a hook (this includes only a very small number of species — see Chapter 5 and Table 5.3). Balme (1983) points out that the use of the spear/harpoon on many different fishing expeditions for different species, will display the same selectivity pattern as the use of the less selective trap. This criticism of the use of selectivity of gear to reconstruct fishing is applicable to all types of highly selective gear, the patterns of which can be obscured by the mixing of remains from different fishing expeditions.

4.8.6: Weirs

Weirs and barriers are generally unselective, taking all fish impeded by the structure (Colley 1986b; Bowdler & McGann 1996). However, the nature of weir fisheries, commonly constructed for the exploitation of certain migratory species, often results in the dominance of a small number of species in catches. Furthermore, fishermen often select the fish that are extracted from barriers or weir traps both for size and species. These factors complicate the determination of the selectivity of such structures: a very selective catch can be made using an essentially non-selective gear.

4.8.7: Poisons

Poisons are unselective, taking all fish present within the active space of the poison (Bowdler & McGann 1996). However, it has been observed that certain species are more resilient to poisons than others. For example, the recent polluting of sections of the River Tisza in Hungary with cyanides resulted in the mass mortality of all fish species with the exception of catfish (Silurus glanis).

4.9: Selectivity of Active and Passive Gears

Active and passive gears have different species selectivity. The use of passive gears such as set nets, traps and lines eliminates the need for the fisherman to constantly monitor gear. This type of gear is
more likely to take active species due to higher feeding rates and a larger home range and is dependent on fish movement, which is affected by a number of factors including atmospheric pressure, prevailing currents and transmitted light. Active gears can be used to take both active and more sessile species. The efficiency and selectivity of active gear is more dependent on the skill of the fisherman in locating fish and operating the gear than on fish movement (Lagler 1968, Engås & Løkkeborg 1995). The range of species and sizes that can be taken by the various active and passive techniques would make it impossible to distinguish these two types of gear from faunal remains alone.

4.10: The Importance of Fish Size Determination

The gear selection approach (and indeed an alternative approach detailed below) requires the identification and quantification of fish species represented and also the accurate reconstruction of the size range of the fish within the assemblage. Identification depends on the availability of modern reference collections and to a large extent on the skill of the archaeo-ichthyologist. The determination of fish size from preserved skeletal elements has been the focus of much research.

Fish growth follows a sigmoidal curve (Wilkinson 1981; Le Gall 1984). Growth depends on physiological and environmental factors; the most important external factors being quality and quantity of food and temperature (as fish are ectothermic, their metabolism is determined by environmental temperature). Growth therefore reflects seasonality, with active growth in the warmer months and minimal growth in winter. The seasonality of growth allows the age of archaeological samples to be determined by two main methods: the Petersen length-frequency technique, which assumes that all individuals of the same age will be the same length (crude), and growth-ring analysis of bones, scales or otoliths. The two zones of annual growth are clearest on otoliths. Otoliths have been recognised as accurate indicators of fish size and age since the late 19th century and as they can be distinguished to species, they are frequently used to reconstruct fish length by the single regression method (Casteel 1976a). Otolith growth is incremental and varies with food availability, resulting in two annual bands of growth, which can be used to calculate season of death — smaller daily or weekly increments can be used to refine seasonality studies. Scales, which are relatively common on archaeological sites and also grow incrementally and continuously, have also been used (less successfully due to size variation of scales from different parts of the body) to reconstruct size, seasonality and weight. Associated problems with the use of scales are reduced growth of scales with size, false annuli, regeneration of lost scales and marginal erosion of scales due to spawning stress.

"The ossified vertebrae of fishes compose one of, if not the most commonly found remains of fish in archaeological investigations" (Casteel 1976a:72).

It is usual for the spines of vertebrae to be broken or missing. However, the centrum is usually identifiable to family or even species level and have been used to calculate MNI (minimum number of
individuals). Annular growth rings have been used to assess age at death and seasonality, and the width of the vertebrae can be accurately related to the length of the fish by a single regression method.

Given the recovery of such remains as otoliths and vertebrae in an assemblage, the size reconstruction should be considered reasonably accurate for these remains. The difficulty then lies in assessing how accurately prehistoric fishing strategies can be reconstructed on the basis of gear selectivity.

4.11: Criticism of the Gear Selection Approach

It is clear from the discussion of selectivity patterns above that fishing gear can be (but are not necessarily) operated to select fish in terms of species and/or size ranges. However, whether this can be used to reconstruct prehistoric fishing strategies remains a subject of debate. Owen & Merrick (1994) and Colley (1983, 1984, 1986a, b) take the view that the fish selectivity of the various types of fishing gear does not offer sufficient resolution to permit the reconstruction of fishing techniques from faunal remains. As indicated above, a number of selective techniques such as gillnetting, line fishing and trapping can produce assemblages similar in appearance.

To overcome these problems, provisos to the use of selectivity patterns to reconstruct fishing methods in archaeological contexts have been proposed. Owen & Merrick (1994) suggest that an analysis of the representation of the species in assemblages (e.g. which exhibit sedentism or territoriality), will indicate changes in fishing practices or harvest pressure. Balme (1983) and Bowdler & McGann (1996) make the point that the stratigraphy of a site must be understood if fishing practices are to be meaningfully reconstructed from faunal remains in order to ensure that the products of individual fishing expeditions are not confused. At any site where there is no record or accurate publication of stratigraphy, or where diagenetic processes have obscured the stratigraphy, this type of reconstruction should not be conducted. Unfortunately, this eliminates many of the fish assemblages recovered from Mesolithic sites across Europe (in particular, although not exclusively, those excavated in the late-19th and early-20th centuries). In addition, many recently excavated sites have occupation layers that span large time frames and yet most studies present the fish fauna as a single body of data.

Even if archaeologists acquaint themselves with gear selectivity and restrict studies to assemblages known to have been the result of one deposition event (and assuming the one deposition event contained the remains from only one fishing expedition using only one fishing technique) there are so many additional factors that influence the selectivity of any one type of gear, including mode of operation of fishing gear, the use of different bait types and seasonal changes in bait preference, abundance of fish, prevailing currents and gear saturation, that it is questionable whether reconstruction of prehistoric fishing methods from assemblage structure and gear selectivity is a reliable technique.
Debates concerning the usefulness of gear selectivity as a reconstruction technique have not addressed the problem of context; i.e. the selectivity of a gear is dependent entirely on the context of operation. A gear that can be operated in a very selective manner, such as gillnets, can also be operated in a very unselective manner depending on how taut the net is hung or if the net chokes. Moreover, gears generally assumed to be relatively unselective, such as the trap, can be operated in a highly selective manner. For example, traps can be set in coastal zones to exploit schools of migrating fish. This will result in an assemblage with a limited size/age range of fish of a small number of species, mimicking the patterns associated with highly selective gears such as gillnets and spears. Whether a gear exhibits a selection pattern depends on the mode of operation of the gear rather than on any intrinsic selectivity properties of the gear. Pertinent to the reconstruction of Mesolithic fishing methods is the temporal scale of the fishing activities: the use of different types of selective gears over a considerable time frame will produce assemblages with a varied range of species and sizes on a site suggesting the use of non-selective fishing gear.

The assumption that gear selectivity patterns are a useful construct in the assessment of prehistoric fishing practices has resulted in limited interpretations of the available data. This is exemplified by Balme (1983): despite acknowledging that selection patterns of a specific fishing gear can be duplicated by a number of methods, the limited number of species and size ranges identified at a number of prehistoric sites on the Darling River, New South Wales were interpreted as evidence for a highly selective gillnet fishery. This problem is further compounded by the apparent need in archaeological studies to attribute the fish remains identified as the result of one fishing expedition and/or fishing technique, even in situations where artefactual remains would argue to the contrary. For example, Bowdler & McGann (1996) attempt to reconstruct fishing method on the basis of gear selectivity to account for the remains of six different species exhibiting various size ranges recovered from open shell midden sites in the Shark Bay region of Western Australia. Though they acknowledge that more than one fishing technique could have been used Bowdler & McGann then dismiss the use of a number of fishing methods on the basis that they could not produce the observed variation in species and size ranges. Even if it is accepted that fishing gears can produce archaeologically identifiable selection patterns, it is probable that different methods were employed in the pursuit of the various species identified. Bowdler & McGann themselves state that observation of Aboriginal subsistence practices at the time of first contact with Europeans records a number of different fishing methods.

This type of interpretative problem (the assumption that mixed assemblages result from the practice of non-selective fishing techniques) is apparent in Mesolithic studies reconstructing fishing methods from faunal remains employing the gear selectivity approach. A number of assemblages from Mesolithic sites in Denmark that contain mixed fish sizes and species (e.g. Ertebølle, despite the lack of evidence for traps at this site; Norsminde and Skateholm [Enghoff 1986, 1994]) have been
interpreted as evidence for the exclusive use of traps or to imply that traps were the most important or efficient type of gear employed in the Mesolithic fisheries of this region (e.g. Enghoff 1983, 1984, 1986, 1991, 1994a, b, 1995). Enghoff's findings have influenced a number of subsequent interpretations of Mesolithic fishing practices. To infer that traps were the predominant fishing gear used in the Mesolithic on the basis of species and size variability observed in assemblages, in light of the above information, seems unfounded. It is possible that traps, which constitute an efficient fishing method, that require relatively little input in terms of labour compared to yield, were commonly used for fishing in the Mesolithic period in Scandinavia. This is supported by an overwhelming number of ethnographically observed non-industrial fisheries that use traps in conjunction with weirs. However, the argument has become somewhat circular: in the knowledge that ethnographically observed groups use traps for anadromous and seasonally concentrated species, the expectation is that Mesolithic groups would have exploited these resources using traps; the structure of the faunal assemblages is then 'found' to correspond to this. This cannot be directly inferred from the fish fauna recovered from these sites as indicated above by the experimental findings relating to the species and size selectivity of traps and other gears. Inferring the primacy of trap fishing in the Mesolithic provides only a one-dimensional view of fishing and fishing gear, which the artefactual record indicates must have varied significantly, both seasonally and intra- and inter-regionally. The wide range of fishing artefacts recovered from Mesolithic contexts and the effort put into the production of many of these pieces suggests that other forms of fishing were of at least equal importance, economically and/or culturally. At Tybrind Vig, where preservation is exceptional and excavation extensive, the variety of fishing implements recovered indicates the range of gear that may once have existed at a number of sites focusing on fishing for subsistence (Malm 1995). A greater quantity of wood has been recovered at Tybrind Vig than any other Mesolithic site and dominates the finds on the site. It indicates the extent to which fishing implements made of friable materials may be lost. It seems unlikely that trap fishing would have been universally used for all large-scale or subsistence fishing in the Mesolithic, given the time and effort put into the manufacture and maintenance of other types of fishing gear. It may well be that a large part of this gear was being used in conjunction with traps and weirs or barriers but these other methods may have been used in isolation in areas where topography prevented the practical or efficient use of traps or weirs. A number of gears may have had primary roles in subsistence fishing activities on varying temporal scales corresponding to diurnal and seasonal variations in fish behaviour. There may have been a scheduling of activities to exploit, most effectively, temporal and/or spatial concentrations of fish with combinations of passive and active fishing gears.

Traps do capture a wide range of sizes and species of fish, but not all of the fish found at Mesolithic sites are likely to have been caught in this manner (see Chapter 5). Even within sites, the use of traps for specific species does not preclude the use of different types of gear for different species or for certain size ranges in waters of varying hydrology or substrate within a small area. Johnson (1979) states that modern peasant fishing groups of southern Portugal use a variety of different technologies because,
"Different technologies result in pressure being exerted on different ecological niches, and alternating patterns of utilization limit the pressure exerted on any one niche" (1979:244).

It is probable that prehistoric groups would have understood such mechanisms of stock maintenance.

A further major problem associated with the reconstruction of fishing methods from faunal remains is the assumption that the recovered assemblage is representative of the original catch. Selection of certain species or sizes of fish may have occurred after the landing of the catch (frequently observed ethnographically) or there may be differential processing of the various types of fish. Even if future studies can elucidate and distinguish the exact nature of selectivity patterns produced by different fishing gear, problems in reconstruction based on gear selectivity are further compounded by the complexities of taphonomy and differential preservation that affects every archaeological assemblage (see Chapter 6).

The use of gear selectivity patterns in the reconstruction of Mesolithic fishing practices is not considered an appropriate or meaningful technique for the purpose of this study.

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1 In theory, passive gear can be left unsupervised but in regions where fish are concentrated, the gear is constantly monitored so that fish can be removed immediately when caught — there is the danger that gear will be damaged if left too long and fish are too concentrated or that catches will be appropriated by other fishermen (E W Nelson 1899; Kroeber 1976).

2 Thigmotaxic species actively seek shelter in response to danger. Such species, e.g. eel, feel more secure when in contact with objects (including fishing gear and fishermen).
Chapter 5

The Use of Fish Behaviour to Determine Fishing Strategies

5.1: Reconstructing Fishing Practice from Knowledge of Fish Behaviour

Reconstructing fishing methods from the size and species selection of different types of fishing gear based on inadequate data can result in erroneous conclusions (as discussed in Chapter 4). Knowledge of the behaviour of fish provides an alternative method for reconstructing fishing practices. Both the gear and techniques that are most suited to the efficient capture of a particular fish species and seasonal variation in vulnerability to capture are determined by the biological adaptations and behaviour of that species. Thus, the range of fish species identified in an assemblage suggests the method of capture. This provides a parallel approach to ethnographic analogy (Chapter 3) and numerical correlation in the reconstruction of fishing practice (Chapter 7). There have been limited attempts in previous studies to include the behavioural, biological and ecological characteristics of selected fish species (generally the most commonly identified species at the site), in the reconstruction of fishing methods from faunal assemblages. The application in this study of that information in a more rigorous fashion (i.e. assessing the range of behaviours and ecology of all the fish species identified to provide an indication of all fishing practices at a site) may improve reconstruction of fishing practices.

The behaviour of the fish species identified at European Mesolithic sites (Table 6.2) was used to determine the greatest temporal and spatial vulnerability of each species and the most probable methods of capture, based on seasonal variations in behaviour. The main factors influencing the vulnerability of all fish to gear such as habitat, acuity of senses, grouping behaviour and breeding patterns are given below and summarised in Table 5.1. Table 5.2 lists the species found at Mesolithic sites, their geographic distribution, size and aspects of behaviour. Table 5.3 details the accessibility of fish species and their seasonal and diurnal vulnerability. The most effective methods of capture of each of the species identified at Mesolithic sites based on species-specific patterns of behaviour, habitat and gross biological characteristics are detailed in Table 5.4. These data are compared to the most common methods ethnographically documented for the capture of species. This information can then be combined with data concerning the local topography and hydrology of water fished, ethnographic and ethnohistoric records on recent non-industrial fishing practices, recovered fishing-
related artefacts and fish remains to suggest fishing strategies employed by Mesolithic groups. A full discussion of fish species representation at sites and how this pertains to Mesolithic fishing practices in light of the results of the correlation analyses of fish species, and artefacts recovered at Mesolithic sites, will be given in Chapters 6 and 7, and a case study is presented in Chapter 8.

5.2: Fish Biology, Ecology and Behaviour in Relation to Fishing Methods

There is a great disparity in scientific knowledge of different fish species. The behaviour of present-day commercially exploited species is the most completely understood. This is a consequence of the large body of research conducted in laboratories and in the natural environment to assess both gear efficiency and the effects of over-fishing on population stocks. Findings based on research and experimental studies can only be considered representative of natural behaviour if the equipment used to study the fish in no way interferes with normal behaviour (Aronov 1971). There is evidence to suggest that experiments performed under laboratory conditions are not representative of normal behaviour (Vyskrebentsev 1971). Rates of response to stimuli have been observed to be considerably slower than in the natural environment.

There also exists a considerable body of literature detailing methods of angling as a sporting and leisure activity and the behaviour of angled species. The information that is provided by such works is generally anecdotal in form. It is possible, however, that such observations and those made of traditional fisheries are equally as informative as laboratory studies given that captivity may alter behaviour.

The wide variation in the behaviour of different species of fish is observed to influence choice of fishing gear, choice of fishing grounds and seasonal scheduling of activities in traditional fisheries. It is assumed in this study that prehistoric groups subsisting predominantly on fish and other aquatic resources would have had a similar knowledge of variability in fish behaviour as do analogous, ethnographically observed, groups and would have undertaken fishing activities accordingly (this is supported by the correlation studies discussed in Chapter 7). However, there is some debate on this point (Pálsson 1991). Protasov (1971) and Morrill (1980) argue that knowledge would be minimal because fish inhabit a different medium: essentially taking the view that fishing involves the capture of an invisible prey. The variety and sophisticated technology demonstrated by extant Mesolithic fishing implements and the time invested in their manufacture would suggest that Mesolithic groups were skilled fishermen and, as such, are likely to have had a good understanding of the behaviour of their prey. Given the great dependence on aquatic resources in many regions, fishermen of the Mesolithic would have had at least as an extensive, and possibly greater, knowledge of their prey as fishermen today. Studies suggest that in many cases groups depending heavily on aquatic resources have a more detailed system of classification of fish species than expressed in Linnean nomenclature.
and in many instances offer insights into the behaviour of fish not analysed in modern scientific experiments (e.g. Best 1929; Rostenlund 1952; Kvaase 1956; Kroeber & Barrett 1960-62; N J H Smith 1981; Polaco & Guzman 1994).

The biology, behaviour and habitat of species that are not today considered important either as food or angling fish is generally poorly understood. There is little incentive (financial or otherwise) to conduct research projects to rectify this situation. This is a hindrance to the reconstruction of prehistoric fishing practice. To some extent this bias in available data will skew the discussion of the results of the analysis undertaken in this study to those most documented species. However, as the range of species identified at Mesolithic sites consists of, in the main part, species that are commercially fished and farmed or considered valued food fish (see Chapter 6), any bias in the available literature is minimised in the discussion of Mesolithic fisheries.

5.3: Gross Behavioural Characteristics Influencing Location and Method of Fishing

Fish should not be viewed as a single resource with universally applicable methods of capture or vulnerability. It is necessary to understand the behaviour of each species of fish if the reconstruction of fishing strategies is to be meaningful (Coutts 1975a; Wilkinson 1981; Colley 1986b; Engås & Lekkeborg 1995).

"For a fishery to be successful, gear alone and the knowledge of how to make it is not enough. It is necessary to know when and where a successful fishery may be expected, and which tactics should be used" (von Brandt 1984a:276).

Biological adaptation varies significantly amongst fish species. This can affect the successful operation of fishing gear. Gross behavioural characteristics are species-specific and are influenced by maturity, photo-period, food availability, presence of predators, atmospheric temperature and hydrological conditions (Nikolsky 1963; Manteifel 1971; Helfman 1993). In many instances the effects on behaviour, resulting from different stimuli, cannot be distinguished in the observed actions of fish. These phenomena are therefore discussed as a single category.

Temperature, salinity tolerance and physiological adaptation determine species distribution (Nikolsky 1963; Wheeler & Jones 1989). There are significant differences in the species available in marine and freshwater and on a smaller scale within these zones. The location of fish within a water body influences gear choice and susceptibility to capture. Marine fish are generally divided into three sub-groups relating to their primary habitat: littoral species, inshore species and offshore species (Wheeler & Jones 1989). These categories can be further subdivided according to the depth of water inhabited, i.e. surface; mid-water or bottom dwellers. Freshwater fish are similarly sub-divided into three
categories on the basis of the regions of the river they inhabit: the trout or upper section of mountain waters with fast currents and stony substrates; the barbel or middle section with moderate to fast currents; and the bream or lower section with slow currents, soft substrata and significant vegetation (Nikolsky 1963; Bone & Marshall 1982). Though two main categories are defined according to salinity tolerance, marine and freshwater, many species can tolerate a range of salinity. To determine the exact location of Mesolithic fisheries it is relevant to further divide fish species into five categories relating to salinity tolerance:

1. Primary freshwater species that cannot tolerate saltwater.
2. Secondary freshwater species that inhabit freshwater but can tolerate saltwater.
3. Anadromous and catadromous species that move between salt and freshwater as part of their life cycle.
4. Marine species that cannot tolerate freshwater.
5. Marine species that predominantly inhabit saltwater but can tolerate freshwater.

See Table 5.2 for species details.

5.3.1: Senses

The acuity of the senses of the different species of fish varies according to biological adaptations. The differences influence not only the choice of gear but may also determine the timing of fisheries on a day to day basis.

5.3.2: Hearing and Lateral Line

The auditory acuity of fish influences the success of fisheries and can be exploited to increase the efficiency of certain gears. Fish are sensitive to infrasonic, mechanical, sonic and ultrasonic vibrations (Nikolsky 1963; Pinkas1969). Auditory acuity is greatest in freshwater species. Noise, which rapidly attenuates in water, is amplified by the swim bladder. The swim bladder is an organ present in the majority of teleosts that acts to maintain buoyancy. Localised displacements of water are detected by the lateral line — mechanical and chemical receptor cells located in the epidermis in cartilaginous species and along the back bone of teleosts — which is particularly developed in large, fast swimming fish such as tuna. It enables fish to orient to currents in rivers (minimising energy expenditure) and to surface feed at night (detecting food through changes in the surface tension of water). A combination of the auditory senses and the lateral line are used to accurately detect the location and source of vibrations (including vibrations produced by fishermen or fishing gear) and allows the fish to avoid such sources if they are considered to pose a threat. Even where absolute silence is maintained or set gears are used self-induced water movement is used by the fish to detect and evade stationary objects such as fishing gear (Nikolsky 1963; Bone & Marshall 1982; Walker 1988; Bleckmann 1993;
Hawkins 1993). The detection and avoidance of gear is more problematic in the use of passive gears. Active, encircling gear is most suited to the capture of species with well-developed hearing or lateral line.

The success of fisheries may be improved by exploiting auditory acuity and production of noise. Fifty species of fish produce sounds by grinding teeth, rubbing spines or pectoral fins together, drumming the body wall above the swim bladder, muscular contraction of or release of gas from the swim bladder, and the movement of water. Species that emit noises are generally active in crepuscular periods when visual stimuli would be ineffective (Protasov 1971). The noises are intended to attract mates, warn con-specifics of the presence of predators or as echo-locators (Bone & Marshall 1982; Hawkins 1993). The noises emitted by fish can reveal to fishermen the location of target species. Noises can also be mimicked by the fisherman to lure or frighten fish toward gear (Nikolsky 1963; Wheeler 1978b; Bone & Marshall 1982; Hawkins 1993). Repetitive noises will generally concentrate fish whereas loud, sudden noises tend to disperse shoals (Solov’ev 1971).

5.3.3: Smell and Taste

There is no distinction between the senses of taste and smell because of the medium inhabited. Chemical stimuli are detected by taste and olfactory cells located in the nose, mouth and sometimes the skin and barbels of fish. Olfactory sensitivity varies among species but is most highly developed in migratory species. Response to chemical stimuli can be used to lure or frighten fish to gear and thereby increase capture rate. Olfaction is primarily used for the location of food and prey, which is stimulated by the presence of amino acids, but also acts as an aid to migration, identification of predators and in courtship and breeding (Malyukina 1971; Walker 1988; Hart 1993; Hawkins 1993). The most common response to chemical stimuli exploited by fishermen is the reaction to food, i.e. baits. Baits are used in all traditional fisheries to increase the effectiveness of passive gear and ground baiting may be used to concentrate fish when using active gear. There are other uses, such as lures of receptive females to concentrate males or the use of males to concentrate fish as a territorial response. Pheromones released from the skin of injured fish act to illicit a fright response (seeking cover, crowding, rapid swimming and immobility) when detected by con-specifics or phylogenetically close species. This response is used by fishermen to concentrate fish that are then taken with encircling gear or to guide fish to gear depending on the specific response of the prey. Reactions are strongest to low concentrations of these pheromones. For example eel can detect phenylethyl alcohol in a dilution of one drop in 8000 billion tons of water. These pheromones are not produce in the breeding season in species with abrasive spawning habitats such as the salmon (Oncorhynchus/Salmo spp.) (Tricas et al. 1997).
5.3.4: Sight

Certain species use sight to navigate (generally only in clear waters where light can penetrate to 800m), to locate food or for defence. These categories of fish species, such as fast swimmers, predators and shoaling species, tend to have well developed sight: sedentary species and species using other methods to locate food often have poor sight (Nikolsky 1963; Guthrie & Muntz 1993; Tricas et al. 1997). Most freshwater species are near sighted with vision to approximately 15m. Vision over a greater distance is not necessary in most inland waters due to high organic particle content that results in rapid attenuation of light with distance or depth (Nikolsky 1963). Species-specific variations in visual acuity influence the choice of fishing gear and mode of operation. It is the visibility of fishing gear that allows fish to evade capture. Gears used for fishing species with good vision during the day are almost always active or baited gear. All baits or lures must be highly visible and take the shape and size of natural foods. However, such species are most often fished at night, to reduce gear visibility, using either passive or active gears dependent on the specific behaviour of intended prey (Vyskrebentsev 1971; Holden 1979).

5.4: Social Behaviour

Shoaling is an adaptive behaviour offering protection; the larger the shoal, the smaller the individual risk of predation during feeding or migration (Pitcher & Parrish 1993; Milinski 1993). It is a characteristic of fish inhabiting large bodies of water with little shelter: shoals of freshwater species are generally smaller than shoals of marine species (Nikolsky 1963; Pinkas 1969; Pitcher & Parrish 1993). The availability and spatial distribution of food usually determine the size of a shoal and its species composition. Visual stimuli are used by shoaling species to impart information to conspecifics about food, migration and the presence of potential threats. This dependence on visual stimuli for shoal cohesion generally leads to shoal dispersal at night. There are exceptions to this, e.g. shoaling species that concentrate in surface waters during crepuscular periods to feed (see Table 5.3). Concentrations of shoaling fish during daylight are most efficiently exploited with encircling gear such as seines. The response to signals varies depending on their strength and the physiological state of the fish (Protasov 1971; Radakov 1971b). Responses include compaction of the shoal, dispersal or rapid changes of direction. The synchronised response to visual stimuli results in shoals evading fishing gear more effectively than solitary fish (Nikolsky 1963; Wheeler & Jones 1989). Unpredictable variations in shoal response to stimuli limit applicability to fishing practice. The shoaling adaptation of certain species (e.g. mackerel [Scombridae]) can be exploited by fishermen to concentrate the fish on moonless nights using artificial light sources (Solov’ev 1971). Other shoaling species (e.g. herring [Clupea harengus] and sprat [Sprattus sprattus]) are taken in the traditional fisheries of Scandinavia, Scotland and Germany by using artificial light to frighten fish towards gear (Ben Yami 1976). A simpler method, lighting a fire on the beach to draw shoals of fish toward the
shore, is practised in the Cameroons and Australia. There are three possible explanations of the reaction to artificial light sources: curiosity, the shoaling response to light or the association of light with feeding (Ben Yami 1976).

An attraction or fright response to artificial light sources is also exhibited by a number of non-shoaling species and is used to guide fish to gear (Pavlov 1971; Manteifel et al. 1971; Solov’ev 1971). Torches (made from the bark of resinous trees in Europe) and fires set on canoes are still used in non-industrial fisheries in Europe, Asia, America and Oceania, particularly in eel (Anguillidae) and pike (Esox lucius) fisheries, to concentrate the fish, which are then speared (J G D Clark 1965; Ben Yami 1976). This response is not pronounced in demersal species and is inhibited in the presence of predators and during spawning (Zilanov 1971).

Shoals or large concentrations of fish have been observed to be less susceptible to the action of piscicides than smaller groups of fish, there is no known reason for this anomaly (Pinkas 1969).

Solitary species or species forming small groups are more efficiently taken with individual gear such as projectiles and hooks or passive baited gear such as traps.

5.5: Feeding Patterns

Most of the behavioural responses of fish are the result of the need to balance the risk of predation with the search for food (Magurran 1993). The food preferences of fish vary between species, individuals and sexes and are determined by physiological makeup, resource availability and individual preference. The majority of temperate water species are piscivores. More primitive, generalised and, usually, large-mouthed species tend to be crepuscular or nocturnal predators. Larger individuals are active longer into the crepuscular period; smaller fish are more likely to inhabit submerged shelters — both relate to the risk of predation. Most temperate water predators inhale prey whole making them particularly susceptible to capture by hook and line (Bone & Marshall 1982). More specialised species generally feed during the day on small plants and animals, though they may feed on moonlit nights if they inhabit clear waters. Freshwater species are commonly herbivores and/or insectivores. Some predatory freshwater and marine species will consume waterfowl. Mammals are relatively unimportant to fish diets though sharks do eat seal (Phocidae) and pike (Esox lucius) and grayling (Thymallus thymallus) have been observed to eat small mammals that fall into the water and sturgeon (Acipenser sturio) are reported to take seal pups and have been fished using piglets as bait in Lake Baikal, Russia.

Diurnal variations in the spatial distribution of fish and, therefore, vulnerability to capture are a consequence of feeding behaviour. Diurnal migrations undertaken by many demersal marine species
from deeper waters to surface waters to feed at night can be exploited by placing gear at set points in the migration route. All species are more vulnerable to capture when feeding as there is a reduced response to danger and less suspicion of baited gear (Engås & Løkkeborg 1995). Patterns of feeding vary on a daily and seasonal basis. Fish as poikilotherms are less active, and are therefore less likely to feed, during the colder months in temperate latitudes (Nikolsky 1963; Wilkinson 1981). The rate of metabolism is no higher than necessary to sustain minimal activities (Walker 1988). This limits response to all forms of baited gear. For example, cod (Gadus morhua), which feed on the surface at night spend the day at a depth of ca. 30m, however, in autumn they inhabit shallower water (<15m), move in a smaller home range and are inactive at night (Engås & Løkkeborg 1995). Diurnal vertical feeding migrations are characteristic of temperate Atlantic species (Helfman 1993). Minimal movement and slow swimming speeds of fish in winter also reduces the chance of encountering passive gear.

The presence of large predators in a region will make smaller fish more suspicious of baits and gear and reduces capture rates (Morill 1980). Females of all species, which have greater nutritional requirements, are more likely to continue feeding even in the presence of predators (Magurran 1993). Feeding behaviour is only completely suppressed in the presence of predators when the threat of predation is greater than the risk of starvation (Hart 1993). Fish are least likely to respond to baits when other food sources are abundant and hunger is satiated (Colgan 1993). Regular ground baiting prior to fishing and competition for food can reduce suspicion and increase catch rates (Clifford 1989).

5.6: Learned Responses

Behaviour varies considerably between species and among fish at different stages of development (a consequence of biological adaptation), but it has also been observed to vary between individuals of the same age group and species. Older individuals of certain species (e.g. carp [Cyprinus carpio] and catfish [Silurus glanis]) appear to have learned through experience, by evading or escaping capture, to be wary of fishing gear and bait (Townsend 1924; Wheeler 1978b; Colgan 1993; Magurran 1993). Carp (Cyprinus carpio) have acute vision and hearing and learn to associate noise and movement on the riverbank with danger and will avoid fishing gear (Clifford 1989). They learn from previous encounters and alter behaviour accordingly. Pike (Esox lucius) learn to avoid bait if the same bait is repeatedly used.
The spatial distribution of fish varies seasonally and annually (Engås & Løkkeborg 1995). Changes to spatial distribution on a seasonal basis, predominantly a consequence of the feeding and spawning behaviour of fish, can result in increased vulnerability to capture, often by specific fishing methods at certain times of the year. Variations in spatial distribution are associated with differences in the condition of fish (see Chapter 2). The most significant changes in condition are observed in the breeding season. All species are in the best condition (and therefore offer the highest nutritional value) immediately prior to spawning or spawning migrations (Rostlund 1952; Colgan 1993). It is knowledge of these seasons of vulnerability and prime condition, which often coincide, that permits the most efficient exploitation of aquatic species (Radakov 1971b; Limp & Reidhead 1979; Wilkinson 1981). Fishing methods suited to the capture of fish in the season of greatest vulnerability may differ from the most efficient capture methods at other times of the year.

The practice of efficient offshore fisheries requires a sophisticated knowledge of the movements of the target species. Many marine species, which predominantly inhabit deeper, offshore waters, may enter shallower, coastal waters to spawn or may make temperate dependent migrations to inshore waters. In contrast, several species migrate to deeper water to spawn or move from inshore waters to deeper waters on a seasonal basis, dependent on temperature changes. Predictable migrations of this type make such species especially vulnerable to capture at this time. There has been confusion in the literature regarding the availability of deeper water and offshore fish species and the role of offshore fishing in the Mesolithic. This is discussed in Chapter 7.

The spawning migrations of anadromous/catadromous species concentrate fish temporally and spatially, making them most vulnerable to capture and most efficiently exploited with large-scale gear at this time (Rostlund 1952; van Wijngaarden-Bakker 1985; Engås & Løkkeborg 1995). Taking fish immediately prior to spawning is not only effective in terms of the nutritional quality of the fish but may also reduce competition for food at spawning grounds and thereby improve fish stocks (Rostlund 1952). Many anadromous fish die after spawning and this has the adaptive advantage of contributing to food at the breeding grounds (Nikolsky 1963). Spawning migrations are stimulated by changes in water temperature, therefore, anadromy is more pronounced in northerly latitudes due to increased seasonality (Schalk 1977). Often described in the anthropological and archaeological literature as abundant, these species do exhibit spatial and temporal variations in availability (Schalk 1977; Ibbotson et al. 1994). Abundance in rivers varies locally according to runoff. Lindstrom (1996) takes the view that it is the degree of seasonal concentration of available species that determines the extent to which human populations will exploit anadromous resources regardless of overall abundance of fish in local waters. In more southerly latitudes the spawning season is much longer and runs are generally less concentrated, occurring throughout the year. Lindstrom argues that it is the extended
spawning season combined with a greater diversity of freshwater species that makes anadromous species less important to human populations exploiting aquatic resources.

Feeding is inhibited during spawning migrations making baited gear less effective (Engås & Løkkeborg 1995). Catches can be increased by the use of pheromones to attract fish to gear at this time. However, the spatial concentration of spawning fish makes them suited to capture using large-scale gears such as nets, weirs and traps, without the use of lures. In terms of ethnographically observed groups, anadromous and catadromous species are most commonly taken with barriers and weirs.

Many freshwater species that are otherwise solitary, or form only small groups, will gather in very large schools to migrate to or at spawning grounds, again increasing susceptibility to capture by large-scale gear.

5.8: The Influence of Hydrological Conditions on Fish Capture

Hydrology, substrate type, bottom depth, chemical and thermal stratification, prevailing weather conditions, temperature and barometric pressure will affect both the species present and their behaviour and as a consequence will influence the fishing methods practised (Lagler 1968). Certain bodies of water or fishing grounds lend themselves more readily to specific types of fishing gear and to mass capture techniques: in contrast certain types of gear are totally ineffective in specific water conditions. Fishing practices observed ethnographically are seen to vary according to the hydrographic conditions encountered in lakes, rivers and at sea.

5.8.1: Riverine

The fishing of inland waters (rivers and lakes) is considered to involve smaller risks to the fisherman than sea fishing (Wing 1978; Bjerck 1995). The productivity of fresh waters varies considerably depending on a number of factors including temperature, precipitation, runoff, gradient and sedimentation (Cannon 1996). In conditions of dense vegetation, bright light, turbid water and high runoff the lack of light reflected from underwater greatly reduces visibility for the overhead observer. Many species have counter-shading, which enhances this 'invisibility' (Nikolsky 1963). The use of passive gears may be more effective in these conditions. However this 'invisibility' in turbid and coloured waters offers protection from predators while feeding, concentrating fish populations and making them less suspicious of gear and bait (Lagler 1968; Clifford 1989). Locating fish in rivers in spate or during summer flash floods may be difficult and the sheer volume and speed of water may make fishing impractical at this time. However fish inhabiting these coloured, fast moving waters feel
secure and have to increase their energy/food intake to maintain their position in the water so may respond to baited hooks cast from the shore. Smaller fish may move closer to the shore out of the main river flow during floods to preserve energy. Fishing floodwaters as they recede is less taxing and less dangerous to the fisherman and may be very productive with larger individuals becoming trapped in shallows, which can be taken by hand or scooped up in baskets.

Tidal rivers have two to four tides each day. Evening low tides particularly concentrate feeding fish. Tidal rivers tend to have less vegetation, facilitating the use of nets. Strong currents and turbulence in tidal rivers make fishing with light tackle impractical. Highly visible baits work best in these conditions.

Many freshwater species permanently inhabit, or move to, the shelter of vegetated water to spawn as this region offers some protection from predators (Wheeler 1978b; Clifford 1989; Ibbotson et al. 1994). Dense vegetation limits the use of active gears such as encircling nets that may roll up and permit fish to escape. Lines tend to snag or tangle in vegetation, resulting in the loss of prey and hooks. Weirs often collapse under the weight of vegetation deposited by currents. These areas are usually fished with set nets or traps and projectiles in surface waters for larger individuals. Certain species such as carp (Cyprinus carpio) and chub (Leuciscus cephalus) are so secure in vegetated waters that they enter very shallow water and can be taken by hand or with scoop nets, cover-pots and collecting baskets.

Active gear is more commonly used in unvegetated and faster stretches of rivers, deeper water or areas of water that naturally concentrate fish such as river mouths, eddies, waterfalls and whirlpools.

In colder conditions fish inhabit slacker water to save energy and concentrate in the warmer, deeper regions of small bodies of water. Fishing in winter under ice is most efficient when pursuing fish that respond to bait through the winter or rest in shoals (e.g. bream [Abramis brama], pike [Esox lucius], and roach [Rutilus rutilus]). Fish that lie inactive in small groups or in isolation are not easily taken in winter. This group includes the majority of Cyprinidae and catfish (Silurus glanis) (Løugas 1996).

5.8.2: Lacustrine

Lacustrine and riverine environments are fundamentally different in terms of fluctuations in water level and are fished using different techniques. Hickling points out that,"Fishing methods on lakes therefore tend to be similar to those used in marine inshore fisheries" (Hickling 1961:90).

Devices relying on currents or large changes in water levels are generally not used in lakes (Worthington & Worthington 1933). Water quality influences species represented in lakes, e.g. where
eutrophication occurs perches (Percidae) will be replaced by cyprinids (Cyprinidae) — the result of differences in the importance of vision for feeding. The size of the lake and availability of food determine the maximum size of the fish present. Species inhabiting temperate lakes tend to be nocturnal, resting in shoals or in vegetation during the day (Helfman 1993). Species that are active in the day tend to rest in exposed areas of lakes at night. Lacustrine fishing is therefore most productive at night.

There are seasonal variations to the distribution of fish within lakes. As in riverine environments, fish move to the deepest parts of the lake in the colder months. In spring vegetation growth at the margins, providing food and shelter and spawning grounds attracts many species to the lakeshore. More short-term variations in fish distribution can be caused by the action of prevailing winds. Strong winds will force food and oxygenated water across a lake and the fish move to follow the food. Fish are frequently observed to concentrate at the inlets of lakes where food is washed downstream and into lakes. The relatively unpredictable movement of fish on a diurnal basis in lacustrine environments restricts the use of unbaited gear. All forms of baited gear and ground baits are used within lakes depending on prey species. Longer-term variations in fish distribution such as intra-lake spawning migrations to or from rivers and movement to deeper waters in colder periods may be exploited using large-scale active or passive gear, with or without bait.

K M Stewart (1989) and Worthington & Worthington (1933) suggest that lake fishing requires a greater knowledge of hydrology and fish behaviour than riverine fishing because the river provides a 'direction' of fish. However, this can be applied only to the movement of anadromous and catadromous species.

5.8.3: Estuarine

Estuarine waters have the highest productivity (up to ten times more productive than neighbouring coastal waters) owing to tidal action causing increased nutrient mixing and the interface of fresh and salt water (Andersen 1991; Yesner 1980).

"Estuarine environments above 40 degrees latitude on high-relief coasts have been identified as those which entail the lowest risks and the least effort for the acquisition of subsistence resources... Estuarine environments should also allow for greater sedentism; other wave-stressed coastal environments and interior zones should be occupied in lower densities and be exploited less intensively than estuarine zones" (G A Clark 1983:97-98).

Due to the 'Coriolis effect' there is a stronger flood current on the left side of an estuary (looking toward the sea) and stronger ebb current on the right side in the Northern Hemisphere (Cordell 1980).
This is reversed in the Southern Hemisphere. These variations in current influence the timing of net fisheries in tidal regions: net fishing is avoided during the strongest tides. Estuaries tend to become shallower from head to mouth and thus a suitable depth for netting will be available somewhere along the shore. Areas with strong currents are known to restrict the mobility of fish and disperse chemical stimuli rapidly and are therefore more effectively fished with active rather than passive gear (Engås & Løkkeborg 1995). Daily tide cycles determine when and where various gears can be used effectively. Under estuarine conditions, gillnets, trot-lines and traps are most efficiently used when allowed to drift slightly in weak current. Barrier devices are very efficient except during neap tides when current and depth changes are minimised. Drag/encircling nets such as seines are ineffective in estuaries at spring and neap tides as the medium velocity currents they require occur only during the rising and falling phases of the tide cycle. Estuaries are rich in invertebrates, which support large fish populations/concentrations. Much of the estuarine fauna moves in and out with the tide.

"The widespread utilization of estuaries as nursery grounds is one of the features that distinguishes them from other marine environments" (Cordell 1980:36).

Fish are distributed according to their salinity tolerance. Adults of several marine species can be found near the mouth of estuaries. The young of many marine species inhabit the more brackish waters of estuaries that are a good source of food and offer shelter. They often move close to shore during strong tides to stay out of the currents (Darling 1982). Peeler crab (Brachyura) are common in estuaries in spring and attract many of the species found in these waters and are excellent baits. The productivity is lowest in the area between fresh and salt water, the location of this zone varies with the seasonal tide cycles and in deep estuaries these salinity gradients are vertical (i.e. no brackish regions). Each estuary has a unique configuration, which affects the structure of salinity gradients, fish distribution and therefore fishing strategies (Grindley 1969).

5.8.4: Marine

Latitude and nutrient content influence the productivity of marine waters (Rowley-Conwy 1983). Tropical and sub-tropical waters have a large number of species at low concentrations, more temperate waters have a smaller number of species in greater abundance. The action of the large thermocline in temperate waters causes upwelling of nutrients from the sea bottom and increases productivity throughout the food chain. Marine species, particularly pelagic species, are less predictable in terms of spatial distribution than freshwater species, making marine fisheries inherently more risky than freshwater fisheries.

The wave action encountered on rocky shores can make fishing very dangerous in these areas. Bottom, set lines and nets are inappropriate for rocky substrates that may snap lines, blunt hooks and
damage nets: traps are the preferred gears in these circumstances. In very soft substrates traps may sink into the substrate and become too heavy to lift and are generally not set in such conditions. Weirs are not used on very exposed shores where wave action may cause the gear to be swept away.

Sea lochs and fjords may have very steep drop-offs permitting the fishing of deep-water species from the shore with long-lines.

5.9: Discussion

The influence of hydrological conditions and fish behaviour on the choice and operation of fish gear discussed above, can be used to add resolution to the reconstruction of Mesolithic fishing practices. The use of fish remains to reconstruct past fishing strategies on the basis of biology, behaviour and ecology implicitly assumes that these factors have not altered since prehistoric times. However, the distribution of species may have changed, partly owing to changing climate but also a consequence of the overexploitation of many species by recent commercial fisheries. The action of climate on fish distribution and behaviour is evident even over the last hundred years. Records dating from AD 1900 detailing salmon (Salmo salar) fisheries indicate that there have been uniform changes in the time of year of capture in Scottish rivers, which corresponds to the northward movement of warm water currents over the last century (Summers 1995). This would suggest that the use of migratory species in the reconstruction of site/activity seasonality in temperate zones (e.g. van Wijngaarden-Bakker 1985; Belcher 1994b) should be performed with caution.

There are further indicators of the change in species distribution ranges available from medieval documents and archaeological excavations. The large populations of sturgeon (Acipenser sturio) documented to have ascended the Thames, Seine, Ebro and Po to spawn in medieval times no longer exist (de Rohan-Csermak 1963). Records also suggest that sturgeon may have entered further into the northern and middle areas of the Baltic in prehistoric times than in present times.

Of significance to the question of whether Mesolithic fisherman practised offshore fishing is the documentation indicating that many species now considered to be deep water or offshore species were commonly caught in inshore waters in the past. Though hake (Merluccius merluccius) inhabits deep offshore waters at present, it is reported to have been caught inshore along the East Coast of North America in the early 20th century (La Gorce 1924). Large halibut (Hippoglossus hippoglossus) are frequently caught from the shore using hook and line in Iceland. Records indicate that even as recently as 1965, porbeagle (Lamna nasus) was caught much closer to shore than today (Wheeler & Jones 1989).
It is certain that modern industrial fishing practices have reduced the observed size and age ranges of many commercially exploited species. Casteel’s (1976a) report of the size of Beluga (*Huso huso*) recovered from archaeological contexts in Russia indicates that modern fishing pressure has reduced observed maximum size and ages. Today, the maximum-recorded length of Beluga (*Huso huso*) is ca. 4.5m, however at 1st century BC to 3rd century AD, sites specimens over 4m are common suggesting a decrease in size in recent times. At the 14th century site of Berezorskii on the Middle Volga, Russia, remains of 500-560cm were found and specimens exceeding 600cm were found at the 7th/8th century site of Imen’kovo, Russia. Today, the Russian sturgeon (*Acipenser gueldenstaedti*) is not thought to exceed 242cm but examples of ca. 300cm were recovered at the 11th-13th century site of Mtsislav’l in the Upper Dnieper basin, Russia. Large specimens of stellate sturgeon (*Acipenser stellatus*) of 270cm were found at Upper Dzhulat (10th-13th century) on the River Terek, Russia, and sterlet (*Acipenser ruthenus*) of 120cm at the site of Bol’mera on the lower Don, Russia.

"the sub-fossil remains, in addition to indicating greater maximum sizes and ages, show significantly lower growth rates and ages to maturity than do modern examples of the same species" (Casteel 1976: 134).

There is evidence from the remains at Mesolithic sites that larger fish than expected were caught. Baltic herring (*Clupea harengus*) from the Skatoholm sites were found to be up to 40cm in length, today this species rarely exceeds 24cm. This discrepancy is attributed to the greater biomass and large quantities of invertebrates available in the Atlantic period (L Jonsson 1988). A large number of the perch remains from the site of Ákonge, Denmark, are larger than the modern average of 25cm. Enghoff (1994a) has reconstructed the size range of perch (*Perca fluviatilis*) as 11-40cm with the majority in the upper end of this range. The relatively large size of the fish recovered at Mesolithic sites does not alter the primary methods of capture based on behaviour but there is evidence that large marine fish may have been available in more inshore waters than at present. Eighteenth century fisheries report the capture of cod (*Gadus morhua*), halibut (*Hippoglossus hippoglossus*), haddock (*Melanogrammus aeglefinus*), turbot (*Scophthalmus maximus*), flounder (*Platichthys flesus*), rays (*Rajidae*) and other bottom species with hooks from the shore, however, industrial techniques and attendant over-fishing has resulted in a movement offshore of fishing grounds for these species (Jackson et al. 2001).

The selection for certain commercial species has altered the size and structure of fish populations. The numbers of salmon (*Salmo salar*) entering the rivers of Northern Spain are recorded to have significantly reduced since the 18th century (Pokines & Krupa 1997). Many highly prized food fish are apex predators, the large-scale fishing of such species has increased the abundance of smaller herbivorous species, which in turn, has seen a depletion in aquatic plants, particularly kelp forests, which in turn, further alters population patterns (Jackson et al. 2001).
Pollution is another significant factor in recent changes to both hydrology and fish populations. Estuaries, today considered amongst the most productive waters, are severely degraded (with increased sedimentation, turbidity, extreme variations in oxygenation, eutrophication, increased microbial production, dinoflagellate blooms, algae and loss of sea-grasses, dominant suspension feeders, oyster reef habitats) and would have been much more productive in the past (Jackson et al. 2001). This degradation is apparent in the Baltic from ca. 2500 BP (660 cal BC) and may have originated somewhat earlier. The trophic structure of the present day Baltic is known to be very different from that recorded a century ago.

Although commercial fisheries, climate change and pollution may have altered the structure, spatial distribution and size of fish populations, it is assumed for the purposes of this study that gross behavioural characteristics have not altered. It is explicitly accepted that the most appropriate methods for fish capture have remained uniform from prehistory to the present day. It can be suggested that deeper water species may have been present closer to shore in Mesolithic times than today but there is no definitive proof and all such speculation will be avoided in this study — modern distributions of fish species will be taken as representative of prehistoric fish populations.
An analysis of the archaeological data from European Mesolithic sites was conducted with the aim of addressing the key questions regarding Mesolithic fishing practices posed in Chapter 1. The salient archaeological features, artefacts and faunal remains of each site are presented in Tables 6.1–6.5. Fundamental to the execution of archaeological research is the excavation and reporting of single sites. Any extrapolation of fishing practice at a single site or drawn from a small number of sites is prone to errors or biases. The aim here is to draw together evidence from across Europe in a numerical format to avoid the inherent subjectivity of a purely descriptive approach and to question accepted and perpetuated wisdom based on microcosm studies. Conclusions are drawn from studies of correlation among spatial, topographical, artefactual and faunal variables.

6.1.1: Database Construction

Data were extracted from available literature for each site. One problem encountered was the variation in the quality of publications, most notable in early excavations and reports. Categories incorporated into the tables were:

1. Site/find location according to water-body (Table 6.1 and Appendix 1).
2. Ascribed date range and method of dating site/find (Table 6.1).
3. Identified fish fauna (Tables 6.2).
4. Artefacts possibly used as fishing implements (Tables 6.3).

These categories were used to give an overview of Mesolithic fishing (below) and to discern temporal, hydrological and spatial differences in practices (Chapter 7). A number of complicating factors arose during the extraction of the data. In a small number of cases the exact location of the site in relation to shoreline at the time of occupation was not specified. Data from any such sites, though included in the general discussion of finds, are excluded from analyses of variation in fish fauna or gear between inland and coastal sites. Changes in fishing practice between the Early Mesolithic and the Late
Mesolithic were analysed. Only sites where the remains were clearly stratified or securely dated by radiocarbon were included in analyses of temporal variation in practices. Finds from the sites were assigned to one of several categories based on the integrity of site stratigraphy and dating. Only those finds that could be securely assigned to either the Early or Late Mesolithic were included in temporal analyses. A significant number of finds of possible fishing implements are unassociated finds attributed to the Mesolithic period on the basis of typology only. Again, these finds were excluded from all analyses.

Table 6.5 summarises the information contained in the databases.

6.1.2: Analysis of Data

Analyses of fishing gear and fish species were conducted to assess overall occurrence at Mesolithic sites and the relative importance of various fish species and artefacts. Though fishing can be conducted in three different water types — marine, riverine and lacustrine — the location of the majority of Mesolithic lacustrine sites at river outlets prevents any fine-scale resolution of lake as opposed to river fishing activities. Two types of numerical representation were applied: ‘quantitative’, giving counts of gear or fish remains recovered; and ‘qualitative’ recording presence or absence at a site only — see Section 6.2.1 and 6.4 below.

6.2: Discussion of Results

In the following discussion of fishing practice throughout Europe it must be noted that the sites from the Baltic region greatly out-number those known from other regions and that local preservation conditions are, on the whole, better.

6.2.1: Discussion of Artefacts

“A thorough study of the Mesolithic should primarily be based on a material complex where the majority of artefacts deposited at a settlement may be expected to have survived” (Larsson 1978a:28–67).

As Larsson points out, this is far from the case with bone and antler implements, which are rarely preserved in Mesolithic contexts and this, in turn, has serious implications for the study of fishing technology from this period. Only under very exceptional conditions of preservation will a full inventory of fishing artefacts be recovered and only a very small number of sites (all in Denmark) fit this criterion. Such sites give an insight into the range of fishing implements that were available to Mesolithic groups across Europe. In 1885 Rau noted that the majority of the known ‘Old Stone Age’
fishing implements had been recovered from Scandinavia. This holds true today with a particularly large number of finds from Zealand. Any discussion of Mesolithic fishing gear and associated artefacts is therefore inevitably skewed to this area of Europe. It is uncertain whether this bias is the result of specialisation or preservation. The number of underwater sites in Denmark, which have exceptional preservation and contain the widest range of fishing related artefacts, is unparalleled (Andersen 1981, 1987b; Larsson 1983b; Trolle-Lassen 1984; Fischer 1988, 1995a, b). An increasing number of finds of fishing gear, possible fishing related artefacts and fish remains, and the results of stable isotope studies from outside the Baltic zone suggests that in some other areas of Europe, at least, fishing was equally important to subsistence strategies.

6.2.2: Analysis of Artefacts

The analysis of artefacts has been limited to that gear which is likely to have played a significant role in fishing practice or related activities. Qualitative and quantitative analyses were conducted. The qualitative analysis excludes any bias introduced to results by the scale of the fishing gear employed. Large-scale gear such as weirs or nets would be expected to be less numerous than small-scale gear such as barbed points or hooks. Analogy indicates that large-scale gear is communally owned and greater numbers of small-scale gears are privately owned. A further study was conducted which excludes all sites at which only projectile points have been recovered as this dilutes the representation of other artefacts that may be more relevant to fishing practice. In a large number of publications no indication is given of the total number of finds of a specific category of implement. For the quantitative analysis of the data all unspecified counts of gear were given a count of 1. It is accepted that as a result, any such gear may be under-represented. Changes of gear, spatially or temporally, were assessed in relative proportions, i.e. scaling the finds according to the number of sites in each category at which they were found. Any under-representation of gear is corrected by qualitative analysis of the data. It became apparent during the analysis that the possible under-representation of gear recovered in unspecified quantities combined with the huge numbers of projectile points and differential preservation makes qualitative analysis of fishing gear more informative than quantitative results. The various forms of projectile points were also subject to a separate analysis (Table 6.4 and Appendix 2). Additional data concerning the form, dimensions and raw material of specific examples of points of organic materials are also given in Table 6.4.

6.2.3: Fishing Gear Recovered from Mesolithic Contexts

There are very few artefacts recovered from the Mesolithic archaeological record that can be definitively linked to the practice of fishing. This may be due, in part, to the fact that a limited number of technologies are in use in industrial fisheries, which constitute the most immediate frame of
reference for interpretation of fishing gear. At only 82 of the 647 Mesolithic sites/finds from across Europe incorporated in this study were artefacts recovered that can be unequivocally associated with fishing (net or line weights, fishhooks, weirs, traps and floats). These implements indicate that the four main fishing techniques evident in traditional fisheries — netting, spearing, line fishing and trapping — were in use in the Mesolithic. There are several categories of implements, recovered from a much larger number of sites, that may have been used for fishing, but could also have been employed for some other activity.

6.3: Attributing Function to Multi-Functional Implements

The use of multi-functional tools for fishing is suggested by ethnographic analogy. Find location and associated faunal remains should be used to support any specific interpretation.

6.3.1: Projectile Points

Projectile points of various forms and dimensions constitute the largest group of finds of artefacts that may have been used in Mesolithic fishing practices. The quantity of finds, which greatly outnumbers all other categories of fishing implement, can be related to the multi-functional use of this type of implement. It is important therefore to discuss the possible range of functions of projectile points.

6.3.2: Bow and Arrow

Stone tipped arrows and spears are generally associated with the pursuit of terrestrial game. The oldest known bows and arrow shafts come from the upper layer at Stellmoor, Germany (Rust 1937). The association with reindeer hunting results in the general assumption that the bow and arrow was used exclusively for the capture of terrestrial game in the Mesolithic (Friis-Hansen 1990). Though this is undoubtedly the primary function of these implements, it is possible that bows and arrows with retrieval lines were used for fishing in the Mesolithic. It is certain from the recovery of blunts that the bow and arrow was used to take a wide range of small fur-bearing mammals and birds including waterfowl (Figure 6.1). The bow and arrow was observed to have been used by a number of groups for the procurement of large aquatic mammals and fish for subsistence, sport or for prestige (Table 3.1) (Hornell 1929b; Blackwood 1950; Kroeber & Barrett 1960–62; H Stewart 1975; Dosedla 1984; von Brandt 1984a). For example, the Southern Kwakuitl uses the bow and arrow for the pursuit of terrestrial and aquatic mammals, fish and waterfowl, to meet subsistence requirements (Kirk 1986). It is possible that the bow and arrow was used for fishing in the Mesolithic period. Wooden bows and arrows have been recovered from a number of sites that have evidence of fishing activities (Table 6.3).
Experimental studies of arrow use indicate that the use of arrowheads for fishing leaves distinctive traces, which should be identifiable through micro-wear analysis (cf. Fischer 1989b). Generally, it is thought that the presence of flights would exclude the use of an arrow for fishing. However, the Inuit use fish arrows with feather flights with multiple small barbed points (E W Nelson 1899). Although the bow and arrow is used in the subsistence fisheries of the Amazon Basin, it is not particularly efficient for the capture of any but the largest fish and would not be expected to be a primary method of capture.

Bows recovered from Mesolithic contexts are similar in form. Generally, these longbows of elm or yew wood have plano-convex limbs, which are notched at both ends for stringing, and waisted grips (Figure 6.2) (Burov 1990; Blankholm 1992; Bergman 1993; Andersen 1995; Bergman & McEwen 1997; Zaliznyak 1997). Bowstrings would have been made from sinews or plant fibres. The natural grain of the wood is followed in shaping the limbs to reduce chance of breakage. Complete examples are found to measure ca. 154-184cm in length. This form of longbow is thought to have had a range of 150-200m. The sophisticated construction of the examples from the Maglemose site of Holmegaard IV, Denmark, ca. 8000 BP (cal BC), leads Bergman (1993) to the conclusion that Mesolithic bows exhibit a significant tradition of manufacture. The choice of raw material for the manufacture of these bows shows understanding of the properties of different woods. The elastic resilience of the bow is paramount (Bergman 1993). Yew (Taxus spp.) wood is ideal, particularly if the sapwood and the heartwood are included in the bow: the sapwood is suitable for the back of the bow being strong, fibrous and elastic; the heartwood is brittle and can resist compression, making it ideal for the front of the bow. Elm (Ulmus spp.) is also suitable having fibrous sapwood that has a high tensile strength.

There are variations from the general form. One example, from Ringkloster, has an oval cross-section and thin limbs (Andersen 1995). A bow of smaller dimensions made from dogwood from Mollegabet II is notched at only one end. At the site of Vis, Russia, Burov (1996) questions the use of anomalous forms as bows and re-interprets examples that taper at one end as the circular frames of scoop nets – see Section 6.3.10. It is possible that the example from Mollegabet II, which takes this form, was actually a net frame.

It is not in the remit of this study to assess the use of specific lithic points in composite implements. However, it is interesting to note that the role of Bann flakes in fishing implements has been implied from find location (Bann valley, estuaries and lakes), morphology, wear and analogues (Woodman 1977). Groups of flakes have been interpreted as the remains of multi-point fishing spears, illustrated in Figure 6.3.1. However the thick, bulbous base of the Bann flake is not suited to hafting in a spear shaft (Figure 6.3.2). It is analogous to types used for large game hunting by Native American groups.
6.3.3: Slotted Points

The main morphological distinction of various forms of slotted point is the incorporation of flint inserts on one or both sides of the point. On this basis, a functional distinction is drawn — uniserial slotted points are determined to be cutting tools, knives or sickles, biserial slotted points are interpreted as projectiles. It should be noted that uniserial slotted points have been observed to be used as projectiles.

J G D Clark (1936) and Curwen (1941) attribute a function to slotted points analogous to multi-barbed points and hence a role in fishing activities on the basis of ethnographic parallels (Figure 6.4). The Greenland Inuit are known to have used such implements exclusively for the capture of aquatic birds (Rau 1885). Larsson (1978a) also takes the view that slotted points performed the same function as barbed points but bases the hypothesis on archaeological evidence. The argument is based on the large proportion of slotted bone points in comparison to barbed points at Agerød I and the relative scarcity of this form at other contemporaneous sites which exhibit the same economy. Though it is stated that the differences could also be the result of chronological and/or economic factors, it is clear that Larsson favours an interpretation of barbed and slotted points as fishing implements. Sulimirski (1970) attributes a fishing function to slotted points on the basis of their riverine/lacustrine distribution throughout Russia.

Zaliznyak (1997) takes an opposing stance proposing that these implements would have been used for the capture of large terrestrial game. Supporting this interpretation is the general form of the point and the lack of evidence for permanent binding to a shaft. Intact slotted points are symmetrical along the vertical axis tapering to a point at both ends. The flint inserts form a cutting surface parallel to the point designed to maximise penetration of the point and blood loss. This factor and the absence of barbs argue against use for aquatic prey where the primary aim is to retain prey rather than maximise blood loss. The only apparent methods of securing points to hafts are traces of resin. Points hafted only with resin have been experimentally found to be readily detached from the shaft upon penetration of prey (Pokines & Krupa 1997). This would be consistent with use as throwing/thrusting spears for terrestrial game — a detached shaft reduces the chance of the point breaking on impact (Feustel 1985) and prevents damage to the shaft if the animal is not immediately felled and flees through forest. It is common with detachable points for a retrieval line to be attached but the form of slotted points is not consistent with this. It is apparent from the heavy curation of slotted points at Agerød I that they were valued tools and as such it is unlikely that losses would be regarded as insignificant. It may be that the slotted point was so efficient in despatching the animal soon after impact that loss of the point (or prey) was so rare that retrieval lines were not considered necessary. Though the form of the slotted point would appear more consistent with the capture of terrestrial game than fish, they are used for the fishing of large species by the Inuit and many Oceanian groups (Sollas 1911; Larsen &
finds of small awls, clothes fasteners, and spears corroboratory evidence.

Those from Hohen (Andersen 6.5.3-4) are more the Federsee, period is which would have been shallow shore-side sediments, examples made from bird bones of the 6.4). (Table 6.3). In all but exceptional preservation conditions wooden slotted points would remain unidentified. Replication experiments indicate that slotted wooden points are as effective as slotted bone points. Confirmation for the use of slotted points in fishing comes from the microwear analysis of surface polish on the flint inserts of the Tlokowo (Poland) example was found to be consistent with use for fishing (Sulgostowska 1996).

6.3.4: Simple Points

On the basis of ethnographic analogy, simple points may have been employed in a number of fishing implements. For example, as self-spears, hafted as single points and used in the form of a gaff, incorporated as the barbs of composite fish hooks or set in rows in the form of a fish rake. Gaffs, self-spears and rakes are used only in surface or shallow waters for the capture of fish species that could be readily landed. The absence of a barb would preclude use for prey that is likely to struggle to escape or in deeper waters. Simple points of bone, antler or wood occur commonly on sites across Europe (Table 6.3). These range in length from 2.6–270.0cm and have a round or flat cross-section (Table 6.4). Most are broken and the original length is uncertain but in the case of bone/antler the dimensions of the raw material would limit the size of points. Most are made from cervid long bone or antler but examples made from bird bones were found at Ertebolle, Denmark and Viste, Norway (Mathiassen 1948; Schuldt 1961; Andersen 1991). That simple points were used for fishing in the Mesolithic period is suggested by the isolated find of a hazel-wood self-spear along with two large fish in Boreal sediments, which would have been shallow shore-side waters, at Siedlung Forschner on the shore of the Federsee, Germany (Jochim 1998). Other links made between simple points and fishing activities are more tenuous. The numerous short simple points of hazel and bone found at Tybrind Vig and those from Hohen Viecheln, Germany have been interpreted as the tips of fishing spears (Figure 6.5.3–4) (Andersen 1985, 1995; Malm 1995). This interpretation has been made without any form of corroboratory evidence. None of these examples were hafted, so they may not even have been used as spears and could have served a range of functions. For example, they could have been employed as awls, clothes fasteners, in fishing rakes or as ‘eel-sliters’. Andersen (1995) relates the large number of finds of small simple points at such sites as Dyrholm, Denmark, which was ideally situated for the
exploitation of eel (Anguilla anguilla) with the use of this type of point among Pacific Coast groups for skinning eel (Anguillidae) (Figure 6.6). The parallels are striking but it should be noted that eel were not actually recovered from Dyrholm. Short simple points with epipyses (i.e. analogous in form to the eel-slitters of traditional fisheries) are common at Bjørnholt, Denmark, which has faunal remains corresponding to a significant eel (Anguilla anguilla) fishery, but the correlation is not clear at other sites and not apparent over the Mesolithic as a whole. Larger simple points are more likely to have been hafted as spears or lances but again this does not imply use in fishing. Examples were recovered from contexts that imply use as weapons, e.g. Henriksholm-Bøgebakken, Denmark (Verhart 1989; Blankholm 1992). Simple points have been found at sites with evidence for fishing activity e.g. Ringkloster, Tybrind Vig, Norsminde and Ertebølle, all Denmark, where barbed points have not been recovered (Table 6.3). It is possible that simple points took the role of barbed points at this site. Simple points are also numerous at sites with barbed points and have been found in groupings of barbed points suggesting that they were hafted along with barbed points in leisters. It seems likely that the simple point was employed at many sites for a range of functions; domestic, defence, fishing and terrestrial hunting. Only the context of any specific find can indicate that a simple point was used for fishing or incorporated in a composite implement for fishing.

6.3.5. Barbed Points

Barbed points constitute the largest single category of finds in the study. A wide range of forms has been recovered from Mesolithic contexts at intra-site and inter-site level (Table 6.4, Appendix 2 and Figure 6.8). Ethnographic and ethnohistoric records indicate that barbed points were commonly used in the capture of fish and constituted the main method of capture in certain geographical/hydrological conditions or at specific times of the year. Among the Ainu of Japan, fish spears are considered the most important method of freshwater salmon (Oncorhynchus spp.) capture during migrations and at spawning grounds, with all other fishing gear playing a secondary role in resource procurement (Watanabe 1973). Barbed points found in Mesolithic contexts have frequently been linked to the pursuit of fish and sea mammals on the basis of ethnographic analogy and also through archaeological association. Barbed bone/antler or wooden points have been linked to fishing practices at a number of sites of Mesolithic date, based on the find of a pike (Esox lucius) skeleton in association with a point at Kunda, the numerous in situ finds of points in ancient lake beds at Amose, Tybrind Vig, both Denmark, and Lake Lubana, Latvia, the association of barbed points with hooks at Europoort, Netherlands, and the erosion of the tip of the point related to the bacterial secretions of rotting fish at Ulkestrup, Mullerup and Sverdborg I, all Denmark, and by the similarity of the points to leisters used in traditional fisheries (Broholm 1926–31; Indreko 1948; Tringham 1971; J G D Clark 1975; Verhart 1987; Loze 1988a; Pedersen 1995; Andersen 1995). Blankholm (1992) questions the association of the pike (Esox lucius) skeleton with the barbed point at Kunda, Estonia, however the find of the point in situ in a prehistoric lakebed suggests loss during fishing even if there is no direct association with
the pike (Esox lucius) skeleton. J G D Clark (1975) uses the lack of finds of both fish remains and barbed points at the site of Holmegaard IV, Denmark, to support the interpretation of barbed points as fishing spears or leisters. Basing an argument on negative evidence is tenuous, particularly in light of the number of sites at which barbed points are found but no fish remains are recovered (e.g. Star Carr, England) and the sites at which large number of fish remains are recovered but no barbed points are found (e.g. Ertebølle, Norsminde and Ringkloster, Denmark).

Finds of points with hafts (e.g. Ulkestrup I and Åmosen, Denmark, and Hørninge Mosse, Sweden) indicate that these implements were hafted singly (as spears) and in groups (as leisters) (Figures 6.7 and 6.8a.3–4). Blankholm (1992) states that spears constitute a category of implement for which function is unambiguous. However, the spear throwers of Aboriginal groups of South East Australia are analogous to the large single barbed points of Mesolithic sites generally interpreted as tips of hunting or fishing spears. Though the majority of these implements recovered from Mesolithic contexts would have served as projectile points, their exact function (whether used in fishing, terrestrial hunting or for defence) is debated, particularly in areas where preservation conditions are poor; a problem compounded by the large number of unassociated and isolated finds.

A comprehensive study of the contextual associations of barbed points of Mesolithic date from across Northwest Europe conducted by Verhart (1989) indicates that barbed points were used for a variety of functions including hunting and fishing and as weapons. This corresponds to the range of uses documented for ethnographically observed groups (S E Churchill 1993). Despite the range of uses indicated by the contexts of Mesolithic finds, there are significant variations in the interpretation that are subjective rather than inferred from the evidence. The majority of Scandinavian and East Baltic finds are interpreted as some form of fishing implement regardless of the context of the find. However in most other parts of Europe, finds of barbed points are attributed a role in terrestrial hunting (Rust 1937; M W Thompson 1954; Wymer 1962; Hallam et al. 1973; Arambourou 1976; Célerier 1976; Escalon de Fonton 1976; Lorblanchet 1976; Simonet 1976; Jochim 1998) unless associated finds indicate a maritime adaptation (e.g. Straus 1991b; Pokines & Krupa 1997). The site of Star Carr exemplifies this dichotomy. The nature of the site and the activities conducted therein has been the subject of much debate and controversy. However, had this find been made in Scandinavia, it is almost certain, as Price (1985) points out, that the barbed points would be implicitly assumed to be fishing implements and as such, taken as evidence for the importance of fishing at this location. The form of several of the Star Carr barbed points is consistent with that of leisters used in traditional fisheries. The barbs begin more than halfway up the point and incised grooves on the bottom half suggest binding up to the mid-part of the point, common in leister prongs to prevent the wriggling fish pulling the points apart and escaping. Finds of groups of barbed points in close association lend credence to this interpretation (Figure 6.9).
Zaliznyak (1997, 1998) states that fishing would have been of little significance to the economy of groups inhabiting the Boreal forest environment of the Early Mesolithic (based on analogy with taiga zone hunter-gatherers) stating that barbed points were predominantly, if not exclusively, used in the pursuit of forest game. Similarly, Feustel (1985) argues from the association of finds and from parietal art that barbed points, both uniserial and biserial were primarily used for terrestrial game hunting. There is clear evidence for the use of barbed points in the pursuit of terrestrial game: at a number of sites of Late Glacial and Mesolithic date it is clear that barbed points were used in the pursuit of terrestrial game from the morphology of wounds e.g. Stellmoor (Germany), Poulton-le-Flyde (England) and Meiendorf (Germany) (Rust 1937; Hallam et al. 1973; Noe-Nygaard 1974; Feustel 1985). A study of the wounds on 14 terrestrial animals from eight Danish sites of Mesolithic date indicated that these wounds could have been inflicted by a number of implements including lance, spear point, slotted bone point, large barbed harpoons, notched leister prongs, harpoons or large oblique/transverse arrowheads (Noe-Nygaard 1974). Parietal art confirms that barbed points were used for terrestrial hunting: bison hunted with uniserial barbed points are depicted at Grotte d’Isturitz, Pyrénées-Atlantiques, France (Feustel 1985). This interpretation bias of a terrestrial hunting function for subsistence-related artefacts is, at least in part, a consequence of the ‘Man the Hunter’ concept, which was based on the inadequate application of analogies and a misunderstanding of the nature of archaeological faunal assemblages. A study of 96 modern or recent hunter-gatherer groups undertaken by Churchill (1993) concluded that although spears were used for a range of functions (including terrestrial and marine mammal hunting, fishing, warfare and defence from predators) in only half of the observed groups were spears used for terrestrial hunting. As discussed in Chapter 2, it is now known that many Mesolithic groups relied heavily on aquatic resources. However, early excavations and publications tended to emphasise the role of large terrestrial game in subsistence strategies. It is important to note that fish remains (pike [Esox lucius]) were identified at both Stellmoor and Meiendorf, Germany (J G D Clark 1948a) which may suggest that the view of Ahrensburgian groups as exclusively ‘reindeer hunters’ may be due to bias in preservation, recovery and the lack of a coastal aspect from this period.

The initial maritime focus in research strategies and more recent extensive excavation and fine sieving of Mesolithic deposits in Scandinavia led to a significant departure in the interpretation of implement function in this region. In discussions of points recovered from Scandinavia, a function in fishing is generally assumed rather than established (Blankholm 1992). For example, Larsson (1978a) states that the barbed points from Ageröd I were undoubtedly hafted as leisters, despite the lack of evidence to support this. The use of uniserial points in fishing is supported by rock carvings considered to be of Stone Age date from the Karelia region of Russia on the White Sea coast which clearly depict fishermen using uniserial barbed points. Although there is a clear co-occurrence of fish remains and barbed points in Scandinavian Mesolithic contexts a wide range of resources were exploited by these groups and barbed points were not necessarily used for fishing in every case. In an attempt to redress
the balance and move away from the concept of Mesolithic groups as 'hunters', certain archaeologists have taken too extreme a stance. Sweeping statements such as that made by Pokines & Kruppa,

“Barbed points and harpoons...may be functionally useful on terrestrial game, but they are put to better use in an aquatic setting where they can effectively secure the prey which might otherwise sink or float away”

(1997:251)

should be avoided in any discussion of multifunctional implements — intra- and inter-site variation in function may occur. For example, one set of hardwood barbed points are manufactured for all terrestrial hunting and fishing activities by the groups of the Amazon Basin (Curwen 1941; C Smith 1981; Grayson 1992).

There are further biases in interpretations that are not consistent with ethnographic analogy. From the available archaeological literature concerning the subject of barbed points it is clear that uniserial points, points found in groups and points with small barbs are much more likely to be interpreted as fishing implements than single finds of barbed points, points with large barbs or biserial points which are more generally linked to terrestrial or marine mammal hunting (e.g. J G D Clark 1948a, 1954, 1965, 1975; Clarke 1976; Larsson 1978a; Mons 1979; Trolle-Lassen 1984; Loze 1988b; Blankholm 1992; Andersen 1995; Malm 1995; Jochim 1998). Wooden barbed points (e.g. Tybrind Vig) are invariably interpreted as leister prongs (e.g. Andersen 1995). This bias may in part relate to the recent use of barbed wooden points hafted in groups as leisters in traditional/historic fisheries of Scandinavia. Most significant in this interpretation bias would appear to be the finds of wooden barbed points at waterlogged sites which also preserve significant quantities of other fishing related organic artefacts and large fish bone assemblages. However, the association of bone points with coastal, riverine and lacustrine Mesolithic sites should not be taken as 'proof' of the use of these implements exclusively for fishing. As Woodman (1978b) points out, this distribution of points may simply relate to bias in preservation conditions — waterlogging and therefore organic preservation being most common at aquatic locations.

The distinction of the terms 'spearhead' and 'leister' further exacerbates problems of interpretation of function, the former term is generally applied to single points and to terrestrial game hunting, the latter to multi-barbed implements used for fishing. Ethnographic observations indicate that this distinction based on morphology cannot be upheld. The form of multi-barbed points (i.e. leisters) does suggest a function in fishing, but this type of point is also known to have been used for the capture of birds and small terrestrial game (Figure 6.10) (Kroeber & Barrett 1960–62; Schuldt 1961; Kennedy & Bouchard 1990a).

It is impossible to dismiss or confirm the use of barbed points in the pursuit of aquatic resources purely on the basis of number of points hafted, the size of the barbs or the raw material of manufacture. Single points and groups of points, both biserial and uniserial, with varying sizes of
Barbs made from wood, bone or antler and stone have been observed to have been used for the capture of fish, and marine and terrestrial mammals among groups across the globe (Tables 3.1 and 3.2). The study of Bennyhoff (1950) demonstrates the use of all these types for fishing within a single geographic region (Figure 6.11). The difference in the size of barbs cannot be used to differentiate between sea mammal hunting, terrestrial hunting or fishing; large barbs may be used in the capture of large fish; essentially harpooned or pierced if set in a leister. Fish may be taken with smaller barbed points particularly if the fish is to be processed for storage or the skin is used as a raw material.

Barbed points are associated with the pursuit of terrestrial and aquatic animals both in ethnographic observation and the archaeological record. Debating primary function is a moot point. This would be determined by the economy of the particular group in question. It would seem reasonable to assume that a certain number of the points recovered from Mesolithic contexts, hafted singly as spears or in pairs and groups as leisters, were used for the capture of fish. It is assumed in this study that where barbed points have been found they could have been used for the purpose of fishing, even if this is not their sole or primary function. Given that form is not equivalent to function, the typologies proposed by J G D Clark (1936) and later refined by Verhart (1990) should only be seen as descriptors which should be used in the recording of finds.

The association of finds and their method of hafting may be suggestive of subsistence activities. As indicated above, all types of composite and single-piece barbed and simple points have been incorporated into spears, leisters and harpoons employed in traditional fisheries (e.g. Figure 6.12) (Bennyhoff 1950; Kroeber & Barrett 1960–62; H Stewart 1975, 1977; Watanabe 1977). However, not all traditional fisheries use each type of implement; this is culturally determined (Kvause 1956). The analysis of ethnographic records (Chapter 3) documents the use of these implements primarily for eel (Anguillidae), flatfish (Pleuronectidae), pike (Esox lucius), sturgeon (Acipenseridae) and salmon (Salmonidae) in shallow or surface waters and for ice fishing of these species (Table 3.2). Other large fish species are preferentially taken with hook and line and may be despatched with a fish spear. Fish spears/leisters/harpoons are most commonly employed in freshwater and estuarine fisheries.

The form of a point may suggest use. A number of points from Mesolithic contexts have an unusual form that is not consistent with use as thrown spears or harpoons. These forms would probably have been used as thrusting spears (Figure 6.8d.4–6). Hunter-gatherer groups use thrusting spears for fishing and for despatching large mammals (marine and terrestrial). A range of forms of wooden or bone barbed point have been recovered hafted as leisters. This corresponds to the conclusions drawn above concerning ethnographic examples, i.e. barbed point morphology cannot be related to gross functional classifications such as terrestrial hunting, marine mammal hunting and fishing. However, within a single functional category, such as fishing spears and leisters, barbed point morphology may be used to indicate the types of fish species pursued. Single point fish spears are used to impale the fish: generally larger individuals taken in clear waters with high visibility. Leisters with two prongs
can be used to retain fish without impaling. This type of leister is frequently used in traditional fisheries for the capture of anadromous species for storage or where the skin of the fish is utilised as a raw material (Table 3.3). Multiple barbed points, like fish spears impale the fish but conditions of use differ: they are used for the capture of a range of species in turbid or coloured waters where visibility is reduced and in the capture of species that burrow into substrates. Leisters used in traditional fisheries across Europe for salmon (Salmo spp.) and eel (Anguilla anguilla) fishing take the same basic form as those recovered in Scandinavian contexts and often have detachable heads with retrieval lines, though now manufactured in metal (Best 1929; Fenton 1969; Jenkins 1974; von Brandt 1984a; Went 1951).

Hafting methods and the association of finds attest to the use of single and multiple barbed points in Mesolithic Europe. Both types, as discussed above, could have been used for fishing. Single point spears are inferred from traces of resin, incised grooves to facilitate hafting and the general form of the points recovered at Hohen Viecheln (Schuldt 1961). Examples from Åmosen and Friesack (Germany) still bear the traces of a 2-ply twisted cord of plant fibres used to secure the point to the shaft (Figure 6.8a.5) (Larsson 1978a; Gramsch 1992). Similar finds with traces of mastic and binding come from a number of sites including Ågeröd I, Fäl Mosse and Rablevssjön (Sweden) (J G D Clark 1936b; Newell 1973; Feustel 1985). These methods of hafting points using vegetable fibre cords and resin to secure points to shafts are identical to the methods most commonly observed ethnographically (Feustel 1985). Leather or sinews are less commonly used as binding materials.

Hafted or bound multiple-point spears (*i.e.* leisters) are also attested. Examples retaining traces of binding are known from Hørminge Mosse and Siretorp (Sweden), and Skjoldnaes and Ulkestrup II (Denmark) (Figure 6.7). Finds of groups of points (generally three to five points including one point that is not barbed), their association implying hafting as a leister but all traces of the original binding having decayed have been made at Horne and Mullerup. The lack of detailed publication or illustration of these finds limits discussion.

Two main forms of wooden leister prong have been identified: one long and slender, the other short and broad (Figure 6.12). The different forms represent a technological adaptation to use on soft and hard substrates respectively (Andersen 1995). Andersen suggests that both forms would have been used for eel fishing on the basis that the leisters were lost during fishing in front of the settlements. This is an inadequate explanation, many species could have been fished in the immediate vicinity of the settlements. It is likely that the long, slender leister was used for eel fishing based on the analogous leisters used in recent Irish fisheries for spearing yellow eel (Anguilla anguilla) in estuarine mud. The design of the leister is clearly adapted to the capture of the serpentiform eel. This type (Figure 6.13) differs from the reconstruction shown in Figure 6.12 only in the addition of a central simple point, which impedes escape. Yellow eel (Anguilla anguilla) lie completely beneath the substrate when not feeding and can be detected and impaled at low water by the distinctive mark the
fish leaves on the mud surface (Went 1951). The latter form could have been used for the capture of a wider range of species inhabiting shallow waters.

Wood may have been favoured for the manufacture of these implements because it is relative easy to work and the availability of naturally curve pieces of wood that would require little shaping but also because the dimensions of the point is less limited than those manufacture from bone or antler. Wooden leisters have only been found at sites with exceptional preservation conditions (i.e. waterlogging) such as the Danish sites of Møllegabet, Tybrind Vig, Åro, Vedbæk, Holmegaard, Brabrand, Dyreholm and Kolind (Mathiassen 1948; Albrethsen & Brinch Petersen 1976; Aarims-Sorensen 1980a; Andersen 1995). It is likely that these implements were in more widespread use than the archaeological record suggests. It is also possible that a significant number of barbed points had been constructed using a wooden shaft with flint inserts taking the form illustrated in Figure 6.14; this form of point would be archaeologically ‘invisible’.

6.3.6: Harpoon

It is clear from examples of simple and barbed points with perforations that some of these points were not securely hafted but rather used as harpoons (Figure 6.8d.2–3). The use of the ‘true’ harpoon is often associated with hunting sea mammals or other aquatic resources (e.g. J G D Clark 1948b; Zvelebil 1978; Straus 1991b; Lüugas 1996). Rozoy states of true harpoons (from Azilian and Ahrensburgian contexts) that,

“Nobody doubts that their use was for fishing” (1978:160).

Harpoons commonly serve this function in ethnographically observed groups. It is assumed that retrieval lines would tangle on vegetation when used in terrestrial hunting, an explanation given by Northwest Coast groups for the limited use of harpoons in the pursuit of terrestrial game (Kroeber & Barrett 1960–62; M C Nelson 1997). However, the Agta of Luzon, Philippines, use the bow with multi-barbed arrows and a retrieval line in terrestrial hunting so this use cannot be excluded for archaeological finds.

Harpoons occur across the European Mesolithic, both spatially and temporally, but occur most commonly in south-west Europe at Early Mesolithic (i.e. Final Magdalenian and Azilian) sites. Multivariate analyses of these points conducted by Mons (1979) and Peterkin (1993) conclude that the morphology of perforated points is sufficiently distinct from that of unperforated points to indicate different functions. This conclusion is not upheld by ethnographic data.

A large body of ethnographic literature indicates that harpoons were commonly used for large and voracious fish, particularly in coastal waters and the tidal reaches of rivers, by Arctic, sub-Arctic and temperate hunter-gatherers (Table 3.2). Not all groups with harpoon technology use them for fishing
they may be used exclusively for marine mammal hunting. The use of detachable points with retrieval lines allows the fish to struggle without damaging gear. The morphology of a number of finds without perforations and ethnographic analogues of these implements suggests that these were also used as harpoons with the line attachment facilitated by some other means. Forms with large barbs or notches at the base may have been intended for use as harpoons, the notches/barbs facilitating line attachment.

J G D Clark (1975) has noted a correlation between finds of seal (Phocidae) remains and barbed points with a spacing of at least 2cm between the barbs and also states that points with a large single barb would have been used for sea mammal hunting. Those with medium set barbs were found in association with both terrestrial and aquatic animals. Narrowing use to a specialised function cannot be supported on the basis of morphology alone. Large points with a single barb are often perforated at or above the barb to produce a toggling action. Toggle head harpoons are most commonly associated with Arctic groups who use these implements predominantly for the capture of marine mammals but toggle head harpoons are used for fishing and for terrestrial game by Arctic groups and in more southerly latitudes. Toggle-head harpoons have been recovered with fish fauna at the small cave site of Odmut, Montenegro, in Mesolithic and Early Neolithic deposits — Figure 6.8d.2 (Srejović 1975). Unfortunately, although fish remains were recovered from both Mesolithic levels at Odmut these have not been identified to species and the possible use of the toggling points in fishing practices cannot be assessed.

It is possible that the size of the barbs may relate to function (though this is not confirmed ethnographically) but it is more likely to relate to technological efficiency. Smaller barbs are less likely to break on impact and make the point easier to remove from prey (Feustel 1985). Larger barbs would be suited to the capture of animals that are likely to fight fiercely to escape, e.g. large predatory fish. There is a correlation between flat barbed points and coastal location in Britain implying use for the capture of marine mammals (Bonsall & Smith 1989). This coastal bias is evident for finds of perforated barbed points across Europe (Table 6.4). The coastal distribution of these finds does not indicate functional exclusivity; i.e. these implements are commonly used in the fisheries of groups also exploiting sea mammals. The distinction drawn between the capture of sea mammals and large fish is subjective rather than functional. It should be noted, however, that lances are ethnographically documented in the pursuit of large sea mammals only among Northwest Coast groups (Bennyhoff 1950).

6.3.7. Clubs

Clubs are used by most groups that depend heavily on larger fish species for subsistence, particularly for salmon (Salmonidae), sturgeon (Acipenseridae), catfish (Siluridae) and cod (Gadus spp.) when taken by methods which do not immediately kill the fish, e.g. trolling, nets and hooks.
Clubs made from the ends of tree branches were recovered at Holmegaard I and Brabrand (Denmark), and Vis I and Nizhnee Veret'e I (Russia) range from 30-36cm in length. An example from Holmegaard I, which is 31cm long, may have been shaped with the use of fire (Figure 6.15). Feustel (1985) suggests that these clubs would have been used to take pike (Esox lucius) in ice fishing. Traditional fisheries use clubs to stun the fish under the ice, which are then rapidly hauled. Details of fish remains recovered at these sites are limited. It is known that pike were taken at Holmegaard I so it is possible that the clubs were used to despatch large fish. Fishing clubs of the specific form identified at Holmegaard I are known ethnographically (Figure 6.16).

Stone clubs, ranging in size from ca. 12–50cm, are known from Vlasac I and Lepenski Vir (Serbia, Iron Gates) and have been interpreted as clubs for killing fish (Srejovic & Letica 1971; Prinz 1987). The complete examples are analogous in size and form to the clubs used by Northwest Coast groups for despatching large fish or in warfare (Figure 6.16) (H Stewart 1975). Those of hardwoods or stone were used for fish with tougher skins such as sturgeon (Acipenseridae); clubs of lighter woods were used for less robust species such as salmon (Oncorhynchus spp.) (Kroeber & Barrett 1960-62). The large sturgeon (Acipenser sturio) taken at the Iron Gates sites would require some form of implement to despatch them once landed. Sturgeon (Acipenser sturio) was not identified at either Vlasac or Lepenski Vir, but the significant quantities of catfish (Silurus glanis) recovered at Vlasac (estimated to weigh up to 100kg) and smaller numbers at Lepenski Vir could have been despatched with clubs.

6.3.8: Hooks

Hooks are a category of implement that can invariably be linked to fishing although the Inuit and Coast Salish also use them for the capture of waterfowl (E W Nelson 1899; Blackman 1990). Hooks have been described as rare finds in archaeological contexts (e.g. Rau 1885; Rostlund 1952; J G D Clark 1975). This scarcity is attributed to a preference for larger-scale techniques or the friable nature of the raw materials often used for hook manufacture in traditional fisheries. For example, hooks are exceptionally common at Mesolithic sites around Lake Lubana, Latvia, which is attributed to the use of slate in manufacture and the durable nature of these hooks (Loze 1988a). The natural buoyancy of less durable plant materials may be preferred to bone or stone for hook manufacture for fishing in surface and mid-waters (Rau 1885; von Brandt 1984a). Large numbers of hooks have been recovered at sites such as Skipshelleren, Viste, Gressbakken, Advik, Nyelv Nedre Vest and Rottjärnslid (Norway), and Franchthi and Cyclops Cave (Greece). However, the lack of finds of hooks at other Mesolithic sites is not simply a consequence of preservation bias. The numerous finds of other types of fishing gear at submerged sites suggests the scarcity of hooks also reflects the use of other types of gear more suited to the intended prey or local hydrological conditions and may be linked to the limited response of migrating species to baits.
The earliest known hook was recovered from Boreal contexts at Pulli, Estonia (Zaliznyak 1997). Early hooks of the Baltic region are unbarbed and generally U-shaped (e.g. Figure 6.17.2) (J G D Clark 1948a; von Brandt 1984a; Feustel 1985). Unfinished examples and blanks, e.g. Mullerup and Bjørnsholm, Denmark, and Gäsen and Viste, Norway, indicate the method of hook manufacture. These examples have been made from splinters of bone with the use of a drill (e.g. Figure 6.17.9).

Three forms of line attachment are apparent: perforation, swelling or indentation. Single-piece, V-shaped hooks, which are sometimes barbed, appear in the later Mesolithic alongside U-shaped examples (J G D Clark 1965; Trolle-Lassen 1984). J G D Clark (1975) attributes this development to a new focus on pike (Esox lucius) fishing: this does not correspond to the findings of this study, which indicate the importance of pike (Esox lucius) fishing throughout the Mesolithic. The form of the crook is functionally rather than stylistically determined (de Rohan Csermak 1963; Croes & Hackenberger 1988; Allen 1996; Croes 1997). Thus, the U- and V-shaped hooks recovered at Mesolithic sites may have been used in two distinct fisheries. The scarcity of V-shaped hooks in the Early Mesolithic may reflect the inland location of finds rather than the late development of these hooks. Single piece V-shaped hooks are more likely to be broken at the bend by fighting species than U-shaped hooks. For this reason, U-shaped hooks are preferentially used for cod (Gadus macrocephalus) fishing by Northwest Coast fishermen with V-shaped hooks more commonly used for halibut (Hippoglossus stenolepis) — see Figure 6.18 (Croes & Hackenberger 1988; Croes 1997). Examples from Nyelv Nedre Vest and Gressbakken, Varanger fjord, have an indentation or a swelling at the bend and another from Agerød ID has a small perforation at the bend that may have facilitated float attachment (Figure 6.19). Hooks floated in this manner (known as ‘samalovs’ in Eastern European fisheries) are fished with the crook pointing toward the substrate (Figure 6.20) (de Rohan-Csermak 1963). Floated U-shaped hooks have been used in traditional fisheries for the capture of large predatory species such as catfish (Silurus glanis), sturgeon (Acipenser spp.) and pike (Esox lucius) in freshwater and in marine cod (Gadus morhua) fisheries (de Rohan-Csermak 1963; Renouf 1989). These types of fishing are further suggested by the line sinker and float recovered at Siiversti, Estonia. In an early work, J G D Clark (1948a) suggests that it is the larger hooks of the Maglemose period (e.g. Mullerup) that were specifically developed for the capture of large species including pike (Esox lucius) (Figure 6.17.2). Interestingly, the occurrence of hooks at inland sites is predominant where specialised pike fisheries were conducted — particularly sites located on the shores of ancient lakes. Barbed points are the dominant form of artefact at this site and would have been an efficient method of capture during the spawning season. The hooks may have been used to take pike (Esox lucius) when resting in deeper waters and possibly for fishing under ice in winter. Naturally-pointed bones of large animals may have been used as ice picks in winter fishing, a function proposed by J G D Clark (1948a) on the basis of 70 finds recovered from the bottom of Lake Kunda near the Kunda-Lammasmägi site, Estonia. The faunal remains at this site demonstrate a significant pike (Esox lucius) fishery (J G D Clark 1948a).
Fish hooks from coastal Danish sites of the Ertebolle period are generally smaller than hooks from inland sites of the Maglemose period (Figure 6.17). The known Ertebolle examples are ca. 2.0–3.9 cm in length and are barbless. Andersen (1995) suggests that hooks of the type found at Ertebolle were used for eel (*Anguilla anguilla*) fishing on the basis of similar hooks used in modern summer eel fishing in the Limfjord region. Hook fishing is seen as a small supplement to trap fishing at these sites. This is assumed despite the fact that the only remains of fishing gear at the type-site of Ertebolle were five fish hooks. Trap fishing may have been important at these sites but hook fishing may have been equally important on a seasonal basis. There is the implicit assumption in Andersen’s (1995) interpretation of hook function that all gear is produced with the intention of exploiting a single species at the Limfjord sites, i.e. eel (*Anguilla anguilla*). Correlation studies indicate that there is a significant relationship between finds of hooks and cod (*Gadus morhua*) remains (both qualitatively and quantitatively), suggesting that this was the primary function of hooks in coastal regions — see Chapter 7. Coastal groups of the Northwest Coast considered the seasonal cod (*Gadus macrocephalus*) and halibut (*Hippoglossus stenolepis*) line fisheries equally as important a subsistence activity as the riverine weir and trap capture of anadromous species.

Brinkhuizen’s (1983) study of fishing gear from north-west Europe (specifically Sweden and the Netherlands) suggests that hooks are generally larger in coastal locations than inland sites, and this is attributed to the larger size of intended marine prey. This is not supported by Mesolithic evidence from Denmark. The average size of hooks at coastal sites is smaller than hooks at inland sites. Although there is no clear relationship between the size of hook employed and the prey captured, the strength of the hook will limit the size of fish that can be taken: larger hooks are generally more resilient and will be preferred for the capture of large individuals. Certain species recovered from inland sites can grow extremely large and remains of large pike (*Esoc lucius*) and catfish (*Silurus glanis*) from certain inland sites are significantly larger than the majority of the remains from Danish coastal sites. The use of small barbless hooks in the Ertebolle period is suggestive of active line fishing.

Renouf (1989) notes a decrease in the shank length of the hooks from Gressbakken compared to Nyelv Nedre Vest, which is attributed to style or function (Figure 6.21). Variations in shank form are generally stylistic considerations and do not impact on function (Allen 1996). However, Renouf does not discuss gross morphological variations in hooks from the Varanger sites. These variations in hook form at the Varanger sites can be related to distinct fishing practices. The single piece hooks from the site take two forms; barbed and unbarbed. It is probable that these hooks performed different functions. The barbed examples resemble the hooks of the Saami and Inuit groups used for marine fishing (Figure 6.22). The presence of barbs at the point and bend suggests use in baited set-line fishing — the barbs acting to retain the bait and hold the fish. The unbarbed examples are similar to Mesolithic finds from sites on the exposed North Sea coast and in the Baltic region and were possibly used in more active line fishing (Figure 6.21).
Hooks are much more common in Neolithic contexts and the first definite examples of composite hooks are said to date from this period (Brinkhuizen 1983; Choyke & Bartosiewicz 1994; Løugas 1996). Although the identification of composite hooks from the finds of small barbed points at Sønderholm and Bloksbjerg, Denmark, remain inconclusive, definite examples of composite hooks have been recovered at the Varanger sites (Figure 6.23). The crooks took two main forms. The first type, described by Renouf as a small harpoon point (similar to those found at Sønderholm) would have been incorporated into composite hooks as illustrated in Figure 6.24. The other form of crook depicted in Figure 6.23 is analogous to that of trolling hooks used by the Maori for large marine species (Figure 6.25).

It is possible that a large number of composite hooks remain unidentified. The use of microliths as crooks is possible in the form of the Greenland example (Figure 6.26). Unless found with the shank bound to the crook, this form would be archaeologically invisible.

Plummets made from perforated oval, flat pebbles were found in the Late Ertebølle contexts of the Kolind midden, Denmark, and Tybrind Vig, at the Åmose site of Hesselbjerggaard, Denmark, at Ostrovul Mare, Romania at the Varanger fjord sites of Gressbakken and Nyelv Nedre Vest and possibly at Hohen Viecheln (Figure 6.27). The association of some of these finds with hooks, their size and morphology, all suggest that the plummets were used in line rather than net fishing. The use of line sinkers correlates to fishing at depth, bottom fishing or fishing in very fast currents. Unmodified sinkers, which can only be tenuously identified in archaeological contexts, have been used in traditional line fishing. The Northwest coast groups use sinkers that are not firmly secured to the fishing line and are left on the substrate when the catch is landed (Figure 6.28) — the use of this method of fishing would limit the recovery of line-sinkers from archaeological sites. Wooden floats with two perforations are also likely to have been used with lines rather than nets. An example is known from Mollegabet I, which has the remains of a plant fibre fishing line (Skaarup 1995a). The double perforation allows the float to be repositioned along the line according to prevailing water conditions and bait choice. It should be noted, however, that no hooks were recovered in the substantial artefact inventories at Mollegabet I. Bottom fishing with hook and line and possibly with long lines for cod (*Gadus morhua*) and other deeper water species is evident from the fish species and their biological adaptation. The use of line weights and floats is consistent with fishing for demersal species, where the line must be weighted to keep it on the bottom with the hook floated to keep it clear of the substrate. This clearly ties in with the fish species identified at the Varanger sites and at Mollegabet I. An oval float from Silversvi, similar to those recovered at Antrea, Finland, was attached to a stone sinker by cord (Burov 1992). This would have served as a line sinker for bottom fishing, the float would have held the hook and any bait used above the substrate surface (*e.g.* Figure 6.29). Sinkers are not generally attached to net floats. This provides an excellent illustration of the difficulty in reconstructing fishing practice on the basis of finds of either sinkers or floats, which can be equally
used in line or net fishing. Often, the size of the float or sinker is used to determine function but for the capture of large species such as catfish (*Silurus glanis*), beluga (*Huso huso*) and some species of sturgeon (*Acipenser* spp.), large floats and sinkers may be employed in long-line fishing.

The small number of preserved fragments of fishing lines suggests a preference for plant materials. Traditional fisheries employ a number of different raw materials including nettle (*Urtica* spp.), hemp (*Cannabis sativa*) and tree bark fibres and roots, sinews, hide of terrestrial and marine mammals and kelp (*Laminaria* spp.). Kelp (*Laminaria* spp.), as a plant natural to the marine environment, does not arouse the suspicion of fish and is widely used for lines in coastal fisheries. Vegetable materials are used where available; all other materials are used in regions with short growing seasons. Line floats recovered from Mesolithic contexts are made from bark or wood. A wide range of less durable materials could have been used such as birds feathers, hollow pumpkins, animal lungs, bladders, reeds and grasses (Table 3.1).

### 6.3.9: Bi-Points

Bi-points may be interpreted as fish gorges depending on the association of finds. However, these implements have a range of functions (Rau 1885; Hobler 1990). Only where there is evidence for a central line attachment is a bi-point reliably interpreted as a gorge (e.g. Varanger Fjord examples — Figure 6.23). Gorges were used to take small mammals and birds as well as fish. Bone bi-points made from bird bone, measuring 5–8cm in length are known from Mullerup, Mecklenburg (Germany) and Kunda. The use of bird bone for these implements may indicate use in fowling. It is common practice to use the bone of the intended prey for hunting/fishing implements among the Eskimo, regardless of the properties of the raw material — a form of sympathetic magic. Bi-points that have no central line attachment could form the barb of a composite fishhook. This is widely observed in the hooks of the native Northwest Coast groups. Where detailed the dimensions of the bi-points recovered at Mesolithic sites where fishing is known to have played a significant role in subsistence correspond to those used as gorges by Native American groups (Rau 1885). There is little discussion in the available literature of the role bi-points may have played in Mesolithic fishing. However Aaris-Sorensen (1980) does suggest that small points recovered at Maglemosegård may have been the points of composite hooks.

### 6.3.10: Nets and Net-Related Artefacts

There are few finds of actual net fragments, however, nets and net-related artefacts have been recovered across Europe in relatively large quantities (Table 6.3). The analysis of artefact representation at sites indicates that nets and net-related artefacts are significantly more common in
Mesolithic contexts than traps and weirs. This finding contradicts observations of traditional fisheries. In temperate latitudes, where anadromy is pronounced, groups exploiting aquatic resources generally depend heavily on anadromous resources where available and it is most common to exploit such species using traps and weirs. To some extent, the Mesolithic emphasis on nets reflects geographical variation in species availability over the area of the study. It is possible also that the relative scarcity of traps and weirs could be explained in terms of the durability of net sinkers in comparison to the organic materials used in the construction of traps and weirs. Although this is undoubtedly true, modified net sinkers occur at only a small number of sites. In some regions where anadromous species were available there is suggestion of net fisheries. Net fishing appears biased to inland sites, particularly the Iron Gates and East Baltic region, i.e. there is a preference for net fisheries that cannot be explained simply in terms of preservation bias.

Finds of net fragments are most common in the East Baltic region. Finds of net fragments alone do not prove that net fishing was practised at a particular site. Rock paintings from the Western Cape region of South Africa depict the use of nets for the capture of small herbivores (Manhire et al. 1985). Nets were commonly used by Siberian groups for the capture of game birds and waterfowl and by the Karok for a range of terrestrial prey (Kroeber & Barrett 1960–62; Zaliznyak 1997). The association of net fragments with floats and sinkers provides convincing evidence for net fishing.

All recorded net fragments from Mesolithic contexts are made from plant fibres (willow [Salix sp.] and sedge fibres [Veronica sp.]). They all exhibit a similar method of manufacture; 2-ply right twisted cord, with a 'sheet-bend' knot and have similar mesh size of 4.5–6.0 cm (J G D Clark 1936, 1975; Stjernquist et al. 1953; Feustel 1985; Gramsch 1992; Burov 1992, 1998; Andersen 1995). The sheet-bend knot (Figure 6.30) is a technique used in modern and ethnographically observed netting manufacture (Stjernquist et al. 1953; Kroeber & Barrett 1960–62; Feustel 1985). The only exception to this is the occurrence of knotless netting alongside the more common sheet-bend knot netting at Friesack (Figure 6.31). The knotless netting constitutes the oldest European finds of net fragments, dated to ca. 9700 BP (9200 cal BC); knotted netting appears in later contexts at the site, dated to ca. 9300 BP (8500 cal BC) (Gramsch 1992). The variability in vegetable material used to make the nets may relate to local availability or cultural tradition (Table 3.1). A wide range of materials are used for net manufacture in traditional fisheries, including giant kelp, horse hair, baleen and sinews in regions where vegetable materials are in short supply (Rau 1885; Curwen 1941; Dumond 1987; Churchill 1993; Zaliznyak 1997; McCartney & Veltre 1999). Plant materials are more commonly used in temperate regions: nettle (Urtica spp.), hemp (Cannabis sativa), plaited willow (Salix spp.) twigs, the fibrous inner bark and roots of trees, flax (Linaceae) and cotton (Cyperaceae) (Best 1929; Hornell 1929b; Kroeber & Barrett 1960–62; Jenkins 1974, 1984, 1991; Taksami 1975; N J H Smith 1981; Cleland 1982; Silverstein 1990; Shnirelman 1994; Zaliznyak 1997). The use of hemp (Cannabis sativa) fibre cord, which contains a chemical attractant, or aquatic plants such as kelp...
(Laminaria spp.), which reduces the suspicion of fish, may increase the effectiveness of net fishing. It is probable that the nets were tanned to improve durability and reduce visibility.

The relatively large mesh size of the net fragments recovered at Mesolithic sites indicates that medium and large fish were the intended target. The very small number of finds of actual net fragments means that this type of generalisation must be viewed cautiously. Burow (1992) suggest that large pike (Esox lucius) would have been the focus of net fishing at inland sites, however, fishermen tend to avoid taking pike in nets as their sharp teeth can quickly bite through the net (Holden 1979). Not only does this result in loss of catches but it is also very costly given the time and energy expended in the manufacture of nets. The best-known find from Antrea, Lake Ladoga, comprised net fragments, weights and floats. Seventeen oval pine-bark floats up to 30cm long and with a perforation at one end were preserved; four of these had net fragments attached (Figure 6.32). Modern floats are generally smaller than this. However, the Inuit used analogous forms to floats set nets (Figure 6.33). Larger floats may have been required in prehistory, as nets of natural fibres are heavier than nets of artificial materials. J G D Clark (1965, 1975) interprets the finds as the remains of a seine (on the basis that this type of net was within technological capabilities) and from the distribution of the weights and floats estimates the original length of the net as 27–30m and depth as 1.3–1.5m. Feustel (1985) has recalculated the length as a minimum of 170cm. Weights are only very occasionally used with seines, they add to the weight that must be hauled and are not necessary with heavy nets (Hornell 1929a, 1929b; Kroeber & Barrett 1960–62). Floats and sinkers are prerequisites of set nets (Kroeber & Barrett 1960–62). Set nets would have required the same technological expertise to manufacture as seines, can be left unattended, used in vegetated waters and would not require a boat to set out and haul. Set nets are the most commonly used type of net in traditional fisheries. They are frequently lost in bad weather or rough waters — this may explain the in situ find at Antrea. On the basis of the float found at Vis I, Burow (1992) speculates that nets would be large. However, at 6.3cm in width, this float is very much smaller than those recovered at Antrea (Figure 6.34).

Often, the only indicators of net fisheries are floats and sinkers. Floats are used not only to hold nets taut but also to mark positions of set nets for fishermen (Rostlund 1952; Cleland 1982). Recovered floats are all made from bark or wood and take one of two forms, long sub-oval floats with a perforation at one end and circular, oval or angular floats with a central perforation (Figures 6.32 and 6.34) (J G D Clark 1936; Schultd 1961; Tringham 1971; Burow 1992; Zaliznyak 1997). The former is used to float set nets in traditional fisheries, the latter is used with a range of net types. Ethnographically, floats are made from a wide range of materials such as reeds, unmodified pieces of wood or bark and bundles of reeds, but few would be identifiable as floats in archaeological contexts (Rau 1885; Hornell 1929b; Bowdler & McGann 1996; Dortch 1997; Zaliznyak 1997). Twenty-six bark or wood floats were preserved at Hohen Viecheln, implying a larger fishery than suggested by the faunal remains (Schultd 1961) — see table 6.2. Obvious floats like these may be rare finds at
Mesolithic sites because it is not necessary to perforate the bark for use as a float. Perforating the bark may be time consuming and increases the risk of breakage (Schwantes 1928).

As mentioned above, the presence or absence of floats and sinkers may suggest the type of net fishing practised. Net sinkers, which are commonly made of stone, would be expected to be common at sites where net fishing was employed. These are rare finds even at sites where net fragments have been recovered. It could be argued that this is a consequence of the use of unmodified stones for this purpose (e.g. Rau 1885; E W Nelson 1899; Best 1929; Worthington & Worthington 1933; Rostlund 1952; Hickling 1961; Kroeber & Barrett 1960–62; McFeat 1966; H Stewart 1975, 1977; Boissier 1984; von Brandt 1984a; Steane & Foreman 1991; MacDonald 1994; Zaliznyak 1997). For example, the net sinkers from Antrea were unmodified and were identified as sinkers only because of their location and the presence of cord around 31 examples (J G D Clark 1936, 1975). Weights from Kunda, Henauhof Nord II (Germany) and Neolithic levels of Zvidze, Latvia, consisted of small stones or gravel wrapped in birch bark — Figure 6.35 (Tringham 1971; Loze 1988a; Jochim 1998). Without the preservation of the bark covering there would be no indication that the gravel had been used as weights for fishing. Ethnographically, it is common for stone net sinkers to be modified in some form — notching or grooving to facilitate line attachment. However, unmodified animal bone, shell and lumps of fired clay may also be used as sinkers (Rau 1885; Sollas 1911; Worthington & Worthington 1933; Hickling 1961). A significant number of net sinkers from archaeological contexts may have been misidentified or remain unidentified. For example, a stone artefact from Birsmatten, Switzerland, is analogous to the notched sinkers used in the historic fisheries of the Susquehanna Valley, Lancaster County, USA (Figure 6.35 and 6.36). The 'mace head' and another perforated stone artefact from Hohen Viecheln are analogous to sinkers for set nets in European and North American traditional fisheries (Figure 6.37.2 and 6.38) (Rau 1885; Sollas 1911; Schuldt 1961; H Stewart 1975, 1977; Pettigrew 1990). A fragment of a possible perforated stone sinker was recovered at Friesack (Figure 6.37.1). Its association with net fragments supports this interpretation (Gramsch & Kloss 1989, Gramsch 1992). A perforated stone dredged from off the Norwegian coast at Store Fiskebank (Figure 6.39) is analogous to net/line sinkers. This interpretation is supported by the fact that it was dredged up by fishing boat nets: there has been found to be a link between Mesolithic sites and finds and present day good fishing areas in a number of studies. However, over-interpretation should be avoided, perforated discoid artefacts can function equally as spindle whorls or as net or line sinkers and bolas can be mistaken for grooved rounded sinkers (H Stewart 1975; Gould & Plew 1996).

The weights from the Iron Gates sites are modified with a pecked groove (Srejović 1969a, b, 1972). The absence of such finds at many sites may indicate that nets were not weighted. This is consistent with the use of seines where the weight of the net holds the mesh taut but addition of net sinkers would unnecessarily increase the weight of the haul. Finds of net sinkers would suggest the use of set nets, frequently used in heavily vegetated waters. Finds from Schela Cladovei, Romania, which are probably of Neolithic date (personal comment C. Bonsall), are notched at one end, implying use for
nets (or possibly lines) suspended above the substrate (Figure 6.40), consistent with use for set nets in vegetated waters (Bonsall et al., unpublished data). This type of net is commonly set a night to reduce visibility and as such would be used for the capture of nocturnal species.

Seines were probably also used in the Mesolithic. Seines are often operated without either floats or sinkers and the only archaeological correlate in this case would be net fragments, which are generally preserved only in waterlogged deposits. The behaviour of fish species and location of the fisheries of the Iberian coast, particularly the fisheries of the estuaries of Muge and Sado valley in Portugal, are consistent with the use of seines. The context of find sites in this region is not conducive to the preservation of organic materials other than bone. This type of net is generally used for shoaling species that are active during the day.

Eight pieces of wood from Vis I, initially identified as bows were, upon re-inspection, interpreted as the circular frames for scoop nets with diameters ranging from 45–130cm (Figure 6.41). Two types are evident: those with holes perpendicular to the flat axis of the hoop to secure the frame and unperforated examples. Landing nets of this type are used in most traditional fisheries and are the commonest type of net documented in riverine fisheries. These nets are used in shallows to take concentrations of fish and in conjunction with weirs.

More tenuously linked to net fishing are categories of artefacts whose exact function is uncertain but which are analogous to implements traditionally used for net manufacture. Possible ‘netting needles’ or fish-scaling knives are known from a number of Mesolithic contexts (Figure 6.42 and Table 6.3). J G D Clark (1936) favours interpretation as a netting needle rather than a knife due to the perforation at one end and the wear at the other, which is consistent with the backwards and forwards movement of plaiting a net.

Implements analogous to the net spreaders of the Northwest Coast groups (Figure 6.43) have also been recovered at a number of Mesolithic sites (Figure 6.44 and Table 6.3). Wooden examples of this type of implement were also recovered at the Neolithic Swiss Lake dwellings where finds of nets and associated implements are relatively commonplace (Rau 1885).

Net gauges, used to maintain uniform mesh size across nets, which would be expected at the sites of groups dependent on net fishing, have not been identified (Best 1929; Gifford 1939; Kroeber & Barrett 1960–62; H Stewart 1975; Jenkins 1984). This may be due to the artefact type not being sought or due to the use of other means of measuring mesh size.

The use of fish pulses in the Mesolithic period is speculative. Perforated discs (of wood or antler burrs) analogous in form and size to implements used in recent northern Eurasian fisheries to drive fish toward gear (nets or weirs) have been recovered from Ageröd I, Nasbyholm and Sjödiken.
(Sweden), Holmegaard (Denmark), Torvala (Estonia), Havelland and Satrup (Germany), and Vis I, Novgorod and Nizhnee Veret’e (Russia) (Figure 6.45). Burov (1992), cites in support of interpreting these implements as pulses rather than floats, the hafted example from Novgorod. Similar hafted discs of bark/wood are evident in the inventory at Hohen Viecheln where finds of bark/wood floats imply the use of nets. The co-occurrence of these implements with other net-related artefacts concurs with their interpretation as pulses. These implements have been alternatively interpreted as the base to poles used to propel boats over soft substrates to prevent the pole sinking (Feustel 1985), digging stick weights (Broadbent 1978), and as possible net weights (Schwantes 1928). These implements could equally have served as spindle whorls used in the manufacture of cords for nets and lines and other domestic purposes (Figure 6.46).

According to J G D Clark (1975) and Loze (1973), crosshatched designs incised on a range of bone implements may be representations of netting (Figure 6.47). Crosshatched designs incised on bone points are known from Mesolithic contexts at Iron Gates sites where net sinkers are the only definite gear recovered and often found in levels which contain high densities of fish remains (Srejovic 1969; Prinz 1987). Supporting evidence for the crosshatched design representing netting is taken from engravings on implements interpreted as netting needles, net spreaders and pulses (e.g. Figure 6.45). As the mesh motif is recovered on a pulse and bow fragments at Vis I, Burov (1989a) extends this interpretation regarding the net motif as symbolising success in hunting or fishing. Engravings of mesh designs are not restricted to organic materials. A sandstone slab from Agerod I is engraved with a mesh design similar to those found on bone artefacts (Figure 6.48a). Similar patterns occur on flint cortex at Agerod I-III and at Kyrkjesande, Norway (Figure 6.48b). Althin (1950) does state that these could have been the result of working of the cortex. Lithics with similar engravings are relatively common finds on Upper Palaeolithic sites. There is less inclination to interpret mesh designs on non-organic materials as representations of netting than on organic implements. There is, in fact, no reason to assume that mesh designs on any artefact, irrespective of raw material, represent nets. This is a clear case of the evidence being moulded to fit a theory rather than a hypothesis being derived from the available data.

6.3.11: Traps

Solitary traps and traps set in weirs are considered by many authors on Mesolithic fishing to be the primary method of fish capture. The identification of assemblages consisting of a non-selective range of locally available species leads Enghoff (1995) to conclude that the “main fishing tools used by the Kongemose and Ertebolle fishermen were stationary fish traps which were left in place near the coast for at least one night” (Enghoff 1995:72).
The small number of finds of gull (Laridae) remains at the Skateholm sites in Sweden is argued, by L. Jonsson (1988), to be consistent with the use of traps and small scale gear which did not attract large flocks of gulls. *(n.b. This is subsequently contradicted with the statement that the lack of benthic species argues against the use of traps at this site). Mellars (1978) proposes that the smaller inshore fish identified at the Oronsay sites, Scotland, could have been taken in traps or weirs. (Mellars avoids discussing the method of capture of larger species that are perhaps less suited to capture in traps/weirs.) As discussed in Chapter 4, a number of different fishing techniques could produce these assemblages. In this study, traps and weirs are discussed separately. Traps, both solitary and those associated with weirs, are relatively rare finds at Mesolithic sites. Given the limited evidence, the role of trap and weir fishing in the Mesolithic should not be overstated.

Andersen (1995) gives two categories of Mesolithic trap: those with round entrances and those with semicircular or rectangular entrances (Figure 6.49). A more relevant division for determining mode of operation is the method of retention: trumpet or funnel traps and non-return devices or throated traps, both of which are known from Mesolithic contexts. Brinkhuizen (1983) makes the vague statement that the type of trap (throated or trumpet) employed by ethnographically observed fishermen is determined by the speed of water. In fact, it is the strength and direction of the water current that determines the form of trap employed. Trumpet traps with wide mouths are set in weirs or in isolation only in waters with strong unidirectional currents that retain the fish. Non-return devices are generally used as solitary baited traps in marine or lacustrine waters with little or variable current but may also be used in conjunction with fences that guide the fish to the trap. A further distinction that can be drawn is the method of weaving. Traps from Northwest European Mesolithic contexts have an open weave, implying use for larger fish (Brinkhuizen 1983). Close-woven basketry fragments from Vis I could conceivably have been part of fish traps (Figure 6.50) but the recovered fragments are too small for function to be ascertained. Burov (1998) interprets the plaited fragments, which consist of thin strips of pine (*Pinus* spp.) wood (0.1-0.2cm wide) tied together with plant plait with a total width of 0.5-0.8cm, as traps and as such argues for two distinct fishing traditions for north-east and north-west Europe. Close woven trumpet traps are used for the capture of smaller cyprinids in traditional fisheries of Eastern Europe (vom Brandt 1984a). However, the small fragments recovered at Vis I could have a number of interpretations, e.g. matting, windbreaks or clothing.

The largest surviving example of a trap, from Fjellenstrup, Zealand, is 2.95m long with a maximum width of 90cm at the mouth, narrowing to 20cm at the base. The framework had been strengthened by placing two or three cross-strips together at spaces of 5.5-6.5cm. The raw material and form of construction of fishing traps used in traditional eel fisheries of Scandinavia is very similar to those of the Mesolithic period (Brinkhuizen 1983, Pedersen 1995). Pedersen therefore proposes that this category of trumpet trap, which includes the oldest securely-dated trap from Villingebaek (Figure 6.51), Zealand, was used for eel (*Anguilla anguilla*) fishing (J G D Clark 1975). Although they may have been set with the intention of taking migrating eel, their use is determined by hydrological
considerations and species biology (i.e. migratory or estuarine concentrations of fish) and as such, the traps could be used to take a range of species active within the tidal zone. The use of trumpet traps to take a full range of tidal species is observed in the traditional fisheries of the estuaries of England and Wales (Jenkins 1974, 1984).

Mesolithic examples of throated traps are similar in form to modern traps used in traditional fisheries of Finland (Feustel 1985) — Figure 4.16.2. Throated traps are known from Nidløse, Denmark (Figure 6.52), and Nebbe Mosse, Lille Knabstrup (Figure 6.53) and Nøddekonge, Sweden (Albrethsen & Brinch Petersen 1976; Aaris-Sørensen 1980a; Enghoff 1994a). This corresponds to the inland lakeshore location of these finds: use in lacustrine waters precludes reliance on currents to retain the catch and requires non-return devices to retain the catch. Non-return devices are also known from coastal locations. An example from Jonstorp, Sweden, was found to contain the remains of a cod (Gadus morhua) ca. 45cm in length. The capture and retention of fish of this size would require sturdy traps (Brinhuizen 1983; Enghoff 1983; Andersen 1995). In traditional trap/weir fisheries of anadromous species in North America, weirs are generally set with trumpet traps or open-mouthed nets in waters with strong unidirectional currents. Throated traps on the other hand are used in waters with little or variable currents, generally in isolation, but occasionally in conjunction with weir fences which guide fish to the trap increasing gear efficiency. Palynological analysis of the sediments from which the Nebbe Mosse example was recovered revealed that the trap had been used in shallow water with surface vegetation, suggesting that the trap had been used singly and may have been baited (Stjernquist et al. 1953).

Brinhuizen (1983) devised a classification of traps based on morphology, and presence and type of throat. In this classification system a developmental sequence from trumpet traps to throated traps is implied. Despite the fact that Brinhuizen states that the typology has no chronological significance, he then uses this system to indicate that more 'primitive' forms of traps were in use in the Sub-Boreal period than in the Mesolithic period. This is based on the comparison of the Magleby Long find (Sub-Boreal period) and the Lille Knabstrup (Denmark) traps (Atlantic period). This ascribed simplicity is a determination of the author rather than an indicator of functional sophistication. It is probable that throated traps did develop from trumpet traps but the sequence of this development is uncertain and trap types cannot be considered primitive or sophisticated on the basis of the presence or absence of throats. The use of trumpet traps may reflect the use of weirs and as such, indicates a larger scale of fishing and co-operation for weir construction. The data presented indicates that both trumpet and throated traps may have been in use in the Mesolithic and the Early Neolithic.

A typological classification of all traps from archaeological contexts is a necessary prerequisite for the reconstruction of fishing practices. Several finds from Boreal deposits are described simply as traps
with no further information on form or size, which makes determining exact function impossible (e.g. JGD Clark 1936).

Traps made from netting supported on wooden frames are known from the Early-Middle Neolithic (on the basis of palynological analysis of surrounding sediment) at Nebbe Mosse (Stjernquist et al. 1953). The remains of pike (Esox lucius), tench (Tinca tinca) and roach (Rutilus rutilus) were found in association with this trap. Maori fishermen used netting traps of this type for a range of freshwater species but predominantly for eel fishing. It is possible that traps of this type were also used in the Mesolithic but have not been preserved.

As with the majority of other types of fishing gear, traps are multifunctional and are used to take birds and small mammals as well as fish (Graburn & Strong 1973; Zaliznyak 1997). The context of finds may indicate use for fishing.

6.3.12: Weirs

According to Pedersen (1995), weirs in use in the Mesolithic period of Europe are similar to those used throughout prehistory and up to recent times in traditional fisheries: fences of wattle and/or stone guide the fish to basketry traps or nets (Figure 6.54). Historic examples in Denmark were used for the autumn runs of silver eel (Anguilla anguilla) and an analogous form has been preserved at the Neolithic site of Oleslyst (Figure 6.55) (Andersen 1995, Pedersen 1995). One of the largest Early Holocene weirs, that at Nekselo, Denmark, extends over 200m into the sea and is 15–20m wide. It has been dated to the Early Neolithic. However, two hazel (Corylus sp.) poles found in situ have been dated to the mid-Ertebolle, suggesting continuity in the use of permanent fishing structures at this site from the Mesolithic. The best-preserved Mesolithic weir, at Halsskov, Denmark, dates to the early Ertebolle. Two structures at the site consist of a 9m length of fence dating to ca. 5850 BP (4750 cal BC) and a system of stakes and woven rods 18m in length dated to ca. 6320 BP (5300 cal BC) – again implying continuity of site function. Hundreds of pointed hazel (Corylus sp.) sticks standing vertically in gyttja at Tybrind Vig have been interpreted as the structural remains of a fish weir (Andersen 1981, 1985, 1987a). Thin split ends of alder (Alnus glutinosa) branches woven with twigs of Viburnum sp., also at Tybrind Vig, are interpreted as part of a fish weir, possibly part of a wattle screen.

Although clear examples of weirs have been preserved, there are several finds that are more tentative in their identification. Stakes with fire-hardened tips found at Mollegabet II take the form of spears, however, the location (coastal gyttja) and number of finds suggest that these stakes were part of permanent fishing structures (Grøn & Skaarup 1991; Skaarup 1995a, 1995b). The small number of pointed hazel (Corylus sp.) stakes (15-200cm in length) in the underwater refuse area at Ringkloster have been interpreted as the remains of fish weirs or other stationary gear by Enghoff (1994a, 1994b).
and Andersen (1995). The steeply sloping shore at Ringkloster (P. Rasmussen 1995) is more consistent with the use of traps rather than weirs. Four large wooden posts of alder (Alnus sp.) or birch (Betula spp.) up to 30 cm in diameter and sharpened to a fine point at Vænget Nord, Denmark, may be the foundations of a fishing platform (K S Petersen 1986). The island itself was submerged ca. 7000 BP and the area seems to have been used as a fishing ground after this time. Thirteen finds of ‘tinder’ sticks from Hohen Viecheln that are 25-30 cm long with a square x-section may in fact be part of a fishing structure (trap or weir).

The type of substantial weir evident at Nekselø is not apparent in the Mesolithic period. This raises the question of what form Mesolithic weirs took. The weir is one of the most commonly employed gears in the traditional freshwater and estuarine fisheries of North America and Europe. A wide range of weir forms are known ethnographically from the simplest earthwork barriers to the largest complex constructions that can run for hundreds of metres, be tens of metres wide and set with many retaining devices and walkways that permit constant monitoring and hauling of catches (Kroeber & Barrett 1960–62). The small number of finds of Mesolithic date is the result of the nature of these constructions, which are readily destroyed by the action of tides and currents after abandonment. Stone foundations, where used, may be preserved but this type of construction is generally undertaken only on exposed coasts and cannot be dated by absolute methods. There is no chronological development in size or form of construction so this type of structure cannot be dated typologically (Lutins 1992). A further factor influencing the identification of finds is the construction of these fishing structures outside settlement areas. Weir fisheries of anadromous species are often conducted from seasonal fishing stations located some distance from residential bases. The simplest types, such as earthwork dams and log barriers, even if preserved, would not be readily identified as weirs in archaeological contexts. The small number of weirs securely dated to the Mesolithic take the form of simple barriers used to concentrate fish.

It is only at Tybrind Vig that weir fences of Mesolithic date have been recovered in association with a trap. The trap at this site has a throat, which is consistent with the hydrological conditions of the find location, in the immediate vicinity of the settlement. The form of weir proposed by Pedersen (1995) on the basis of analogy with traditional fisheries in the region consists of a basket trap, leading fyke net and a wattle-guiding fence (Figure 6.54). The recovered net fragments are too small to assess the possible manufacture of bag nets, however, the finds of probable net frames at Vis I and the netting traps recovered at Nebbe Mosse suggest that this technology may have been available. Weir fences and traps are documented from the site of Zamostje II, Russia. However, the site has not been fully excavated and is the subject of preliminary reports: the form of the traps is not given and it is not clear whether they were found in association with the weir fences.

There are several reasons why traps may not have been recovered at weir sites. The weirs may have been simple barrier devices used to concentrate fish that are taken with other forms of gear. Coastal
groups may have employed tidal weirs that trap fish on the receding tide and which do not require traps to retain the catch. The weirs may have been set with collecting nets or active fishing of the weirs may have been conducted with dip or lift nets, which have not been preserved. Finally, it is possible that the remains of traps set in the weirs are in such a degraded state that they are indistinguishable from the wattle fence remains.

6.3.13: Mesolithic Watercraft and Related Artefacts

There are relatively few finds of watercraft in Mesolithic Europe and most are known from Scandinavia and the East Baltic. This is predominantly due to the friable nature of the raw materials used in the construction of prehistoric watercraft but may have been compounded by the re-use of raw materials such as timber, even if only as firewood (McGrail & Switsur 1975).

The most complete example of a dugout comes from Tybrind Vig — Figure 6.56b (Andersen 1987b). The general form can be discerned: U-shaped, approximately 10m long, 50–65cm wide and weight of 200–500kg. This takes the same form as a contemporaneous example from Præstelyngen, Denmark (Johnstone 1980). A possible anchor stone found with the Tybrind dugout may have served to hold the vessel underwater to prevent it drying out and splitting. This dugout, another less complete example from Tybrind and an example from Møllegabet II all had removable bulkheads which Andersen (1987b) suggests may have been to reduce weight or prevent radial splitting (Gron & Skaarup 1991; Skaarup 1995b). An alternative explanation is the removal of heartwood, which decays very rapidly.

The complete Tybrind Vig dugout would have been worked from a tree at least 12–14m in length, 3–5 tons in weight and 100–150 years old. Lime (Tilia spp.) is one of the easiest worked woods (least likely to split) at this size and weighs less than other species at the same size. The second less complete dugout from Tybrind Vig shows traces of repair, implying that watercraft were highly curated. A hole had been repaired with a packing of gravel and tar or fat which was then covered with an unknown material that was sewn into place. This type of long, slender vessel would have required skill to navigate. It is unlikely to have been used in rough/exposed waters and was probably confined to inland waters (Andersen 1987b; Burov 1996).

Clay hearths have been found in a number of dugouts (e.g. two finds at Tybrind Vig). It is possible that fires were set to act as a lure for night fishing (Andersen 1987a). This practice is commonly observed in traditional eel (Anguillidae) fisheries. Andersen (1987a) speculates that the hearths may even have been a symbol for home. Ethnographic sources suggest less prosaic explanations: that hearths were simply used as a source of warmth or for cooking catches (Sollas 1911). Consistent with such a function is the clay hearth from the Øgaardø III boat of Late Neolithic date, which contained the remains of charcoal, charred twigs and fish bones (Skaarup 1995b).
Finds of paddles, known from northerly latitudes in Europe, can be used to infer the use of boats at sites or in regions where remains of boats have not been preserved (J G D Clark 1954; Albrethsen & Brinch Petersen 1976; Andersen 1987b). Examples from Zealand tend to have an elliptical form (Figures 6.57a.3, 7 & 8 and 6.57.b.9–10). The blades at Duvensee and Friesack, Germany, and Holmegaard, Denmark, have elongated elliptical blades. Ethnographically, it is observed that variation in blade form relates to water conditions, specifically the density of underwater vegetation (Burov 1996). To prevent snagging or losses in dense vegetation, narrow pole paddles are preferred. In the late Atlantic, pole paddles dominate finds of this artefact type in north-east Europe (Figure 6.57b.6). In clearer waters, large blade paddles, which provide more efficient propulsion, can be used. The blades from Tybrind Vig, Denmark, and Rude II, Germany, are morphologically suited to use as both a pole and as a blade — this type of implement is necessary for navigating against strong currents (Figure 6.57b.8–12). Some of the observed differences may stem from stylistic or cultural rather than functional considerations. Among the North Coast Salish paddle blade forms differ according to differences in the size and type of watercraft men and women are permitted to use (Kennedy & Bouchard 1990a). Burov (1996) questions whether narrow poles were used as paddles, suggesting that the Star Carr find may in fact be a ski pole, comparing it to finds at Kalvtrask, Sweden (Figure 6.57b.6). Schwantes (1928) states that the function of the Duvensee example is also questionable. However, the blade shows traces of fire hardening (J G D Clark 1936), which is consistent with waterproofing techniques. Feustel (1985) assumes that the examples from Satrup bog and Rude II are spades, despite the morphological similarity to implements from contemporaneous sites that are interpreted as paddles (Figures 6.57a.3 and 6.57b.10–12). The shaft diameter of one example from Rude II is reported to be 2.1cm (Feustel 1985). This seems very narrow for a spade that would be expected to be subjected to large stresses along the shaft and therefore susceptible to fracture. Feustel also states that the ‘spades’ show no traces of wear and gives the explanation for this anomaly as use on stone-free ground or pristine, unused implements. The absence of wear and the shaft diameter are both consistent with use as paddles. Three decorated paddles from Tybrind Vig have exceptionally long shafts and very thin blades. Andersen (1987b) suggests that their unusual form implies a ceremonial/status rather than utilitarian function, with the décor marking ownership.

Andersen’s (1981) preliminary report on the site of Tybrind Vig details a cobbled area found at the contemporary shoreline which is speculated to be a boat mooring area. Modifying the landscape to make suitable boat mooring areas or stop-off points is associated with Late Mesolithic occupation at Moynagh Lough, Ireland (O’Sullivan 1998). Two clay knolls (10.5m and 9m across) were artificially enlarged by spreading mud, stones, brush and twigs around the edges.

Frequently, dugouts are found in association with human remains and in some cases there is clear evidence of interment in boats. Boat burials containing the remains of young adult males have been recovered at Åmø and Møllepåabet II (Grøn & Skaatrup 1991). At Møllepåabet II, the entire boat and burial had been wrapped in elm (Ulmus spp.) bark. The central part of the dugout and an associated
prehistoric contexts: amongst ethnographically observed groups but remain unidentified. McGrail (1979) points out the similarity of this burial to a find at the Late Neolithic site of Øgaarde III, ca. 3950 BP (2460 cal BC), indicating a continuity of funerary practice. Three land burials of Mesolithic date have the remains (areas of darkened soil) of structural features from which boat burial can be inferred. Amongst the grave goods found in association with the boat burials were three leister prongs at Mollegabet II and a large harpoon point at Skateholm II; this possibly represents the burial of fishermen and sea mammal hunters with their gear and boats. Skaarup (1995b) draws an analogy between the burial ritual evident in the boat burials of the Mesolithic and Early Neolithic and the funerary practices of the Mok of the Malayan Peninsula.

"Although the distance in both time and space between the Mollegab find and the Mok burial rites is very great, there are striking parallels. These can best be explained by presuming that there has been a universal religious conception behind the boat burials, both on land and at sea, of the boat as a well suited means of transport for making the journey to the kingdom of the dead" (Skaarup 1995b:57).

Though finds of dugouts are more common in the Late Mesolithic, Andersen (1987b) points out that the sophisticated construction of the Tybrind Vig examples implies a long tradition of dugout manufacture. Replication experiments indicate that two people using Mesolithic technology could work this type of dugout in one week. Early dugouts are also known; the boat at Pesse, Netherlands, which resembles a trough (Figure 6.56a), dates to ca. 8300 BP (7350 cal BC). This dating is supported by palynological evidence (Feustel 1985). However, Johnstone (1980) questions whether this is in fact a boat, suggesting that it may have been a coffin. Charred areas suggest that fire was used to work the wood (or may be the result of funerary ritual). This was also reported for the Friarton (Scotland) dugout reported to come from Boreal deposits but which is no longer extant and so this early date cannot be confirmed (Geike 1879).

The Varanger sites contain a find unique amongst European Mesolithic sites, namely, a vabein of bone — a mount attached to the gunwhale of a boat.

"It may therefore be assumed that fishing was done with a hand-line dragged up and down over the gunwhale" (Simonsen 1965:398).

Despite the large number of paddles, dugouts and other associated finds from Mesolithic contexts (both Early and Late) and the clear sophistication of construction, Rozoy (1978) states that the use of boats in the Mesolithic period would have been limited. Though the available evidence would argue against this, there is relatively little evidence for watercraft and associated artefacts within Mesolithic Europe as a whole. It is possible that only a small part of the inventory is known or recognised. McGrail (1979) points out that only complete or nearly complete dugouts can be identified as such in prehistoric contexts: small fragments and parts of watercraft may have been recovered in Mesolithic contexts but remain unidentified or misidentified. Skin and bark watercraft are generally considered (amongst ethnographically observed groups) to be more reliable in rough waters and open seas than
the dugout (Figure 6.58). The umiak of the Inuit of south-west Alaska was so efficient for the hunting of mammals at sea that it was adopted by the Yankee whalers in preference to the New Bedford whaling boat (Johnstone 1980). The remains of skin watercraft are even less likely to be preserved than dugouts. A possible boat rib from a skin boat was recovered at the Ahrensburgian site of Husum, Germany (Bednarik 1999). The association of a paddle and wide strips of bark at Ulkestrup, Denmark, and at Star Carr, England, may support Johnstone's (1980) suggestion that bark canoes would have been constructed in the Mesolithic. Implements analogous to historic/modern boat thwarts occur at Tybrind Vig and Magleø, Denmark (Figure 6.59). (It should be noted that Andersen [1995] re-interpreted the thwarts from Tybrind Vig as the remains of fish traps frames). The complete example from Magleø measures 47.5 cm, which corresponds to the widths of the dugouts of this period. The use of thwarts suggests the use of skin/bark boats, the thwarts acting to secure the framework. Rock carvings of reportedly Stone Age date and evidence for sophisticated skin working implies that such technology was available to Mesolithic groups. Skin boats are depicted at Rodøy, Evenhus and Skjomen, all West Norway and at Zalavmga on the White Sea coast (J G D Clark 1975; Burov 1996). Using the scale of the occupants of these boats as a guide, Johnstone (1980) has reconstructed the dimensions of these craft at ca. 4 m. This is similar to the dimensions of the curraghs used until recently in Britain and Ireland. Skin boats or coracles are more suited to the safe navigation of coastal waters and open sea than dugouts and their use in coastal areas is widely assumed (e.g. J G D Clark 1946; Woodman 1978a; Johnstone 1980; Schmitt 1995). The rolls of birch bark recovered at Star Carr are explained as raw material for the manufacture of bark boats or as repair kits for boats (C Smith 1992). Feustel (1985) points out a number of other uses to which the bark rolls could be put, such as the manufacture of bark vessels/containers, for floats, torches or footwear. Though ethnographic examples of bark boats are commonplace, there is little evidence to suggest manufacture/use in the Mesolithic.

Johnstone (1980) suggests that the (controversial) evidence for skin working at Star Carr may be related to the manufacture of skin coracles. The probable use of the site as a hunting stand for the exploitation of terrestrial game, primarily as a source of raw materials, is consistent with Johnstone's hypothesis. It is possible that the coracles were produced on site — they could be easily carried back to the coast or could have been used as the transport between the site and the coast.

6.3.14: Miscellaneous Finds

Found in two Mesolithic contexts in Denmark, it is clear from breakage that the tail spines of stingray were used as artefacts, possibly as points for weapons (Best 1929; Rosenlund 1986). The Australian Aborigines used the tail-spines of stingray (*Dasyatis* sp.) in spears used for fishing (Ghaleb 1996). At Svinninge Vejle, Denmark, the basal part of a stingray (*Dasyatis* sp.) tail spine was recovered from a settlement context, dated to ca. 7000 BP (5890 cal BC). The site is located on a large shallow bay that
would have been ideally suited to stingray fishing. However, stingrays (*Dasyatis* spp.) do occasionally shed tail-spines, which re-grow (Whitehead *et al.* 1986). The presence of ray tail-spines is not, therefore, necessarily indicative of active fishing of this species.

Worked spurdog (*Squalus acantias*) spines have been recovered at the inland sites of Åmosen (Enghoff 1994). Though Enghoff states that their function is uncertain, it is common ethnographically to incorporate fish bones as the barbs of composite fishhooks.

6.4: Analysis of Fish Remains

There are large variations in the presentation of faunal data in publications. For example, on the basis of biases in skeletal element representation Renouf (1989) proposed a system for reconstructing original proportions of species. The validity of such methods is highly questionable due to problems with differential deposition, preservation and recovery (Section 6.5 below). Only NISP\(^i\) (number of identifiable specimens) counts of recovered remains are considered in this study. Quantitative analysis of the fish fauna indicates the relative abundance of species within sites and can indicate the most economically important species (Table 6.2 and Figure 7.1). Although MNI\(^i\) counts may be more representative of the relative abundance of the species recovered at a given site (Marshall & Pilgram 1993), and combined data on MNI, NISP and weight estimates may be most informative on the importance of certain fish species to economy (Rick *et al.* 2002), many of the published reports that contain faunal counts do not include MNI data or weight estimates. For all sites where only species lists were reported, each species was arbitrarily assigned the value 1. Many sites with fish remains had to be omitted from the study because of insufficient publication of finds. A comparison of the total count of fish remains for each species quantified can indicate the economic importance of fish within each site. However, owing to the huge difference in assemblage size, this information was relatively meaningless for inter-site comparison. As a significant number of assemblages were reported in terms of percentage abundance of species rather than actual counts, all values were converted to percentage representations in order to standardise the data set. Nevertheless, inter-site and inter-regional comparisons of species representation, using this data set, may be skewed by small assemblages, differing taphonomic processes or by ‘unusual’ sites with very high proportions of a single species.

Therefore, a qualitative study of species representation was undertaken in parallel to reduce the effects of taphonomic and assemblage bias in regional comparisons of fishing practice (Figure 7.2). A disadvantage of this method is the possible over-estimation of the role attributed to economically unimportant or inadvertently caught species. This is readily rectified by comparison with quantitative data.
Several categories of fish were identifiable to family level only. For this reason, fish representation was analysed according to all categories given in publications and also by groupings of the categories that were identified to family level.

6.4.1: Fish Species Exploited by Mesolithic Fishermen

A total of 126 categories of fish comprising at least 101 different species, were identified in 182 assemblages from across Europe, demonstrating the sophistication and diversity of Mesolithic fisheries (Table 6.2).

The results obtained from the qualitative and quantitative analyses are largely comparable. Inland fisheries focused on pike (*Esox lucius*), catfish (*Silurus glanis*) and cyprinids (*Cyprinidae*). Assemblages recovered from coastal sites are dominated by cod (*Gadus morhua*)/Gadidae, flatfish (*Pleuronectidae*) and pike (*Esox lucius*) (Table 6.2 and Figure 7.1–7.2).

A breakdown of the geographic distribution of these finds indicates that a relatively small number of species were exploited in comparison to the number of species that would have been available in local waters. Worldwide, there are about 25,000 species of teleosts and numerous species of elasmobranchs and agnathan fish (Miller & Loates 1997). The limited number of species recorded at Mesolithic sites across Europe may be due, in part, to differential preservation or problems associated with varying standards of excavation, collection, post-exavation processing, identification and publication, which varies geographically. For example, the archaeo-ichthyological studies of Enghoff (1995), conducted on faunal assemblages from sites across Denmark have greatly enhanced the number of species that were exploited in the Mesolithic. Similarly, detailed analyses of remains from other areas may also improve knowledge of Mesolithic fishing practices. However, even with detailed excavation and sieving of samples, studies carried out in laboratory conditions, on samples from Bjørnholm (Jutland) using very fine meshes, indicate that the bones of small species (e.g. stickleback [*Gasterosteidae*] and small cyprinids [*Cyprinidae]*) are likely to be under-represented (Enghoff 1991).

There are also huge inter-site differences in the quantities of fish recovered. This may be due to preservation, excavation technique or identification methods but the possibility that certain sites originally had relatively large assemblages cannot be dismissed. For example, the settlements at Vedbæk (Denmark) are reported to have had very dense concentrations of fish with up to 40,000 bones recovered per square metre, of which, only a small sample has been identified (Aaris-Sørensen 1980). This suggests fishing on a very large scale.

Despite the provisos detailed above, the limited number of species identified at each site and the relative proportions of these species suggest a pattern of specialised exploitation at certain sites (Table
6.6). The specialisation varies according to geographical location of the site and local availability of species. Most of the identified species (both freshwater and marine) could have been caught close to shore being permanent inhabitants of, or seasonal and occasional visitors to, inshore waters (Tables 5.2 and 5.3).

6.4.2: Uniformity in Prey Species

The majority of the species that have been identified at Mesolithic sites are exploited commercially or farmed today for flesh or other products (Table 5.4). This would suggest a preference for the same type of food species today and in Mesolithic times (or this may be a consequence of the focus of fisheries research on commercially exploited species [Pinkas 1969] and possibly the more common occurrence of these species in modern comparative assemblages). All of the species today considered unpalatable occur as relatively small proportions of site assemblages and at a small number of sites, suggesting they may have been taken incidentally in the pursuit of other species. However, culturally based judgements of the palatability of different species of fish should be avoided. The presence of sticklebacks (Gasterosteidae), exploited in recent times for oil only, in the ‘stomach contents’ of inhumations at Skateholm implies a role as food fish (Larsson 1988b), even if only in a ritual context.

Although at least 101 species of fish were identified overall, only a proportion of these were identified at any individual site. Taking Bjørnsholm (Jutland) as a case in point, it has the largest number of identified species (34 in total) but only 9 species are present in significant quantities. This represents only a small proportion of the species that would have been available and does not reflect the relative abundance of these species in local waters. In contrast, Enghoff (1995) states that the species represented at Danish Mesolithic sites are an ‘unselective’ sample of locally available fish and on this basis argues for the primary use of unselective traps by Danish Mesolithic fishermen. Of the 126 marine and anadromous species inhabiting East Danish coastal waters 42 have been identified at Mesolithic sites but of these species, only five were the focus of fisheries (cf. Whitehead et al. 1986). This is even more pronounced at sites on the south-west Swedish coast of the Skagerrak where specialisation in two species (cod [Gadus morhua] and ling [Molva molva]) is apparent. The situation is not as simple as Enghoff implies. Enghoff’s use of the term ‘unselective’ obscures the competence of Mesolithic fishermen. Many species that would have been present in local waters are absent from sites. In terms of the relative quantities of the species represented at sites it is also clear that Mesolithic fishermen were highly selective in their choice of prey and scheduling of fishing activities even if (and it is argued elsewhere that this is not always the case) the fish were taken with unselective techniques; largely avoiding the capture of fish with relatively little food value.

In terms of presence/absence and percentage representation, pike (Esox lucius), gadids (Gadidae), flatfish (Pleuronectidae) and cyprinids (Cyprinidae) are the most common species found at Mesolithic
sites (Table 6.2 and Figure 7.1–7.2). Pike (*Esox lucius*) dominates finds both in terms of the number of sites at which it has been identified (76) and in terms of mean percentage abundance at sites (33%), though variations are evident regionally. Though most commonly identified at inland sites, it has also been identified at 23 of the 90 coastal sites incorporated in the analysis, surpassed only by gadids (*Gadidae*), including cod (*Gadus morhua*), eel (*Anguilla anguilla*) and the combined category of flatfish (*Pleuronectidae*) in coastal regions.

6.5: Taphonomy, Diagenesis, Recovery and Identification

"it is well to remember that archaeologists discussing fishing in prehistoric times are often compelled to use very limited evidence" (Hongo 1989:339).

6.5.1: Taphonomy and Diagenesis — Prevailing Wisdom

The assumption that an archaeological assemblage is representative of the material originally deposited by a group underlies the reconstruction of both past fishing techniques and the determination of the role of aquatic resources in Mesolithic subsistence/economy. It is accepted that if such assumptions are not made, the study of fish assemblages becomes merely a catalogue, not permitting the reconstruction of past human behaviour. However, any interpretation based on fish remains must be tempered with the understanding that all assemblages will have been affected by taphonomic and diagenetic processes and methods of recovery, recording and identification (Lubinski 1996, Wheeler & Jones 1989).

The main factor thought to bias archaeological assemblages is differential preservation. Generalisations concerning faunal assemblage preservation are widely accepted, even where contradicting experimental results have been demonstrated to negate these assumptions. These generalisations concerning bias in representation in archaeological contexts can be classified into three main groups (summarised in Table 6.7):

a) Bias and/or differential preservation resulting from the conditions of depositional environment:

1. The mineral content of otoliths results in better preservation than other elements in alkaline environments (Wheeler & Jones 1989; Bowdler & McGann 1996).
2. Acidic environments are detrimental to bone preservation; alkaline environments favour bone preservation.
3. Fish bones may be transported to, and deposited in, archaeological contexts by non-anthropogenic activities (Wheeler & Jones 1989).
4. Fish assemblages can be the result of natural or anthropogenic deposition. The seasonal inundation of sites in floodplain areas and the use of underwater refuse areas by Mesolithic
groups may bias assemblages. A number of studies have been carried out to determine criteria that distinguish man-made from natural assemblages with fairly unsuccessful results (van Neer & Muniz 1992; Stewart & Gifford-González 1994). Wheeler & Jones (1989) suggest that undesirable fish would be discarded at site of capture and not landed — this was only the case in Senegal if the fish were caught a long way offshore (van Neer & Muniz 1992). It is general practice to discard unwanted parts of fish in water among North Pacific Coast groups (Hoffman et al. 2000). Fish selection was usually done at the landing site. This suggests that many of the fish remains found in refuse may have been caught by man but did not actually contribute to diet.

b) Differential preservation due to the varying biology and morphology of fish species and individuals:

1. Fish bones are generally less well preserved than mammal bones due to the differences in structure — a consequence of medium inhabited (Nichol & Wild 1984).

2. It is assumed that larger, more robust, bones will be over-represented in archaeological deposits compared to smaller, less robust bones, both within and between species. For example, Wigen & Stucki (1988) state that, in general, vertebrae are more commonly preserved than cranial elements.

3. Cartilaginous species are susceptible to rapid decay and are therefore not well preserved in archaeological deposits (Rostlund 1952; Benecke 1986; Enghoff 1986; Leach & Boocock 1993; Desse-Berset 1994). Certain, more calcified parts of cartilaginous fish, such as the scutes of sturgeon (Acipenseridae) and the vertebrae of smoothhound (Mustelus mustelus) may be preferentially preserved (Walker 1988; Enghoff 1991; Nicholson 1996a).

4. Fatty species are less likely to be preserved due to rapid autolysis, i.e. structural breakdown of fats within the bone (Enghoff 1986; Prummel 1986). Fatty bones are also more likely to be scavenged from refuse areas (Enghoff 1986). A corollary of this is the good preservation (and possibly over-representation of lean species on archaeological sites [Enghoff 1986, 1991]). The bones of lean species such as cod and perch are well-preserved (Rostlund 1952; Benecke 1986; Enghoff 1886, 1991).

5. The bones of adults preserve better due to higher mineral content (Nicholson 1996a).

6. In sites with hand collected assemblages, the bones of larger species are more conspicuous and are therefore likely to be over-represented. The bones of pike (Esox lucius) are particularly conspicuous in excavated deposits (Noe-Nygaard 1983). Pike (Esox lucius) are a common feature at the sites analysed in this study. Noe-Nygaard states that their dominance at many sites may not be due to targeting of this particular species but to recovery techniques. However, the pike (Esox lucius) is a good food fish, which preserves well and as a difficult fish to catch, may have been associated with prestige and therefore may well have been specifically targeted by Mesolithic fishermen. Furthermore, Enghoff (1986) states that pike (Esox lucius) bones are often poorly ossified, which may lead to preferential decay. It seems probable that the Mesolithic pike (Esox
Lucius) fishery was significant, particularly in lacustrine environments, which is their favoured habitat.

c) Differential preservation resulting from processing, cooking and ingestion of food:

1. The place of processing biases the archaeological record. The various processing methods observed ethnographically would influence recovery in archaeological contexts. The removal of the brain results in fragmentation of cranial elements and would result in under-representation in archaeological contexts (K M Stewart 1991). Discard practices may result in the archaeological invisibility of fish bones. Due to the very rapid degradation of fish, they may be gutted/filleted at sea or on the shore at landing sites (Colley 1986a). Bait-fish are unlikely to be evident or identified as such in faunal assemblages.

2. Lutins (1992) suggests that fish bones may have been burned prior to discard to reduce smell, this would influence preservation.

3. Cooked bones are likely to be underrepresented (Richter 1986a; Lubinski 1996). Thermal denaturation of bone occurs at 60°C. Heating increases porosity of bone, increasing the surface area and therefore susceptibility of bone to decay. Vertebral elements were found to be under represented at sites on Lake Turkana where fish were known to have been dried or roasted (Stewart & Gifford-González 1994). Richter (1986a) proposes that thermal denaturation of bone is one method of determining the anthropogenic or natural origin of an assemblage — this would only be applicable where the fish had been heated. There are many ethnographically observed and modern examples of the consumption of raw fish. It is probable, given the nature of the Mesolithic sites, that many of the remains recovered come from fish that were processed for cooking and not yet cooked.) It is generally assumed that boiled fish bones will decay rapidly and that burned bones will be preserved owing to the loss of their organic fraction (van Wijngaarden-Bakker 1985).

4. Bone loss through ingestion and digestion is thought to have been considerable (Jones 1984, 1986, 1999). This occurs as a result not only of the actions of the site’s human occupants but also through the activities of scavengers (K M Stewart 1991; Bullock & Jones 1996). Less than 10% of ingested bone survives the digestive tract with significant numbers of robust elements lost. Damage to ingested bones is easily identified (Wheeler & Jones 1989), but some bones pass through the digestive tract unaffected. The whole consumption of small fish is a common practise across ethnographically observed groups.

Limp and Reidhead (1979) devised a method for assessing bias based on the comparison of the range of species expected on a site from the local biomass with the remains recovered. This ignores preferential fishing of certain species and also possible changes in populations since prehistory and cannot be considered a valid method for reconstructing original assemblages.
Colley (1984) proposed a method for assessing diagenesis within sites through the analysis of skeletal element representation. Preservation can be considered good if the frequency of skeletal elements identified for each species is similar to that expected from a complete skeleton. This is an inappropriate method for estimating loss, as it cannot account for pre-depositional processing of fish.

6.5.2: Complexities in Predicting Diagenesis — Experimental Studies

Certain diagenetic changes were thought to have been understood. Generally, it was held that certain changes would be expected to occur depending on depositional environment and as a result of recovery practices. Though these changes could not be quantified, generalisations were made. It was hoped that future research would allow correction factors to be applied to assemblages determined from deposition history. Though there is agreement that differential preservation (as a result of the factors given above) alters the original assemblage deposited, there is as yet no agreement or insufficient knowledge on all the factors that influence this process and the extent to which these factors vary in different environments. There is no standard method of accounting for differential preservation in various archaeological assemblages with different post-deposition histories and therefore no way of extrapolating the structure of the original assemblage from that recovered from the archaeological deposit. Recent studies (Falabella et al. 1994; Nicholson 1996a, b; Lubinski 1996) investigating the effects of processing, cooking and deposition on the preservation of fish remains indicate that the situation is much more complex than previously thought. It appears that many interrelated and inseparable factors contribute to differential preservation. In particular the findings of the research conducted by Nicholson contradict a large number of the above mentioned assumptions concerning bone preservation (see Table 6.8).

Complexities arise in part due to the composite nature of bone and variations in bone composition both between and within species and the various skeletal elements, and also due to the huge variation in depositional environments and histories. The relative surface area of elements may be more important to relative rates of survival rather than robustness or absolute size (Nicholson 1996a). Bone preservation is not merely a function of surface area. The studies of both Lubinski (1996) and Nicholson (1996a, b) have provided more detailed information on the variability of fish bone preservation, which largely contradict the traditional assumptions concerning preservation bias. Both studies involved varying processing and cooking of fish, which were then buried in different environments and later excavated to assess skeletal element loss.

The assumption that mammal bone survives better than fish is not upheld by Nicholson’s finding (1996a). Preservation of mammal, bird and fish bones was variable and did not demonstrate a
straightforward correlation with deposition environment. Acid environments were found to be more conducive, rather than less, to the survival of otoliths.

The view that the large robust bones of lean species will be least susceptible to decay is challenged.

"the dominance in many fish bone assemblages of large-boned fish, particularly Gadidae in a European marine context, has been attributed to their preferential survival in more aggressive burial contexts (e.g. Enghoff 1994:83) This conclusion is not supported by the evidence from Site 15, where the larger fresh cod bones survived no better than the smaller fresh plaice bones" (Nicholson 1996a:525).

The rapid decay of fatty species is also contradicted by the relatively good preservation of the bones of herring (Clupea harengus). Both acid and alkali environments were found to result in significant bone loss, however, acid soils were generally found to be more destructive (Nicholson 1996a, b; Lubinski 1996). More important factors, however, are depth of burial, condition upon burial and presence/absence of covering (e.g. fur, skin), temperature, rainfall, soil texture and most importantly of all microbial action. Only where microbial action is limited will temperature, soil pH and rainfall determine rates of preservation. Nicholson does not make any mention of exposure prior to burial. It is probable that prehistoric inhabitants of a site did not immediately bury their waste but that it was left exposed (or in the case of many Scandinavian sites of Mesolithic date, thrown into submerged refuse areas). It would be interesting to examine the effects of exposure prior to burial and underwater disposal on fish bone preservation rates.

Though limited in terms of species to the lake whitefish (Coregonus clupeaformis), Lubinski (1996) demonstrated that there was differential preservation of skeletal elements within an individual, dependent on deposition environment. It was found that in acidic environments burned head elements decayed most rapidly and boiled trunk elements least rapidly. In alkaline conditions, burned head elements decayed fastest and all boiled skeletal elements showed the same rate of decay.

It is clear that the thermal history and depositional environment does influence preservation. Bone loss will have occurred on all archaeological sites (Lubinski 1996, Nicholson 1996a, b). The consequence of this is that no archaeological assemblage is likely to be representative of that deposited. However, this bone loss occurs in an unpredictable fashion.

There is no simple correction factor and in fact no clear method for discerning how different types of environment and variations in species biology and bone morphology will affect preservation. Nicholson’s findings would suggest that the widely accepted generalisations concerning expected biases of fish bone preservation in the archaeological record must be abandoned until further studies, aimed at clarifying the processes of differential preservation, have been conducted. The complex interaction of at least three factors (chemical environment, inter- and intra-species variation in element decay rates and variation in pre-depositional processing and taphonomic factors) in fish bone
preservation has ensured that no mathematical model has been developed that could extrapolate the original assemblage from the structure of the fish assemblage. A factor that suggests this may never be possible is the complexity of reconstructing the exact chemical history of the deposition environment. So many factors contribute to and influence environmental history that it is unlikely that it could ever be comprehensively reconstructed, particularly given that this would vary both within and between sites. Experimental studies of the influences on prehistoric faunal assemblages would require studies over infeasible temporal scales. Nicholson argues that as a direct consequence of the inability to reconstruct bone loss, the quantification of bone assemblages (especially the use of bone weight) for intra- and inter-site comparison is inappropriate and misleading and proposes that archaeologists

"abandon direct numerical comparisons in favour of an estimate of the frequency with which a species occurs in the contexts or samples under investigation" (Nicholson 1996b:90).

This is too nihilistic an approach and equally as 'misleading' as interpretations based on direct numerical analyses — any estimate of frequency would be based on numerical counts. Archaeological assemblages should be taken at face value. Speculations on original assemblage constituents should be avoided in the absence of supporting archaeological evidence.

6.5.3: Excavation Biases

The second set of factors biasing the interpretation of archaeological faunal assemblages are the methods of excavation, recovery, identification and recording. Variation in excavation and sample processing techniques makes inter-site comparison of absolute data meaningless. Percentage representation of species within assemblages provides some form for comparing site remains. Hand collected samples tend to show a significant bias against the recovery of the fish bones in general and in particular small fish bones and small fish species. The sites at Vedbaek are a prime example of this: the only site where sediments were not sieved, Boldbaner, produced only 23 fish bones compared to thousands recovered at the other Vedbaek sites (Aaris-Sørensen 1980a). Studies conducted on the recovery of fish remains from medieval sites along the Baltic shore indicate that at sites where only hand collection is practised, samples are heavily biased toward the recovery of large sturgeon bones, which are conspicuous in archaeological deposits (Benecke 1986).

Wet sieving and laboratory processing of all archaeological samples included in any analysis is required to rectify the problem of over-representation of large bones and fish species (Enghoff 1991; Choyke & Bartosiewicz 1994; Bartosiewicz et al. 1995; Hüster-Plogmann 1996). Without wet sieving, large quantities of material are lost. Experiments have shown that up to 99.7% of small remains are lost even in samples that are sieved through a 1/8" mesh (Limp & Reidhead 1979; Prinz 1987). Comparison of the efficiency of field sieves and finer sieves at the site of Bjørnsholm revealed
that the use of field sieves resulted in the large-scale loss of bones from small species such as cyprinids (Cyprinidae) and sticklebacks (Gasterosteidae) (Enghoff 1991). The introduction of fine sieving techniques in the processing of samples from Jomon period sites in Japan has resolved a long standing problem in this field, namely, the unexpected absence of salmon (*Oncorhynchus* spp.) remains at these sites. Jomon sites generally show an aquatic emphasis in subsistence activities. The absence of salmon (*Oncorhynchus* spp.) remains was unexpected because the sites are concentrated in the north-eastern region of Japan, an area that contains the best salmon rivers (Matsui 1996). Casteel (1976b) compared the recovery of fish remains from archaeological deposits from two different sampling methods: column samples sorted under laboratory conditions and whole unit samples sorted in the field. He concluded,

"The results indicated that laboratory analysis of column samples required only about one-tenth the effort required for analysis of whole-unit samples...this detailed study of column sample material produced an approximately 30% increase in the types of fishes identified over the number identified in the whole-unit, field sorted samples" (1976b:195).

Fine sieving and laboratory sorting of samples is still not widely practised in many areas of Eastern Europe. Lõugas (1996) states that sieving of excavated materials has only become a regular practise in Estonia since 1990.

### 6.5.4: Identification and Quantification

Methods of quantification have come under criticism for a number of reasons (Nichol & Wild 1984; Renouf 1989; Marshall & Pilgram 1993). Only frequently used methods of quantification are discussed here. The number of identifiable specimens (NISP) counts tend to inflate easily identified species, species with large bones and those with many skeletal elements, and is significantly affected by the fragmentation of the assemblage, which may relate to cultural practices. Modified fragment counts have been suggested as a solution to the problems associated with NISP. However, unless such practises are uniformly introduced across all studies, modifications only further complicate inter-site comparisons. A significant problem is the lack of standardisation within the technique: some researchers count all identified fragments, others only quantify articulated ends of bones. Frequently, authors do not make clear the method that has been used. The analysis of fish assemblages is affected by the very large differences in the number of skeletal elements of the various species resulting in large biases in representation. The number of vertebrae in fish varies from 16 in the moon fish (*Holacanthis ciliaris*), to 50 in gadids (Gadidae), to 115 in eel (*Anguilla anguilla*) (Nikolsky 1963). Minimum number of individual (MNI) counts were introduced to prevent multiple counting of animals and to avoid the problems associated NISP counts of heavily fragmented assemblages. This is very sensitive to sample size with the number of individuals inflated in counts of small assemblages relative to large assemblages and uneven distribution of skeletal elements across a site and leads to
undercounts in very fragmented assemblages. As with NISP counts there is no standardised approach to MNI counts. These problems inevitably affect studies of Mesolithic fishing practices. For example, Enghoff notes at the site of Bjørnholm,

"It must be mentioned that the percentual frequencies of bones of different species cannot be directly translated into percentual frequency of the species deposited in the shell-mound: Different species may have different numbers of bones per individual, and bones from different species have unequal chances of preservation" (1991:106).

One of the biasing factors in this group is identification (O'Connor 1997; Lernau 1986). Lernau phrases the problem succinctly,

"Identification of fish bones is difficult" (1986:52).

Archaeological fish assemblages are identified by comparison with modern reference collections (Enghoff 1991). The accuracy of any identification depends on the skill of the researcher and the quality of the reference collection. The lack of adequate reference collections is a major hindrance to the development of modern archaeo-ichthyological studies (Desse 1994; Desse & Desse-Berset 1996). This has contributed to the relative lack of large sturgeon remains identified at archaeological sites. Easily identified species may be over-represented (Marshall & Pilgram 1993). Cyprinids (Cyprinidae) and flatfish (Pleuronectidae) are difficult to separate to species level having few diagnostic elements (Enghoff 1986, 1989, 1991). Bones are generally more clearly species-specific in older individuals (Enghoff 1986). Lernau (1986) proposes a two-digit nomenclature — the first digit indicating the certainty of identification to Family and the second to species level. Despite these proposals there is still no standardisation in methods of fish identification. Gobalet observed of the ‘blind’ identification of one fish assemblage sent to five specialists,

"The considerable variation in interpretation raises serious questions regarding the accuracy of reporting and the usefulness of the data generated. Little agreement at the species level, wide differences in the total number of specimens in a given taxon, apparently inaccurate identifications, placements of specimens in excessively specific or overly general categories were typical inconsistencies" (2001:377).

Gobalet concludes that in the absence of peer review procedures or methodological standardisation in identification, all interpretations of archaeological assemblages should be viewed with skepticism.

Despite the wide ranging problems associated with the excavation, recovery and quantification of fish assemblages, it is possible to derive information concerning fishing practice from assemblages. Although criticisms of archaeological recovery, quantification and identification are valid, in the absence of prescribed remedial action, published species lists and counts must be accepted to be representative of the original, deposition assemblage. It is accepted that peer-group review and future
developments in method will alter understanding of faunal assemblage formation, quantification and identification and in turn influence interpretation and explanation.

Brinkhuizen's study includes finds from the Mesolithic to the Bronze Age period from the Netherlands.

1 Number of identifiable specimens
2 Minimum number of individuals
3 Teiosts comprise all bony fish
4 Elasmobranchs comprise all cartilaginous species, e.g. sharks, rays.
5 Agnathans comprise all jawless species, e.g. lampreys, hagfishes.
Chapter 7

Change, Variation and Correlation in Mesolithic Fishing Practice

7.1: Spatial Variation in Fishing Practice

An analysis of the types of fish species and fishing-related artefacts recovered at inland and coastal sites attests to variation in Mesolithic fishing practices (see Section 6.2.1 and 6.4). This, on the whole, reflects differences in resource availability and hydrological conditions between the two areas; both of which influence fishing strategy and gear choice.

7.1.1: Coastal Fisheries

It is difficult to assess the role of coastal fisheries in Mesolithic economies prior to the Late Mesolithic period owing to the absence of archaeological evidence. Overall, a greater number of species have been identified at coastal sites than at inland sites (115 categories compared to 47 at inland sites). This is, in part, due to the greater number of good food species available in marine waters, but also reflects the occurrence of both marine and freshwater species at coastal sites. It should be noted (as mentioned in Section 6.4.1) that only a small number of the 115 categories identified were exploited in significant quantities. Fishing coastal and inland waters from coastal settlements is consistently observed in traditional fisheries. However, many of the species identified at Mesolithic coastal sites are secondary freshwater or anadromous species and, as such, may inhabit brackish coastal waters. The presence of secondary freshwater species does not, therefore, constitute proof for extensive freshwater fishing by inhabitants of the coast. (Another possible explanation for the occurrence of secondary freshwater species at coastal sites, given the movement of marine species to interior sites, is that this movement, either of coastal groups or of trade goods, also occurred in reverse.) Inshore and deeper water fisheries are inferred from the range of species identified. Assemblages are most commonly comprised of species available in inshore waters in the immediate locality of sites.
The majority of the fishing activities attested by faunal assemblage composition could have been conducted in inshore waters without the use of boats. However, even in shallow waters, watercraft can be employed to greatly increase the efficiency and/or scale of a catch and allow certain waters to be fished that would otherwise be inaccessible. A small number of the species identified inhabit deep or offshore waters. Other species, for which large specimens are recorded, may inhabit shallow waters as juveniles but are only occasional (usually winter) visitors to inshore waters as adults. In both cases these fish would not be taken in inshore waters in commercial fisheries. This raises the question of whether the occurrence of deeper water species provides evidence for offshore fishing in the Mesolithic period.

The changing climate through the Mesolithic period may have altered species distributions. Warmer water species are thought to have been available in more northerly latitudes of Europe and closer to shore, increasing the number of species available inshore in northern latitudes. This is supported by the repeated occurrence of smoothhound (*Mustelus mustelus*), European sea bass (*Dicentrarchus labrax*), black seabream (*Spondyliosoma cantharus*) and common stingray (*Dasyatis pastinaca*) in Ertebolle midden sites (Enghoff 1995; Rosenlund 1986). However, changes in climate and consequent alterations to species distribution cannot be used to explain the presence of temperate, offshore species at Mesolithic sites in more northern latitudes. Climatic amelioration would be expected to drive cold-adapted species (*e.g.* cod [*Gadus morhua*], ling [*Molva molva*], torsk [*Brosme brosme*] and hake [*Merluccius merluccius]*) into deeper, colder waters. Nor does it adequately explain the presence of open sea, pelagic species at Mediterranean sites of Mesolithic date.

The colonisation of certain regions of Northern Europe implies open water navigation throughout the Mesolithic (*e.g.* the occupation of the Inner Hebrides of Scotland, the colonisation of Ireland, the distribution of Hensbacka sites up to 1km from mainland Sweden, the large number of specialised extraction site located up to 1km from the Norwegian mainland and the colonisation of Corfu and Corsica, some 45km from the mainland (J G D Clark 1965; Simonsen 1965; Forstén & Blomqvist 1974; Rozoy 1978; Woodman 1978b, 1985a; Camps 1991; Schmitt 1995; Wigforss 1995; Finlayson 1998). An analysis of the spatial distribution of sites of Mesolithic date on the Vega Islands revealed a correlation between site location and the occurrence of natural harbours (Bjerck 1990). Clearly, navigation of the open sea was within the capabilities of Mesolithic man but this raises the question of whether it was undertaken on a regular basis and, more importantly for this study, whether offshore fishing was a regular activity.

Glassow & Wilcoxon (1988) argue that the costs of maintaining an extensive offshore fishery, in terms of technological requirements, maintenance and search and capture time, would have been prohibitive for prehistoric groups. Ethnographically, few groups practice offshore fishing solely for
substitution purposes. Most groups avoid open sea travel if at all possible (Kvaale 1956; Kroeber & Barrett 1960–62; Olsen & Hubbard 1984; Rivallian 1984; de Laguna 1990b; Renker & Gunther 1990; Leach & Boocock 1993). There are a small number of exceptions to this such as the Makah, Tolowa, Coast Tingit and Wiyot groups of the Northwest Coast and the Maori of South Island, New Zealand. In these groups, offshore expeditions are generally conducted primarily to attain prestige, adventure or for ‘interesting fishing’ and are only undertaken in good weather. These expeditions are frequently unsuccessful and were therefore not considered to play a primary role in subsistence activities even if successful expeditions produced large yields. Mesolithic groups would have been intimately aware of the dangers of the sea and it seems unlikely that expeditions to open waters would have been undertaken to exploit resources that could be taken closer to shore. It is likely that boats were used predominantly for transport around the coast and for inshore and riverine and lacustrine fishing activities. Even on the larger lakes in Europe, weather conditions can become severe enough to be profoundly dangerous for fishermen in small-scale craft. Unpredictable weather conditions restricted the traditional fisheries of the large lakes of Africa to inshore areas within 2–5 km of the shore (Worthington & Worthington 1933). It is possible that offshore expeditions were undertaken in search of certain species of sea mammals or large fish but it is unlikely that such expeditions would have occurred in the treacherous waters of the North Sea and the Atlantic in other than ideal conditions. Such conditions occur on a small number of days each year. Fishing is further limited if these ‘good days’ do not coincide with the known migration or activity patterns of the intended prey.

It is not possible to determine the existence of offshore fisheries on the basis of artefacts. In contrast, the biology and movement patterns of prey species does shed light on the role of offshore fisheries in the Mesolithic economy. Often cod (Gadus morhua) and ling (Molva molva) have been cited as species inhabiting deep waters, and by implication, their recovery as evidence for deep-water fishing (e.g. J G D Clark 1948a; J M Coles 1971; Enghoff 1995; Wigforss 1995). For example, the co-occurrence of turbot (Scophthalmus maximus), haddock (Melanogrammus aeglefinus) and large specimens of cod (Gadus morhua) at Morton, Scotland, leads J M Coles to suggest, “deep-sea activity, involving a boat” (1971:361).

However, turbot (Scophthalmus maximus) can be taken in shallow inshore waters all year round. Adult cod (Gadus morhua) and haddock (Melanogrammus aeglefinus) are known to enter sea lochs and the deeper areas of shingle or rocky shores at various times of the year to feed and are commonly angled from the shore at this time. None of the three species cited support an exclusive offshore fishery. J M Coles also uses the large size of a single sturgeon (Acipenser oxyrinchus), ca.3 m and 250 kg, reconstructed from a single dermal scute, to imply deeper water fishing. Though sturgeon (Acipenser oxyrinchus) are not found near the coast of Britain today, medieval records indicate large freshwater runs of sturgeon (Acipenser spp.). The sturgeon (Acipenser oxyrinchus) could have been taken in deeper water, on the coast or in freshwater. Moreover, the reliance on a scute to determine size is fundamentally flawed. The size of scutes varies over the body of the fish and because of this, size determinations are grossly inaccurate. Its presence does not in itself lend support to the argument

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for an offshore fishery. On the basis of the finds of large cod *(Gadus morhua)* and ling *(Molva molva)* at Bua Västergård and Rottjärnslid, Sweden, Wigforss concludes that fishing

"must have been carried out from boats and at a reasonable distance away from the settlement in deep waters" (1995:199).

In fact, all the species identified at these sites could have been taken in inshore waters from boats and even from the shore using long-lines in the deep waters of the fjords. The presence of quite small cod *(Gadus morhua)* at Bua Västergård, which are found only in inshore waters, supports an inshore fishery from this site.

A total of seven species, which permanently inhabit offshore regions, have been identified in Mesolithic contexts: hake *(Merluccius merluccius)*, halibut *(Hippoglossus hippoglossus)*, torsk *(Brosme brosme)*, golden redfish *(Sebastes marinus)*, wolf-fish *(Anarhichas lupus)* and Spanish seabream *(Pagellus acarne)* (Table 5.2). These species have been identified at a number of sites but they are all geographically restricted to the coasts of Norway and south-west Sweden and the Mediterranean Sea. A number of other species were identified at Mesolithic sites — cod *(Gadus morhua)*, ling *(Molva molva)*, porbeagle *(Lamna nasus)*, whiting *(Merlangius merlangus)*, brill *(Scophthalmus rhombus)*, bluefin tuna *(Thunnus thynnus)*, haddock *(Melanogrammus aeglefinus)*, pollack *(Pollachius pollachius)*, tope *(Galeorhinus galeus)*, saithe *(Pollachius virens)* and swordfish *(Xiphias gladius)* — adults of these species are generally found in deeper waters and, as such, their presence in Mesolithic contexts has been used to suggest fishing using boats but all can be found closer to shore on a seasonal or occasional basis. The find sites of offshore or deeper waters species across northern Europe are generally located near exposed coastal waters with hard substrates. In many cases the sites are located in areas where deep water can be located near to the shore, e.g. sea loch or fjords (J G D Clark 1948a). This may explain the catches of large individuals of cod *(Gadus morhua)* and ling *(Molva molva)* which may enter these regions in winter to feed. It is the identification of torsk *(Brosme brosme)* and hake *(Merluccius merluccius)*, both offshore species which seldom enter water less than 70m, and golden redfish *(Sebastes marinus)* and wolf-fish *(Anarhichas lupus)* that implies offshore fishing in the northern latitudes of Europe. Hake *(Merluccius merluccius)* is known from only one find at the island site of Olmnäs, off the south-west coast of Sweden. Water of the depth inhabited by hake *(Merluccius merluccius)* is found at a distance of at least 10km from the site (Wigforss 1995). Torsk *(Brosme brosme)*, golden redfish *(Sebastes marinus)* and wolf-fish *(Anarhichas lupus)* are more common, found at a number of the Varanger sites and Kotedalen in Norway (Table 6.2). Unlike cod *(Gadus morhua)* and ling *(Molva molva)* there are no records of their capture from the shore by anglers (La Gorce 1924; Barrett 1997). The depth of the Varanger fjord allows all these species to be taken at relatively short distances from settlements within sight of land. The proportion of each species identified at the sites corresponds to values obtained for modern inshore fisheries in the region (Renouf 1989). Specialised fisheries in offshore species are evident at only eight sites, geographically
restricted to the coast of Norway, the south-west Swedish coast of the Skagerrak and the Mediterranean. Species that may have been caught in deeper waters are known from a much larger number of sites, 63 in total. Capture of these species implies the use of watercraft to access very deep water but not necessarily fishing grounds out of sight of land. The capture of permanent inhabitants of offshore waters enhances the case for deeper water fishing for species such as cod (Gadus morhua), ling (Molva molva) and haddock (Melanogrammus aeglefinus), which, though occasionally present in more inshore waters, are often found alongside the offshore species in archaeological assemblages. For example, there may have existed an offshore fishery of the Skagerrak, suggested by the range of species found at the sites of Rottjärnslid, Dammnen, and Balltorp, Sweden, on the basis of the find of hake (Merluccius merluccius), an offshore species, at the nearby site of Olmänäs. The frequency of deep sea species at the Varanger sites and their distribution in features throughout the sites suggests a regular deeper water fishery using watercraft. It is possible that offshore fishing was attributed a level of prestige not given to other inshore fishing activities. The biological adaptations of the species exploited in offshore or deeper water fisheries, i.e. the habitat and the diurnal patterns and method of feeding of the species, are most suited to capture using hook and line (Table 5.4). Though trawl nets are used in commercial fisheries for the capture of these species, this method requires industrial technology. It is common both in traditional and some commercial fisheries to troll for larger individuals of these species that occur in more inshore waters and in offshore waters. A long-line fishery (set or trolled) would be most effective for the capture of the offshore and deeper water species identified at sites in the northern latitudes of Europe. Torsk (Brosme brosme) is reported to occur predominantly in waters of >150m depth (Fridmodt 1995). This has implications for the length of long-lines used in Mesolithic fisheries, i.e. if the habitat of torsk (Brosme brosme) has remained constant since prehistoric times the lines used must be over 150m long. Long-lines suitable for this type of deep water fishing would have been within the technological capabilities of Mesolithic groups to manufacture (though time consuming and costly in terms of raw materials) and are known from the traditional fisheries of tropical Africa and New Zealand and recent non-industrial European fisheries (Rau 1885; Hickling 1961; de Rohan Csermak 1963; E Martin 1989, 1995; Coull 1996).

In regions where there is little evidence for deeper water fisheries such as the east coast of Denmark, the exploitation of stranded animals is often cited as the explanation for the occurrence of offshore fish and mammal species in small quantities on sites (J G D Clark 1946; L Jonsson 1988; Enghoff 1994a, b, 1995). For example, Enghoff (1994a, b, 1995) suggests that the presence in small numbers of deeper water species such as porbeagle (Lamna nasus) and tope (Galeorhinus galeus) at West Baltic sites may have been stranded animals. It is more likely that both species were taken in the pursuit of other prey fish. Tope (Galeorhinus galeus) and porbeagle (Lamna nasus) are occasional visitors to shallow coastal waters, frequently following shoaling species (particularly herring [Clupeidae] and mackerel [Scomber scombrus]) which migrate seasonally into inshore waters. The capture of these species in present day commercial net fisheries of shoaling species is relatively commonplace and the capture of gravid females on lines fished from the shore is reported.
The large-scale fishing for very large pelagic species and the exchange or trade of lithic materials evident in the Mediterranean from ca. 10,000 BP (9650 cal BC) would argue for a sophisticated type of watercraft and frequent open sea journeys. The colonisation of Corsica and the presence of Spanish seabream (Pagellus acarne) at Monte Leone on Corsica, attest to offshore navigation and fishing in the region. Deep water, tuna (Thunnus thynnus) fishing has tentatively been linked to the obsidian originating in Melos, found at Franchthi, Greece, attesting to the navigation skills, seaworthy watercraft and improved fishing technology of the inhabitants at this time (Jacobsen 1981; Dennell 1983; Tzalas 1999). Although linked with offshore fishing practices in the early Holocene, shoals of bluefin may move into inshore waters on an occasional basis. Bluefin tuna (Thunnus thynnus) constitutes 95% of the fish fauna and 50% of the total faunal assemblage in the Late Mesolithic levels at Franchthi, implying a specialised fishery at this site (Payne 1975). There is a clear association between the finds of these deeper water pelagic species at Mediterranean sites and the occurrence of fish hooks but the number of sites is too small for generalisations to be drawn (Table 6.3). These species are also most likely to have been taken with trolls. Fish hooks recovered at Cyclops Cave (Figure 7.11) are analogous to tuna (Scombridae) trolling hooks of Polynesia and the Northwest Coast groups. Ethnographically observed tuna (Scombridae) fishing with harpoons and hooks among the Northwest Coast groups is documented to have required the same skill and involved the same dangers as whale hunting (Crockford 1994). Tzalas (1999) suggests that the inhabitants of Franchthi Cave used papyrus boats (papyrela) with kayak type oars such as those on the Nile that were still in use at Kerkyra until recently. It is possible, however, that journeys between the Greek Argolid and Melos were achieved by ‘land hopping’ rather than by navigating open sea (Bednarik 1999). Sophisticated fishing practice is also attested at Cyclops Cave on the Sporades Islands (Greece) as early as ca. 10,000 BP (9650 cal BC) (Tzalas 1999). Sixty bone fish hooks (8–60mm in length), fish remains (over 100 species), marine mammals and shellfish are evident in the earliest layers of the site. This may have been allowed by the more predictable, less severe weather and water conditions in the Mediterranean. It seems unlikely that such operations would have been satisfactorily conducted from the type of dugout or coracle typically proposed for the Mesolithic period (see Section 6.3.13 and Figure 6.60).

If Mesolithic groups were regularly practising offshore fishing or travel where the coast is no longer visible this raises the question of how such waters were navigated. Groups practising fishing within sight of land frequently use visual markers to locate fishing grounds and for navigation (Forman 1970, 1980; Igarishi 1977; Cordell 1980). Offshore travel would require some other form of navigation. Polynesians groups exploited their knowledge of the predictable behavioural patterns and migration of birds to navigate the open sea and to locate new lands (Hornell 1946). Records concerning the practices of medieval fisherman off the coast of Ireland indicate that the movement of birds was used for navigation and for the location of certain types of fish (Pálsson 1991).
Future archaeo-ichthyological investigations of Mesolithic coastal sites should pay particular attention to the occurrence of offshore species which act as markers for offshore fisheries.

7.1.3: Inland Fisheries

Fewer species have been identified at inland sites compared to coastal regions but this is to be expected, given the more limited range of food fish in freshwaters. In many inland areas, prime food fish are restricted to a very small number of freshwater and anadromous species.

Freshwater fisheries are fundamentally different from coastal fisheries. Fishing is inherently less dangerous due to the reduced tide and wave action. All of the species identified at inland Mesolithic sites could have been fished from the shore according to the season and location of the fishery and hydrological conditions. This obviates the need for boats for fishing but it is likely that there was widespread use of boats in inland fisheries.

Anadromous and catadromous species would be expected, on comparison with Native American subsistence practices, to be the focus of inland fisheries, given their temporal and spatial concentration and predictability. This is confirmed by the faunal assemblage structure at only a small number of sites and within specific regions. Specialised fisheries of eel (*Anguilla anguilla*) are evident at the Ageröd sites, Sweden, the Mollegabet I and II, Bjørnsholm and Nederst, Denmark and Lough Boora, Ireland and salmon (*Salmo salar*) at Mount Sandel, Ireland (Woodman 1978b; Enghoff 1986, 1991; Andersen 1991, 1995; Grøn & Skaarup 1991; Skaarup 1995a). Andersen (1991, 1995) proposes that the large freshwater drainage in the Limfjord and the corresponding abundance of eel (*Anguilla anguilla*) was responsible for the density of occupation of this region in the later Mesolithic. Fischer (1995) argues that the existence of this type of seasonally available and abundant resource was a prerequisite for stable sedentary settlement. Though counts of fish remains are not always available, the anadromous beluga (*Huso huso*) and various species of anadromous sturgeon (*Acipenser spp.*) certainly played a role in the Iron Gates economy. However, there is little faunal evidence for economic dependence on these species (Figures 7.1a and 7.2a and Table 6.2). Generally, stable isotope analysis would be expected to determine the role of anadromous species in diet (cf. Doucette et al. 1999). However, this technique cannot be employed to resolve the question of whether migratory species of sturgeon (*Acipenser spp.*) contributed significantly to diet in the Iron Gates Mesolithic (Bonsall et al. 2000)9. Smith & Kinahan (1984) describe the archaeological invisibility of the whale; it may be that very large fish such as the sturgeon (*Acipenser spp.*) and catfish (*Silurus glanis*) are, similarly, archaeologically invisible. Large fish may have been processed at landing sites, or immediately upon catching, resulting in bones not being transported to settlement sites. The processing of large fish (e.g. halibut [*Hippoglossus stenolepis]*) at sea or at landing sites has been observed among Northwest Coast groups and these species may be under-represented at sites.
(Crockford 1994). Processing method may explain the recovery of only the scutes of sturgeon (*Acipenser* spp.) or beluga (*Huso huso*) at sites such as Morton and Zvidze, however, this is only one possible explanation for the limited recovery of anadromous species. It is precisely the biological adaptation that permits efficient exploitation of anadromous/catatadromous species, namely spawning migrations and attendant build up of fats, that reduces their visibility in the archaeological record. The intensive salmonid (*Salmo* spp.) fishery at Mount Sandel is known only because the fish remains were calcined due to exposure to high temperature over a long period of time, and this permitted preservation in acidic soils (Woodman 1978a). This gives an insight into the amount of information that may have been lost because of acidic soil conditions.

The ethnographically observed ‘supremacy’ of anadromous species is not reflected in the fish assemblages of the Mesolithic on a pan-European basis nor at inland sites as a whole (Table 6.2–6.4, Figures 7.1a & b and 7.2a & b). Although eel (*Anguilla anguilla*) are the focus of fisheries at a small number of sites, their remains have been recovered at only 37 of the 182 sites included in this study, and at most of these sites they occur in very small numbers. Salmonidae are even less common; salmon (*Salmo salar*) has been identified at only two sites, Mount Sandel and Tybrind Vig, Denmark. The range of species represented at Tybrind Vig and the results of correlation studies makes marine/estuarine capture of salmon (*Salmo salar*) likely. All other finds are unspecified *Salmo* spp. or trout (*Salmo trutta*), which may not represent anadromous fish. The occurrence of eel (*Anguilla anguilla*) at a relatively large number of sites in very small quantities does suggest a bias in preservation but this is no more than speculation.

Pike (*Esox lucius*) has been identified at 50 of 69 inland sites with fish fauna. Pike (*Esox lucius*) has a greater site and abundance representation than the combined occurrence of all cyprinids (*Cyprinidae*) that constitute the major freshwater family of fish. The ubiquity of pike (*Esox lucius*) at sites on the West Baltic led J G D Clark (1975) to suggest a specialised fishery in this region. Pike (*Esox lucius*) do occur at many sites but a specialised fishery can only be considered at sites with large assemblages where pike (*Esox lucius*) dominates. These criteria are met at only a small number of sites most of which lie in the circum-Baltic zone: Åkonge, Østenkær, Præstelyngen, Ringkloster and Svaerdborg (Denmark), Øgaarde, Segeberø and Skateholm (Sweden), Dudka (Poland), Zvidze (Latvia) and Narva (Estonia). Though the concept of a specialised pike (*Esox lucius*) fishery cannot be extended to every site in this region, a preference for pike (*Esox lucius*) at inland fisheries appears to extend across Mesolithic Europe. This may relate to the fact that it is one of the few primary freshwater species that has good food value and that can be captured at any time of year.

The remains of marine species have been identified at a number of sites, indicating, in certain cases, a long-distance trade network. Three shark (Elasmobranchii) teeth found at the site of Tashkovo IV located on a terrace of the River Lesset (Russia) must have originated in the Indian or Atlantic Ocean, implying movement over hundreds of kilometres (Krisjevskaya 1989). Clearly, in this case, the shark
teeth have attained value and desirability as an exotic or prestige item. A category denoted as *Squalus cephalus* was reported at Falkensteinhöhle, Germany (Jochim 1998). This is clearly a typological error. If this is the remains of a member of the *Squalidae* family, its find site is somewhat puzzling and would suggest very long distance movement of goods from the coast. It is more probably chub (*Leuciscus cephalus*). Other instances of marine species at inland sites have more complex explanations, suggesting trade/exchange between coastal and inland groups and/or movement of all or part of the population between coastal and inland areas (*i.e.* France, Scandinavia and Sub-Arctic Norway). This applies to regions where the inland sites are not very far from the coastal regions. At Ringkloster, marine species (small flatfish [*Pleuronectidae*], cod [*Gadus morhua*] and saithe/pollack [*Pollachius spp.*]) constitute 3% of the total assemblage (Enghoff 1994b). The distribution of the marine species in the site suggests that they result from more than one deposition episode. The anthropogenic origin of these bones is inferred from traces of burning on one example. Other marine resources were identified at the site: five oyster (*Ostrea edulis*) shells and a rib and two vertebrae of a bottle-nosed dolphin (*Tursiops truncatus*). Coastal/inland contact or movement is also indicated in the Ámose Basin with the presence of a worked spurdog (*Squalus acanthias*) spine. The location, size and duration of both sites and the overall composition of the faunal remains are consistent with site use as summer fishing camps. Given the availability of fish at these sites, the presence of marine species suggests that coastal groups were moving to these interior locations to exploit freshwater fish on a seasonal basis, taking with them stored resources to meet initial subsistence needs. However, it could be argued that inland groups were trading with coastal groups, exchanging freshwater fish for coastal resources. The different mineral content of marine and freshwater resources may explain the exchange of such similar resources. Marine resources could provide the dietary sodium and iodine requirements that may be lacking in diets based on freshwater resources (see Tables 2.3 and 2.6). It is known ethnographically that the trade of fish is rare between groups who have access to similar resources but commonly occurs between inland and coastal groups with significantly different resource bases. Often, coastal groups exchange resources obtained from shellfish, marine fish and sea mammal for non-aquatic resources such as furs, nuts and the meat of terrestrial mammals.

### 7.1.4: Spatial Variation in Artefact Recovery

The four main groups of artefacts (hooks, projectiles, traps/weirs and nets) were recovered from both inland and coastal sites (Figures 7.3 and 7.4). Fishing-related artefacts exhibit little qualitative variation in spatial distribution at Mesolithic sites (Figure 7.4b & c) with the exception of fish hooks, which are much more commonly recovered at coastal sites. Finds of line weights and of small barbed points interpreted as the crooks of composite hooks are restricted to coastal sites. Although line weights and composite crooks are relatively rare finds, the increased recovery of the combined group of hook-related artefacts at coastal sites suggests that the spatial disparity may be linked to the *Gadidae* line fisheries of coastal regions. However, composite crooks may be unbarbed; small, simple
points could also have served as the crooks of fish hooks. Small, simple points of this type show no temporal or spatial restriction in distribution.

The analysis demonstrated that paddles are more commonly recovered from inland sites whereas boat remains are more evenly distributed between coastal and inland locations implying a bias in preservation. Gorges have been recovered at both coastal and inland sites but are significantly more common at inland locations.

Certain fishing-related artefacts have an exclusively inland distribution. These comprise ice picks, pulses, clubs and net frames. This exclusivity most probably represents the subjectivity of the archaeologist rather than distinct fishing practices. The function attributed to these artefacts is speculative. The expectation of the archaeologist is, to some extent, influencing interpretation although ethnographic analogies are available to justify hypotheses.

The analysis of the database indicates that by far the most frequent and ubiquitous artefacts recovered from sites are bone/antler points (Tables 6.3 and 6.4 and Figures 7.3a and 7.4a). Barbed points constitute the largest single category of find.

7.2: Temporal Change in Fishing Activities

For each category of artefact and fish species, temporal variations in occurrence and abundance were assessed (Tables 6.2–6.4 and Figures 7.1d & e, 7.2d & e, 7.3d–g and 7.4d–g). Four analyses of temporal variation in fish species and fishing-related artefact representation were conducted: using data from all of Europe (quantitatively and qualitatively) and using data obtained only from inland sites (quantitatively and qualitatively). A separate examination of changes occurring only at inland sites was undertaken because of the very small number of early Mesolithic coastal sites. The results indicate a remarkable continuity in the range of economically important fish species sought but demonstrate a developing sophistication of fishing technology.

7.2.1: Temporal Change in Fish Remains

Temporal changes in fishing practice effectively can only be studied for inland fisheries in the Mesolithic period. Large differences in coastal fisheries would be expected. Mesolithic Europe cannot be viewed as a single climatic/environmental unit (Straus 1991b; Dincauze 2000). Temporal
differences in fish exploitation would be expected to be more pronounced in northerly latitudes and in the Baltic region, given the large variation in salinity with the transition from the freshwater Ancylus Lake to the Litorina Sea (which had a greater biomass). This would influence the range of fishing gear employed. At the sites of Ertebolle and Bjørnsholm, where the stratigraphy of fish bone deposition is understood, there is little evidence for any change in fishing practice throughout the duration of site occupation, i.e. the Late Mesolithic period (Enghoff 1986, 1991). Unfortunately, the lack of coastal sites and fish assemblages from preceding periods in this region restricts any understanding of changes in fishing practices before this time in coastal regions. Underwater investigations are increasing knowledge of Early Mesolithic sites and initial findings suggest fishing was important at these sites but there are as yet no detailed publications of fish fauna recovered from these sites. Fishing-related artefacts recovered from Early Mesolithic sites might be used to make very general statements about temporal changes in fishing activities.

There is continuity in the range of species recovered at inland sites between the Early and Late Mesolithic (Figures 7.1d & e and 7.2d & e). This could be taken as evidence for continuity in fishing practices. The validity of this statement is difficult to assess due to the limited number of good food fish available in inland waters.

There are small temporal changes in the abundance of the main species identified (Figures 7.1d & e and 7.2d & e). Catfish (*Silurus glanis*) is more abundant in quantitative terms in late Mesolithic assemblages, i.e. there is evidence for a more intensive fishery at sites but no increase in the number of sites at which it occurs. The increasing importance of catfish (*Silurus glanis*) sees an attendant reduction in the abundance of pike (*Esox lucius*) and a slight increase in cyprinids (Cyprinidae). Guminski (1998) suggests that this may reflect climate changes, warmer and moister than preceding periods, which provide ideal conditions for the flourishing of catfish (Siluriformes) and cyprinid (Cyprinidae) populations.

At individual sites, shifts in species representation may also be the result of local hydrological changes. The increasing frequency over time of marine species at Skateholm is not due to a change in location of fisheries but to the increasing depth and salinity of the lagoon immediately surrounding the settlement.

7.2.2: Temporal Change in Fishing-Related Artefacts

Each of the major gear types has been recovered in both early and late contexts. There are distinct differences in the dominant types of gear used in inland and coastal fisheries both spatially and temporally (Tables 6.3 and 6.4 and Figures 7.3d–g and 7.4d–g).
All temporal variations can only be considered to be independent of the coastal aspect of the Late Mesolithic if displayed independently at inland sites. Although no major gear types (nets, traps, projectiles or hooks) are restricted to either the Early or Late Mesolithic, a small number of fishing-related artefacts are not found in early deposits, namely the barbs of composite hooks, line weights (plummets) and net frames. Net frames are only known from one site and temporal variations in practice cannot be determined from a single occurrence. Small barbed points and definite line weights were recovered only at coastal sites and therefore temporal variation cannot be assessed.

In the Late Mesolithic (in comparison to the Early Mesolithic) net fragments and net weights are found at a greater proportion of sites and in greater quantities. This overall trend is even more significant at inland sites across northern Europe, indicating that this is not merely a consequence of the higher incidence of coastal sites in the later Mesolithic.

Interestingly, the artefacts interpreted as netting needles by J G D Clark (1936) are less commonly recovered from later Mesolithic deposits. This decrease is unexpected given the expected increase in net manufacture. Netting needles of this form are also rare finds in the East Baltic region where nets and net-related artefacts are commonplace, i.e. not a consequence of preservation bias. There are three possible explanations of this: (i) the inaccuracy of the typological dating of some of these implements; (ii) a shift to the use of more expedient tools for netting in later periods, such as those used by the Coast Yuki and the McCloud River groups (Figure 7.5); or (iii) the use of these implements for some function other than netting. The third explanation is the most convincing. Two wooden boards with notches at both ends from Friesack more closely resemble the netting needles used by traditional fishermen for net manufacture (Figure 7.6). Supporting this interpretation is the recovery of both net fragments, cordage and floats at the site. The wooden boards were preserved under exceptional conditions at Friesack and the use of similar implements for netting may have been widespread.

Similarly, finds of implements with supposed net décor (i.e. mesh designs) do not correspond temporally or spatially to finds of nets and net-related artefacts. Though this does not eliminate the possibility that these are representations of nets, other explanations of these designs must be considered equally valid.

The recovery of paddles increases in the Late Mesolithic. This is accompanied by an overall increase in the proportion of sites at which boats have been recovered. However, there is no significant change in finds of boats at inland sites suggesting that the observed increase in boats is a consequence of the inclusion of coastal sites in the later Mesolithic rather than increasing use of watercraft.

Traps and weirs do occur at Early Mesolithic sites but there is a large increase in the number of finds sites and the overall quantity of finds at Late Mesolithic sites (both coastal and inland). These categories of finds occur in very small numbers in the Mesolithic period so explanations of spatial or
temporal variations must be treated with caution. Finds of traps are not chronologically restricted to, but are most common in, the Late Mesolithic period. Traps attributed to the Early Mesolithic, from Priestermoor, Germany, and Koster, Denmark, are unassociated finds — the method of dating these traps is not explicitly stated (J G D Clark 1936). Although the dating of these traps is not secure it can be inferred from the technological sophistication of the traps recovered from the Early Atlantic period onward that traps were in use in the preceding Boreal period.

The increasing proportion of sites at which net-related artefacts and traps/weirs occur and the greater numerical quantities of these implements at sites indicate a trend toward the use of large-scale gear in the Late Mesolithic. It is possible that all these increases are due to preservation bias. However, a trend towards increasing use of large-scale gear in the Late Mesolithic may reflect changes in resource availability and/or scheduling of activities (see Section 8.2 and 8.3). The role of large-scale gear such as nets, weirs and poisons are emphasised in storage fisheries (Bennyhoff 1950). Archaeologically, evidence for the use of nets, inferred from finds of sinkers, comes relatively late in North America (in the mid-Holocene); spears and hooks are the predominant fishing related artefacts at early Holocene sites. This has been linked to the increasing practice of storage through the Holocene (Cleland 1982, 1989; Ames 1985; Fladmark et al. 1990).

No temporal or spatial variation in the proportion of sites at which fish hooks occur was identified in this study. There is a significant difference in actual counts of fish hooks — the result of the very large number of finds at certain coastal sites where specialised line fisheries are thought to have occurred. This coastal focus on hook fishing and the more common use of nets is not only reflected in ethnographically observed subsistence fisheries (e.g. Northwest Coast, Maori, Aleut and Greenland Inuit), but has also been noted at the Jomon sites of Japan from ca. 12,000 BP. (Hongo 1989).

Barbed points are significantly more common at inland sites in the Early Mesolithic period than in the Late Mesolithic. It is possible that this bias is due to the significant number of unassociated finds of barbed points at inland sites that have been typologically dated to the early Mesolithic. An analysis of sites that eliminates all unassociated or isolated finds was therefore conducted to assess the veracity of this temporal bias. The findings confirm the temporal bias in the distribution of barbed points. It can be argued that this reduction in the occurrence of barbed points at inland sites, at which there is continuing evidence for the significant exploitation of fish, supports a shift to the use of larger-scale gear.

In comparison to the Upper Palaeolithic, there is an increase in the number of types of barbed point at Mesolithic sites. Schudlt (1961), and later Feustel (1985), relate this diversification to increasing functional specialisation and the targeting of specific resources. There are no variations in fish species exploitation that could account for this temporal change in form. Any functional explanation for the change must be linked to the exploitation of non-aquatic resources. The spatial and temporal
distribution of barbed point types from across northern Europe conducted by Verhart (1989) indicates that point morphology may be culturally or socially rather than functionally determined. It appears to be related to the distribution of groups of other artefact types, possibly indicating the boundary of social territories in the Late Mesolithic period.

The four categories of barbed point devised by M W Thompson (1954) to describe finds from southwest Europe suggest that there was a shift from simple to toggle-head harpoons between the Magdalenian and the Azilian. M W Thompson attributes this shift to the development of detachable heads to prevent shaft damage when hunting in wooded areas. This does not account for the problems of line use in wooded areas. The shift to toggling points is more consistent with use in aquatic environments where the detached shaft then acts as a float to impede the movement of the prey species.

7.3: Regional Variation in Fisheries Practice

Information concerning regional variation in fishing activities was extracted from the database (see Tables 6.1–6.4 and Figures 7.7 and 7.8). Owing to the large intra- and inter-regional variation in preservation conditions and quantities of recovered artefacts and fish remains, all analyses of regional variations in fishing activities were conducted using qualitative data. There are clear variations across Europe in the types of species recovered at sites of the same basic habitat group (i.e. riverine, coastal and lacustrine). This is largely the result of the local availability of species. Grayling (*Thymallus thymallus*), for example, has been identified as the dominant species at sites on the German stretch of the Danube. This species is an inhabitant of the upper reaches of rivers and has not been recovered at sites in the Iron Gates Gorge.

An analysis of local and regional variation in fishing practices was conducted to assess the homogeneity of fisheries and technologies and the extent of local or regional adaptations specific to locally available prime food fish. Regions of Europe were divided into geographic areas reflecting major topographical/hydrological features rather than depending on traditionally accepted cultural groupings (though in certain cases the two overlap): Atlantic Europe, north and south; Central Europe (including the Upper Danube); Benelux countries; Iron Gates; West Baltic; East Baltic; and the coast of Norway and south-west Sweden. (This may not reflect Mesolithic ethnic distinctions.) Figures 7.7 and 7.8 depict the geographical variations of fish species and fishing-related artefacts. Interpretation of these variations is complicated by a number of factors. Grouping sites on this basis often resulted in very small numbers of sites within a group reducing validity of results. As a consequence of the variation in the type, quantity and quality of evidence for fishing practice in Europe, a study of coastal and inland fisheries is inevitably biased to specific geographical regions. Evidence for inland fisheries comes predominantly from the Danube drainage and the inland sites of the circum-Baltic region. The
fisheries practised in these two distinct regions would be expected to differ given the huge size of the Danube and its tributaries in comparison to the relatively small inland bodies of water (often lakes) fished in the circum-Baltic zone. Coastal fisheries are witnessed at sites along the Atlantic coast of Europe and the Baltic region. Huge variations in the preservation of artefacts, the limited number of sites outside the Baltic area and discrepancies in the publication of fish fauna (particularly with regard to Iberian sites) limits discussion of the implements used in coastal fisheries to the Baltic zone and hinders discussion of temporal changes in fishing gear and exploitation of fish species.

7.3.1: Coastal Norway and South-west Sweden

Faunal remains indicate deeper water and possibly offshore fisheries at all sites in this region. Deeper water species are common with cod (*Gadus morhua*) dominating assemblages. This is also observed for sites facing the Skagerrak on the south-west coast of Sweden. At Nyelv Nedre Vest the proportions of the various fish species in samples from different areas of the settlement exhibit different seasonal emphases in fishing and there is a particular emphasis on saithe (*Pollachius virens*) not evident at the other Varanger sites. This deeper water fishery would have been conducted using set and trolled lines or long-lines. This is the most effective method of capture in terms of the biology and habitat of the species taken. It is supported by the recovered artefacts and corresponds to the observed practices of traditional fisheries.

The diurnal vulnerability of the species fished in these regions implies night fishing of deeper or offshore waters. Temperate predatory species such as cod (*Gadus morhua*), torsk (*Brosme brosme*) and ling (*Molva molva*) are crepuscular feeders and as such are most active and generally most vulnerable to capture at night, although they may be susceptible to encircling gear set in very deep waters, such as modern trawls, during the day if resting in large shoals. As deep-water trawls are not thought to have been within the technological capabilities of Mesolithic fishermen, it is concluded that the line fisheries of the Norwegian coast and the Skagerrak would have been conducted at night with gear set immediately prior to dusk for greatest efficiency. Fishing at night would incur more risk to the fishermen through increased storm action.

Simonsen (1965) correlates the distribution of inland sites in the Varanger fjord region, at points that naturally concentrate fish, with the finds of soapstone line sinkers to suggest a significant fishery of inland waters in this region (Simonsen 1965). It should be noted that these inland sites are lithic scatters, which have been dated on a typological basis only. It is therefore difficult to ascertain the precise chronology of these sites or eliminate the possibility of palimpsests of debris from occupations of varying date. It is not possible on the basis of such tenuous data to determine the role of fishing at inland sites in this region in the Mesolithic period.
7.3.2: Benelux Countries

There are very few finds of fish fauna at Benelux sites. An overview of Mesolithic Europe by Price (1978) states that relatively little is known about the Mesolithic of inland Western Europe due to poor organic preservation with site location in sandy, acidic soils. Though written over two decades ago, sites with good preservation have still not been found in this region. There is evidence for the exploitation of fish from the remains of salmonids (Salmo spp.) and catfish (Siluriformes) and depictions of perches (Percidae) and trout (Salmo trutta) in Upper Palaeolithic contexts (Price 1987; Van Neer & Ervynck 1994). The two very small Mesolithic fish assemblages recovered in this region attest to fishing of freshwater and marine species. All of the species identified at Rotterdam-Bergschenhoek, Netherlands, could have been taken in estuarine waters.

Artefactual finds emphasise the lack of faunal remains. The dredging of fish hooks and a large quantity of barbed points in land reclamation projects at Europoort and Monster, Netherlands, suggests that fishing was significant to subsistence. However, given the limited faunal recovery, it is difficult to accurately reconstruct fishing activities in this region. The artefactual record of unequivocal fishing gear from this region consists of two fish hooks and four traps. In this context, remains of watercraft and paddles are relatively numerous. Given the similarity of the range of fish species recovered to those from the Baltic region, similar fisheries may have existed in these regions.

7.3.3: West Baltic

The West Baltic provides the largest body of evidence, in terms of fishing artefacts, faunal remains and published literature, for Mesolithic fishing practice. On this basis, it could be argued that the unique conditions of the Baltic permitted dependence on fish on a scale not seen elsewhere in Mesolithic Europe. However, this is not supported by stable isotope data — see Chapter 2. The abundance of fish fauna and fishing technology is in part due to the preservation conditions on sites and, in part, to the detailed archaeoichthyology studies conducted in the region (L Jonsson 1988; Enghoff 1995).

The faunal and artefactual remains recovered at sites across the region suggest a more varied fishery than in other coastal and inland regions (Table 6.2 and Figures 7.7 and 7.8). The large number of known sites and the proximity of the interior to the coast in all areas allow a comparison of inland and coastal fisheries. Such intra-regional comparison is not possible for other areas of Europe. Fisheries varied depending on local hydrographic conditions. There is evidence for specialised line fisheries of Gadidae around the exposed coasts of Denmark. In other more sheltered coastal regions there is a wider scope of fishing practices with emphasis on the capture of Gadidae, flatfish (Pleuronectidae)
and eel (Anguilla anguilla). Many of the other species recovered at sites would have been by-products of these main fisheries. The Gadidae would have been taken using lines, flatfish (Pleuronectidae) with traps or hooks and eel (Anguilla anguilla) with traps and fish spears/leisters. Shoaling species such as herring (Clupea harengus) and mackerel (Scomber scombrus), which occur at a small number of sites, were most probably taken with nets. Although the small number of sites with preserved nets or net-related artefacts and fish remains restricts any numerical analysis of co-occurrence, a relationship between the occurrence of net and shoaling species is suggested. The overall role of net fishing in the region appears less significant than in the fisheries of other regions of Europe.

On a regional scale, pike (Esox lucius) and cyprinids (Cyprinidae) dominate inland (lacustrine and riverine) fish assemblages with local specialisation in freshwater eel (Anguilla anguilla) fishing evident. On the basis of the species recovered, lacustrine and riverine fisheries would have been most efficiently conducted with leisters and traps. This is only partially supported by the artefactual record. In addition to the ubiquitous barbed point and the relatively common finds of traps at inland locations in the West Baltic, there is clear evidence for a significant line fishery.

Size reconstruction from fish remains have been conducted for relatively few Mesolithic assemblages, despite the wealth of information they can provide for fishing practice. The behaviour of fish varies according to developmental stages and fish size may therefore be used to refine reconstruction of fishing practice. One area for which there is a considerable body of information is Denmark; again, largely the result of the detailed studies conducted by Enghoff. Most of the fish identified at sites located near sheltered bodies of water with soft substrates are small species or small individuals of species that grow to a large size (Table 7.1) (Trolle-Lassen 1984; Larsson 1984, 1988b; L Jonsson 1988; Enghoff 1995). The small size of most of the fish, the presence of species available inshore on a seasonal basis and growth ring analyses, argue for a summer inshore fishery in the West Baltic region (L Jonsson 1988; Enghoff 1995). Growth ring studies conducted on fish bone or otoliths to determine season of death indicate that the garfish at Skateholm and the cod (Gadus morhua), saithe (Pollachius virens), flounder (Platichthys flesus) and plaice (Pleuronectes platessa) recovered from the sites included in Enghoff’s study were caught in the warmer months. (This does not imply that activity at these sites was confined to the warmer months).

Larger fish are found at sites on more exposed shores with rocky substrates such as Lystrup Enge, Grisby and Nivagaard (Table 7.1). Though cod (Gadus morhua) are quantified as the predominant species at Norsminde, flatfish (Pleuronectidae) dominate certain layers of midden deposits where preservation conditions are exceptional and it is probable that flatfish (Pleuronectidae) were the focus of fishing activities at the site (Enghoff 1989).

Suggestive of freshwater fishing by coastal groups is the wide size range (17-118cm) of eel (Anguilla anguilla) from the sites of Ertebolle, Nederst and Bjørnsholm. This implies the capture of yellow and
silver eel (*Anguilla anguilla*), both of which could have been taken with large-scale gear, such as nets, weirs or traps, during migration. The dominance of larger individuals of eel (*Anguilla anguilla*), i.e. predominantly females, confirms capture in freshwater (Enghoff 1991). From the scale of the fishery, Enghoff (1991) infers the use of traps set at night. Though Enghoff discusses the dominance of large eel (*Anguilla anguilla*), this is not the case at Ertebolle: there are a few larger specimens but the majority range 33–62 cm (Table 7.1). This implies the capture of brown eel (*Anguilla anguilla*) in freshwater or estuarine fishing, which will capture a range of sizes/ages of eel (*Anguilla anguilla*). Roach (*Rutilus rutilus*) from these sites form two peaks in size range suggesting fishing over a short period at the same time each year. This is thought to coincide with the eel (*Anguilla anguilla*) migrations and Enghoff suggests that the roach (*Rutilus rutilus*) at these sites may have been a by-product of freshwater eel (*Anguilla anguilla*) fishing. However, the size range of the eel (*Anguilla anguilla*) at Ertebolle is not consistent with maturity (and therefore migration fisheries) in inland locations. The size of the eel (*Anguilla anguilla*) recovered suggests that roach (*Rutilus rutilus*) may have been a by-product of an eel (*Anguilla anguilla*) trap fishery exploiting migration runs but only if conducted in brackish waters. Freshwater eel (*Anguilla anguilla*) fishing is evident at the Ageröd sites. Both traps and barbed points have been identified at these sites. This may be the exploitation of brown and/or silver eel (*Anguilla anguilla*), which would determine method of capture, but with no estimation of size range to assess this aspect of the fishery.

The occurrence of perch (*Perca fluviatilis*), pike (*Esox lucius*) and a single catfish (*Silurus glanis*) vertebra at Skateholm also suggests freshwater fishing but again these are secondary freshwater species. Specimens of catfish (*Silurus glanis*) have been taken recently in the coastal waters of Öland and Gotland (L Jonsson 1988).

Though trap fishing is the favoured means by which Enghoff explains the presence of all species at Danish Mesolithic sites, L Jonsson (1988) argues against the use of traps at Skateholm due to the absence of benthic species such as viviparous blenny (*Zoarces viviparous*) and bullrout (*Myoxocephalus scorpius*). Many benthic and sedentary species including flatfish (Pleuronectidae) are not readily taken in traps, particularly if the trap is unbaited. These species are most easily captured with spears or leisters at low tide.

If, as Enghoff suggests, a riverine trap fishery for migrating eel (*Anguilla anguilla*) was conducted, the presence of marine species at Norsminde, Bjørnsholm and Skateholm implies a second distinct fishery of inshore marine and/or estuarine regions. The fishermen would be expected, on the basis of ethnographic analogy and common sense, to have used the different types of gear available in the most effective manner, i.e. using a number of different gears for specific fisheries rather than relying exclusively or predominantly on trap/weir fishing. Traps and weirs have only been observed in use for Gadidae where these species are known to pass inshore in large numbers in migration on the east coast.
of North America in modern commercial fisheries (Yentsch 1993) — trap fishing for Gadidae is very unusual in ethnographically observed fisheries.

Many of the inland sites, at which fishing is attested, appear to have been inhabited on a shorter-term basis than coastal settlements, e.g. Praestelyngen, Åkonge, Ringkloster (Noe-Nygård 1983; Enghoff 1994a). Noe-Nygård (1983) argues for two distinct groups inhabiting the coast and inland zones of Zealand on the basis of stable isotope evidence but more recent studies suggest a more complex interaction — see Chapter 2. Growth ring analysis and other seasonal indicators suggest fishing was primarily conducted in the summer months at inland sites, e.g. Ringkloster and Praestelyngen (Enghoff 1994). This coincides with the season of fishing at coastal sites. This has implications for the determination of the participants of inland and coastal fisheries and for the dispersal of groups and scheduling of activities.

7.3.4: East Baltic

Finds of fishing gear at the majority of Estonian Mesolithic sites attests to the importance of fishing in this region (Jaanits 1995). The fish species recovered at early Kunda sites are predominantly secondary freshwater species and in the opinions of Jaanits (1995) and Lõugas (1996) were probably taken in the Yoldia Sea.

Preservation conditions at sites of Mesolithic date in Finland are not conducive to the recovery of faunal assemblages (Forsten 1972). At only two sites (Säärijarvi and Honkajoki) are fish remains numerous. The species identified, as in the case of the early Mesolithic sites in Estonia and Latvia, are secondary freshwater species. Taking into account the different preservation conditions between the two regions, Forsten suggests that the faunal assemblages are similar to those found on contemporaneous sites of South Scandinavia.

As in the west Baltic region there is evidence for a cod (Gadus morhua) fishery in regions with deep water near sites but none of the species identified are exclusively deep water inhabitants. The presence of small numbers of sculpin (Triglopsis quadricornis) and flounder (Platichthys flesus), both species common in shallower waters, known to be susceptible to hook and line, may have been a by-product of an inshore line fishery for cod (Gadus morhua). The limited number of marine species identified at coastal sites on the East Baltic reflects the small number of species available in this region of the Baltic; 39 species compared to 126 in the West Baltic (cf. Whitehead et al. 1986). Secondary freshwater and anadromous species have been identified at a number of coastal sites. However, all of the secondary freshwater species identified are common in the brackish waters of the Baltic Sea and in the absence of primary freshwater species, there is no evidence for freshwater fisheries from these sites.
As in the West Baltic, freshwater fisheries focus on the exploitation of pike (Esox lucius), with catfish (Silurus glanis), pike-perch (Stizostedion lucioperca), perch (Perca fluviatilis) and cyprinids (Cyprinidae) also common. The frequent recovery of barbed points at inland sites has been linked to this fishery and is supported by the correlation analyses conducted in this study (see Section 7.3 below). In contrast to the West Baltic, where growth ring analysis indicates summer fishing, a number of possible ice picks at Kunda may indicate winter fisheries of these species (J G D Clark 1948a).

Nets and net-related artefacts are particularly common finds in this region. Net frames have only been identified at interior sites in this region. From finds of both net floats and sinkers, the use of set nets can be inferred. The relatively frequent recovery of net fragments and floats is probably due to preservation rather than geographic exclusivity. Finds of net weights are no more common in this region than artefacts attributed the same function in the Iron Gates and the sites of the north North Sea coast. Unfortunately, in the East Baltic region, net fragments and net-related artefacts are often found at sites with no fish remains or where assemblages have been recovered but are not reported in detail. Fish assemblages found in association with nets, at Kunda and Narva, are dominated by pike (Esox lucius), catfish (Silurus glanis) and pike-perch (Stizostedion lucioperca). All three species could have been taken with nets but are commonly taken by other methods in traditional fisheries.

The size range of catfish (Silurus glanis) (1.05-2.25m) in Mesolithic layers at Zvidze, Latvia, indicates technological sophistication, if not a specialised fishery due to the limited number of finds (Loze 1988a). Beluga (Huso huso) is represented only by dentales at Zvidze. The dentales were use to reconstruct the size of the fish, and although this is not a particularly precise technique, it indicates the presence of large individuals at the site (ca.1.75-5.00m).

There appear to be a number of sites of Mesolithic date in European Russia that have exceptional preservation and contain a significant number of fishing related implements and artefacts. Amongst these is the site of Zamostje II, which is still being excavated. Preliminary reports indicate that this site, located in a peat bog on the Dubna River, has two Mesolithic and two Neolithic occupation layers (Lozovski 2000). Potential fishing artefacts recovered from Mesolithic deposits include a wide range of spears, arrowheads, uniserial barbed points, simple points, bi-points, fish hooks, a fish fence and two conic fish traps set in the fence. This site has not yet been fully excavated or published.

7.3.5: European Atlantic Coast — South

There are no unequivocal finds of fishing gear in this region. The archaeological record of this region is heavily biased to faunal remains which, in general, are not published in detail. This limits comparative studies both intra- and inter-regionally.
The groups associated with the inland mortuary midden sites of Téviec and Hœdic, France, were exploiting marine resources on a significant scale, evident from faunal remains and stable isotope analyses of inhumations (see Table 2.8 and Figures 2.12 and 2.13). It is likely that these populations had a maritime adaptation with base camps located closer to the coast (Schulting 1996). Abundant fish remains were recovered at the sites of Hœdic and Téviec but poor preservation resulted in few bones being identified (Schulting 1996). The pharyngeal teeth of wrasse (Labridae) were common, from which an inshore line fishery can be inferred. Péquart & Péquart (1954) state that bi-points, recovered at both Téviec and Hœdic, may have been used in this fishery. The other species identified at the sites, meagre (Argyrosomus regius) and ray (Rajidae), can also be taken with lines but are commonly taken with spears in traditional fisheries.

Research in the Iberian Peninsula has focused on specific areas within this region, largely determined by shell midden distribution (González-Morales & Arnaud 1990; Larsson 1996). Problems in interpretation are similar to those encountered for the north European Atlantic coast, namely limited publication of fish assemblages and a scarcity of fishing related artefacts. The majority of the species identified inhabit the brackish water of estuaries or marine inshore waters. This is interpreted as evidence for two separate fisheries, of estuarine and inshore marine waters (e.g. Menédez de la Hoz et al. 1986; Le Gall et al. 1992; Lentacker 1994; Straus 1991b). Lentacker (1994) attributes the narrow size distribution of the mullet (Mugilidae) at Cabeço da Armoreira and Cabeço da Arruda to the use of nets. This interpretation is consistent with observed traditional estuarine fisheries and with the behaviour of the dominant species at all the Iberian sites (Table 5.2). For example, the fishery at Vidigal, which demonstrates a specialisation in smoothhound (Mustelus mustelus), would have been operated in inshore marine waters rather than estuarine conditions but, as with the estuarine species identified at sites across this region, this demersal shoaling species would be most efficiently taken with nets.

The significant fishery of eagle ray (Myliobatis aquila) at Cabeço da Armoreira is suggestive of the use of lines or fish spears but could have resulted from net fishing — this species feeds pelagically. Predatory species most susceptible to line fishing such as porbeagle (Lamna nasus) are also present but in small numbers and may have been a by-product of the net fishery for mackerel (Scomber scombrus) and seabreams (Sparidae). Small numbers of deeper water predatory species frequently follow prey shoaling species into inshore waters.

7.3.6: European Atlantic Coast — North

Again, discussions of fishing practice are limited in this region by the relative scarcity of artefactual remains and by the lack of detailed publications. There are still no detailed reports on the fish fauna.
from the Oronsay sites, only cursory species lists are available. This is compounded by the visibility of shell midden sites that led to early excavation using late 19th and early 20th century techniques and the historic reuse of middens as fertilisers. Large amounts of data must have been lost. The only artefacts that can be related to fishing at Mesolithic sites from the Atlantic coast of Britain are barbed points. This does not correlate to the species recovered. Despite the small number of sites published in detail there is increasing evidence for varied fishing practices across Britain and Ireland.

Large Gadidae were the focus of fisheries at the site of Morton on the east coast of Scotland. This parallels the fisheries of the exposed rocky coasts of Norway and south-west Sweden. Fish remains from the coastal Irish midden sites of the Late Mesolithic are similar to those identified at the Obanian sites of Scotland (Woodman 1978b; Bonsall et al., unpublished data). Relatively small numbers of fish remains are recovered in comparison to the midden sites of the Baltic region. All identified species are inhabitants of rocky shores. Although the majority of the organic artefacts recovered from these sites are barbed bone points, the fish remains are predominantly small individuals of inshore species that could be captured from the shore with lines or taken in rock pools at low tide by hand or with collecting baskets. The presence of mullet (Mugilidae) excludes the use of line fishing for all species. As a filter feeder mullet (Mugilidae) does not respond to bait or hooks and as a shoaling species that commonly enters estuaries it is most suited to net fishing though the use of traps cannot be excluded. The co-occurrence of mullet (Mugilidae), which is unlikely to be taken on lines, and tope (Galeorhinus galeus), which is most vulnerable to baited line fishing at both Dalkey Island II and Rockmarshall may indicate two distinct fisheries. This co-occurrence is also seen at the midden sites of Portugal. It is possible that fishing activities were conducted with artefacts made from plant materials that have not been preserved. With the exception of the barbed points, only one fishing implement has been tentatively identified in this region (a possible bone fish hook from Risga which is of uncertain association [Morrison 1980]). The simple points recovered from midden sites may have been hafted as gaffs or rakes but the use of rakes is unlikely over rocky substrates.

Stable isotope analyses indicate that dietary protein was in large part derived from aquatic resources. However, it is possible that fishing played a secondary role to other subsistence activities at some sites. Seasonality studies of Gadidae otoliths from the Oronsay middens indicates short-term exploitation (a maximum of three months at any one site) of fish at each of the sites. Size comparisons with modern saithe (Pollachius virens) suggests that fishing was conducted at Cnoc Sligeach from the end of June to mid August, at Cnoc Coig in September and November, at Priory Midden in autumn and winter, and at Casteal nan Gillean II, throughout the year, with increased exploitation in June and July. This is interpreted by Mellars & Wilkinson (1980) as evidence for the exploitation of fishing grounds on a seasonal cycle by permanent inhabitants of the island. The seasonality data is equally consistent with alternative explanations such as the scheduling of fishing activities to coincide with sea mammal hunting, which was clearly conducted from the Oronsay sites (Table 2.12). Fishing activities may have been conducted by members of hunting parties from adjacent islands (cf. Mithen
Woodman (1985b) argues for the existence of two separate fisheries (riverine and outer estuarine) at Mount Sandel, based on the recovery of flatfish (Pleuronectidae) and bass (*Dicentrarchus labrax*) alongside salmonids (*Salmo* spp.), at the site. However, both flatfish (Pleuronectidae) and bass (*Dicentrarchus labrax*) will enter freshwater in the lower reaches of rivers. All the species identified could have been taken in the lower river or estuary. Several different gear types may have been used for this fishery but the co-occurrence of flatfish (Pleuronectidae), bass (*Dicentrarchus labrax*) and salmonids (*Salmo* spp.) is consistent with trap fishing. The documented use of nets for bass (*Dicentrarchus labrax*) fishing is a modern development.

Faunal assemblages and artefactual remains from England and Wales show a significant departure from those of Scotland and Ireland. There are suggestions of a large-scale inland fishery with a fish hook, a fish channel, net sinkers and fish remains identified at Thatcham (Wymer 1962; D M Churchill 1962). However, the fishing implements from Thatcham have alternative interpretations. The 'sinkers' may be weights for hide working; the fish 'channel' has been suggested to be a beaver set (which corresponds to the identification of beaver [*Castor fiber*] in the site fauna). Channels of the type uncovered at Thatcham are used by the Shasta to facilitate the capture of migratory species. The channels are used, often with the use of torches at night, to guide fish to collecting baskets, traps or dip-nets. Stones may be placed in the bottom of the channel to provide contrast if the fish are taken with leisters (Kroeber & Barrett 1960–62).

The finds at the Late Mesolithic site of Goldcliff, Wales, indicate a similar fishery to those of estuarine regions of the West Baltic (Lynch *et al* 2000). The predominant species are eel (*Anguilla* 1989) or the Scottish mainland, to provide for immediate subsistence needs. The pursuit of sea mammals may explain the preponderance of barbed points in the artefactual record; an implement not consistent with the species or size range of the fish recovered from most of the Scottish sites.

The Mesolithic economy of Ireland is little understood owing to the prevalence of acidic soils and a resulting lack of organic preservation at the majority of known sites, which is compounded by the interpretational problems of mixed deposits prevalent at midden sites (Woodman 1978b). The limited range of post-glacial fauna in Ireland compared to Britain and continental Europe would have restricted subsistence options (Woodman 1978a, b; MacLean 1993; O’Sullivan 1998). It is therefore likely that aquatic resources were exploited as dietary staples. The significant concentration of sites at the outlets of lakes and at the mouths of estuaries (Woodman 1978b, 1985b; O’Sullivan 1998) and the fauna recovered at Mount Sandel, Newferry and Lough Boora are suggestive of the importance of trap/weir fisheries of anadromous and catadromous species to the Mesolithic economy. The lack of suitable terrestrial and freshwater resources (similar to the conditions of the Northwest Coast of North America) may have led to a focus on anadromous/catadromous species not evident elsewhere in Mesolithic Europe (see Section 8.2 and 8.3).
anguilla), goby (Gobiidae), smelt (Osmerus eperlanus), 3-spined stickleback (Gasterosteus aculeatus) and flatfish (Pleuronectidae). The species and their size ranges are consistent with trap or net fishing (Ingrem 2000, Bell et al. 2000). Ingrem states that the fish would have been taken in traps similar to those from Vedbæk. However, the very small size of the fish recovered would suggest more closely woven traps than those from Scandinavia. The close woven putt used on the tidal stretches of the Severn in traditional fisheries would have been suitable for this purpose (Figure 4.15). The absence of larger fish is puzzling. It is possible as Ingrem suggests that larger fish were processed elsewhere. Another explanation of the small size range of the recovered fish is the discard at landing sites of fish too small to be of economic importance.

7.3.7: Central Europe

Fish remains and fishing artefacts are commonplace at the waterlogged Neolithic Lake dwelling sites. However, the record for Mesolithic fishing activity in the region is scarce. This is in part due to the limited number of waterlogged deposits but also to the limited and biased faunal recovery of early 20th century excavations. Significant investment in fishing, not reflected in faunal remains, is apparent from finds of net floats and sinkers at Hitzkirch-Seematt, Switzerland (Sakellaridis 1979). Although fisheries are evident in this region, there is no indication of any significant dietary dependence. Stable isotope analyses on human bone and the composition of faunal assemblages across the region are, on the whole, consistent with the dominance of terrestrial protein in diet (Hedges et al. 1990a, b, 1992, 1998; Jochim 1998), although, a secondary input from freshwater resources cannot be excluded. In the east Schwabian Alb, south-west Germany, there is a greater emphasis on the exploitation of fish and land birds but there is only clear evidence for large-scale fishing in the Early Mesolithic deposits at Henauhof Nordwest (Jochim 1998). As with inland fisheries of other regions of Europe, cyprinids (Cyprinidae) and pike (Esox lucius) dominate assemblages. All are species that can be taken from the shore and are most vulnerable to capture in shallow waters during spawning. The species identified spawn in two distinct, habitats suggestive of two fishing grounds, (i) heavily vegetated waters, or (ii) clear waters over gravel substrates. Set nets are most suitable for the capture of these species in vegetated waters (see Section 7.3.8 below). Larger species (e.g. pike (Esox lucius), huchen (Huchen huchen) and catfish [Silurus glanis]) may have been taken with barbed points or lines. At no site with a significant fish assemblage has definite fishing gear been recovered but nets, barbed points and a number of hooks have been recovered from riverine contexts. Traps have been found at sites located on ancient lakeshores but these are not associated with fish assemblages.
7.3.8: Iron Gates

The concentration and location of sites in the Iron Gates region reflects the importance of fishing to economy. Upwelling from the whirlpool at Lepenski Vir would have concentrated fish. Lepenski Vir and Vlasac are situated at the base of valley side-slope. Boroneanţ (1999) states that both sites would be most easily accessed by boat. The use of boats, despite the absence of archaeological evidence, is supported by the species recovered. Though the navigation of offshore waters is often discussed, the navigation of inland waters is little mentioned. Watercraft required on small, slow inland waters are assumed to be dugouts, based on the Scandinavian finds. However, navigation of the fast stretches of the Iron Gates gorge may have required more sturdy craft than dugouts as suggested by de Rohan Csermak,

"occasional passage of a wooden vessel through the cataracts of the Iron Gate was a sensational event, but after 1837 undisturbed shipping became a matter of course" (1963:15).

It should be noted that dietary dependence on fish and technological sophistication of fishing gear does not imply the use of boats in fishing activities. Despite possessing some of the most sophisticated watercraft, the native Great Lake groups prefer to conduct their large-scale gillnet fishery for species available inshore on a seasonal basis owing to the inherent dangers of boat-fishing in large bodies of water (Townsend 1924; Cleland 1982).

The trend toward the capture of larger fish species, apparent at the Iron Gates sites, may reflect the hand-collection of assemblages at most sites. At Schela Cladovei, the only site at which sediments were wet sieved, medium sized fish dominate the assemblage (Bartosiewicz et al. 1995). Two main groupings of fish are evident, those that permanently inhabit or seasonally enter inshore waters and those that are found only in the main flow. The first group can be fished from the shore along all stretches of the Danube. The second group (sturgeon [Acipenser sturio] and beluga [Huso huso]) can be fished from the shore only in the steeper regions of the gorge. The occurrence of these species along the lower reaches of the river suggests the use of boats in fisheries (Table 5.2). Dense vegetation, today present in the slower regions of the river, would preclude the use of long-lines from the shore. However, the recent hydrological changes to the lower reaches of the Danube along the Iron Gates with the construction of a hydroelectric dam in the 1960s/1970s would have altered water velocity and therefore plant growth. Vegetation would not have been as dense prior to this development. It is possible that water conditions would have permitted the use of long-lines set from the shore at sites such as Schela Cladovei, in the Mesolithic period.

The species found permanently or seasonally in inshore waters would be most concentrated and therefore most vulnerable to capture during spawning. These species can be sub-divided according to preferred spawning habitat: the first spawn in the clear waters of tributaries over gravel substrates, the
second in dense shoreline vegetation. Traditional fisheries in the region capture fish spawning in tributaries using spears and traps. Those species spawning in vegetated waters are most suited to capture by trap or set net. Few recovered artefacts can be associated with fishing. However, finds of sinkers are consistent with inshore fishing using set nets. Tangle-nets were the most common method of sterlet (Acipenser ruthenus) fishing on the Danube prior to the 20th century (Baculbaşa & Petcu 1969). Dermal scutes make sturgeon (Acipenser spp.) particularly susceptible to tangle nets. Ethnographically, sturgeon (Acipenseridae) are taken in nets only in lakes, with harpoons or hooks being used in rivers and dip-nets used to fish the surface waters of whirlpools (Kroeber & Barrett 1960–62; Needs-Howarth 1996).

No other definite fishing gear has been recovered from Mesolithic contexts in the Iron Gate region. Hooks and traps are known from Neolithic contexts elsewhere along the Danube (Srejović 1972). Large basket traps are used in commercial fisheries in the region, but this method of fishing is not favoured for faster stretches of rivers by ethnographically observed groups (Spier 1930). Long-lines, set from boats or the shore, are the main method of capture of sturgeon (Acipenser spp.) and catfish (Silurus glanis) in Eastern Europe. Lines are not generally used for the capture of anadromous species. However, the long-line fisheries of the Danube and the Volga capture fish by tangling the trunk of the fish on many closely set hooks rather than impaling through the mouth (de Rohan-Csermak 1963). Catfish (Silurus glanis) are often a by-product of line fishing for sterlet (Acipenser ruthenus). Although no definite examples of hooks have been recovered in Mesolithic contexts, the recovery of shellfish remains at Schela Cladovei, the morphology of the sinkers and two fragments of curved bone tentatively identified as circular hooks may correspond to a line fishery at the site (Bonsall et al., unpublished data). Fishery specialisation is evident at some sites. Catfish (Silurus glanis), which were the focus of fishing at Padina range from 89.1cm to 204.0cm in length and those at Vlasac are reported to exceed 100kg in weight — Table 7.1 (Bökönyi 1969, 1972; Clason 1980). Outside the breeding season, sturgeon (Acipenseridae) become docile once captured so may have been ‘ridden’ to shore or snared. Sturgeon (Acipenseridae) and catfish (Siluriformes/Clarias spp./Synodontis spp.) weighing up to 400lbs were taken by these techniques by Native American groups (Kroeber & Barrett 1960–62). In addition to use in inshore fishing, barbed points may have been used for the capture of larger fish in the main flow of the river. However, large catfish (Silurus glanis) were most probably taken with gorges.

Fishing inland waters may be safer than marine fishing in small inland water bodies but the pursuit of very large and voracious species such as catfish (Silurus glanis), beluga (Huso huso) and sturgeon (Acipenseridae) can be very dangerous, and lives are frequently lost in modern fisheries. Fishing at Lepenski Vir would also have had the inherent danger of fishing the whirlpool (cf. von Brandt [1984a]). It is possible that the dangers of whirlpool fishing have been over-exaggerated. For example, it is common practice to fish the whirlpools of the Klamath River with dip-nets (Speir 1930). The upwelling of nutrients, which concentrates fish, makes whirlpools profitable fishing grounds.
7.4: Correlation of Fishing Gear and Fish Remains

Co-occurrence of fishing gear and fish species was analysed to assess probable fishing practice. The hypothesis was that by assessing the co-occurrence of fish species with artefact type, it would be possible to correlate fishing gear with species and indicate most likely methods of capture.

7.4.1: Method

Several problems are associated with this analysis. Firstly, only a small proportion of sites has both fish remains and artefacts (75 sites out of over 600). Publications seldom address both fish remains and fishing gear in detail. Frequently, fish remains and possible fishing implements are recovered at a single site but one or other category is recorded or discussed in little detail. Secondly, there are large numerical differences in the fish remains (fish species totals over all sites range between 1 and 17488 NISP) and recovered artefacts (1 to 644). This reduces the resolution of results in cases where there are very small numbers of fish or artefact remains and also in instances where the number of any category of implement is very large.

Two approaches to correlation analysis have been taken: an overview of all sites and geographical groupings of sites. In the overview, to avoid some of the problems detailed above, the numbers of individual fish for a given species have been replaced with a percentage contribution to the overall fish assemblage at each site. This allowed fish species to be ranked according to their overall importance at all sites; only the most important species were included in correlation study. All sites where a particular species was found were assessed for the presence of relevant artefact types and their abundance, i.e. assessing the artefact type most commonly found in association with any given species. This process was repeated for all species studied. Replication of findings can be used to confirm results. For example, biologically similar species are often associated with the same artefact type and similar correlations emerge from different geographical groups.

The results were then compared to ethnographic and biological data to reinforce the matching of fish species to probable method of capture. Some of the sites that contain no definite fishing artefacts have provided the largest fish assemblages, e.g. Norsminde (Denmark), Vlasac (Iron Gates) and Pont d’Ambon (Dordogne, France). A prime example for artefact recovery in the absence of fish remains is the site of Star Carr. The numerous finds of barbed points, the site location on the edge of a prehistoric lake and the find of a paddle would suggest that aquatic resources were important to the site’s inhabitants. However, no fish remains were recovered from the site (J G D Clark 1954). Many explanations of this anomaly have been proposed, including (i) the recovery methods employed (viz.
the lack of sieving) (ii) the lack of fish in the lake (Wheeler 1978b) — contradicted by the presence of piscivorous birds among the faunal remains, (iii) the possible exploitation of cartilaginous species which are more susceptible to decay, (iv) processing methods (Price 1987; Brinkhuizen 1983), (v) site function — the focus on red deer hunting and skin working at the site (Pitts 1979). The lack of fish remains at the site is only problematic if the site is interpreted as a settlement with remains that are representative of all subsistence activities conducted by the group. If, as suggested by Andresen et al. (1981), the site was a hunting stand/butchering station, essentially a lookout post situated at an intercept point, then there is no reason for fish remains to be found at the site. Stable isotope results obtained from dog remains at Seamer Carr, England, suggest that marine resources were significant to the subsistence of Early Mesolithic populations in this area. The absence of fish bone at Agerod I is attributed to preservation conditions rather than the lack of a fishing industry (Larsson 1978a). The absence or limited quantities of fish bones recovered at Swiss Mesolithic sites is interpreted by Sakellaridis (1979) as evidence for the limited role of fish in Mesolithic subsistence. However, finds of large-scale gear requiring significant investment in terms of manufacture and maintenance, as at Hitzkirch-Seeamatt, Switzerland, contradicts this interpretation. It is possible on the basis of the observed correlation between fish species and gear and other lines of enquiry (fish biology, gear technology and ethnographic analogy) to suggest fishing practices at sites with only one type of data (i.e. fauna or artefacts).

7.4.2: Correlation between Gear and Fish Remains

From the analysis of all Mesolithic sites, seven correlations between artefact type and fish species were determined (Table 7.2 and Figure 7.9):

1. By far the most common artefact associated with pike (Esox lucius) at a site is the barbed point. The presence of large pike (Esox lucius) at West Baltic sites suggested to J G D Clark (1975) that this fishery was conducted with spears, which he links to the large number of finds of barbed points. Wundsch (1961) draws similar links between pike (Esox lucius) and the dominance of barbed points in the artefact inventory of Hohen Viechlen. Both authors suggest that pike (Esox lucius) would have been speared during the spawning season when they enter very shallow water. This is one of the commonest methods documented ethnographically for the capture of large specimens (Table 3.2). Large specimens of pike (Esox lucius) have been identified at Ringkloster and Åkonge (Enghoff 1995). The dominance of large pike (Esox lucius) at Ringkloster may be a result of lack of on-site sieving. However, the presence of large individuals suggested that the fishery was conducted with spears. The results of the database analysis conducted for this study demonstrate that barbed points are more common at inland sites than at coastal locations. However, this is in part due to the large number of finds from inland cave deposits in southern Europe. Perch (Perca fluviatilis) and common bream (Abramis brama) are also found to correlate
significantly with barbed points. Perch (*Perca fluviatilis*) and common bream (*Abramis brama*) also spawn in shore-side shallows in summer and it is possible that both species were taken as a by-product of pike (*Esox lucius*) fishing (but given the high selectivity of spearing/leistering this is unlikely). Although it is possible that barbed points were used for perch (*Perca fluviatilis*) and bream (*Abramis brama*) caught either as a specialised fishery or as a by-product of pike (*Esox lucius*) fishing, the average size of both species is considerably smaller than pike (*Esox lucius*), therefore, they are unlikely to have been taken by this method. As bream (*Abramis brama*) and perch (*Perca fluviatilis*) form shoals, they are more suited to capture with large-scale gear such as nets and traps. The correlation may be a consequence of the co-occurrence of perch (*Perca fluviatilis*) with pike (*Esox lucius*) in assemblages. Interestingly, there is a secondary correlation of perch (*Perca fluviatilis*) and bream (*Abramis brama*) with net décor, which may reflect the use of nets in the capture of these species. Perch (*Perca fluviatilis*) inhabits the same waters as pike (*Esox lucius*) and as a natural food of pike is often taken for bait for pike fishing. Though their exploitation is generally associated with the use of spears/leisters and the correlation analysis of this study confirms this association, pike (*Esox lucius*) would have been taken by other methods. For example, in Early Neolithic deposits at Zvidze the bones of 16 pike (*Esox lucius*), up to 135cm in length, were found in association with trap remains (Loze 1988b)

2. There is a positive correlation between finds of eel (*Anguilla anguilla*) and barbed points. As with pike (*Esox lucius*) this association corresponds to ethnographic methods of capture and was noted in J D Clark's *Inceptive Study* (1948a). In traditional fisheries, barbed points are hafted in pairs or large groups to form leisters. Immature eel (*Anguilla spp.*) are often taken when buried in substrate with multi-barbed or piercing leisters. Migrating, mature eel (*Anguilla spp.*) may be caught for their skin in addition to flesh. Eel-skin can be tanned to make very tough leather (see Section 3.5). In these fisheries, the leister comprises two barbs, which retain the eel (*Anguilla spp.*) without causing damage to the skin.

3. There is a very strong correlation between hooks and cod (*Gadus morhua*), saithe (*Pollachius virens*), ling (*Molva molva*) and other members of the Gadidae family. There is a significant correlation between the presence of cod (*Gadus morhua*) and ling (*Molva molva*) and bone hooks and also between cod (*Gadus morhua*) and boats/paddles at Mesolithic sites, supporting the case for a deeper water fishery using troll or long-lines as observed in traditional offshore fisheries for cod (*Gadus spp.*) and halibut (*Hippoglossus spp.*) (Table 7.2 and Figure 7.9). This correlation argues for the use of hooks not only in deeper water fishing (see Section 7.1.2) but also inshore fishing for Gadidae. This is evident from the strong correlation between the finds of saithe (*Pollachius virens*) and hooks within the West Baltic region where the size of fish recovered indicates an inshore fishery. There is a weaker correlation between cod (*Gadus morhua*) and hooks in the West Baltic region. The use of hooks for the capture of Gadidae corresponds to both biological adaptations of these fish and ethnographic data (Table 5.4). Though these species were undoubtedly taken in traps/weirs in addition to hook fishing, the positive correlation between Gadidae and hooks argues against the primacy of traps as a fishing method at certain sites over
the West Baltic region as a whole and within Denmark (i.e. contrary to Enghoff [1995]). At only two sites where there is evidence for significant cod (Gadus morhua) or Gadidae fisheries are traps/weirs found, Maglesegnærd and Vænet Nord, Denmark. At both sites, flatfish (Pleuronectidae) are dominant in faunal remains and the traps were presumably set for the capture of these species. The use of trumpet traps for the capture of flatfish (Pleuronectidae) is known from sources on traditional fishing practices although it is more common to take flatfish (Pleuronectidae) with fish spears or leisters — Table 3.2 and 5.4 (Watanabe 1972, 1977a; Brinkhuizen 1983). At Maglesegnærd, the recovery of small barbed bone points thought to be the barbs of composite hooks may have been used in preference to traps for fishing of Gadidae and related species. Composite hooks of the type shown in Figure 6.18 were used in traditional fisheries across the Pacific Coast of North America for specialised fisheries of cod (Gadus macrocephalus) and halibut (Hippoglossus stenolepis). Gadidae are the most frequently intended target of traditional long-line fisheries, however, halibut (Hippoglossus hippoglossus), porbeagle (Lamna nasus), ray (Rajidae) and skate (Raja spp.) and in freshwaters, sturgeon (Acipenser spp.) and beluga (Huso huso) are commonly the focus of long-line fishing (Table 3.2 and 5.4).

4. The correlation of bi-points and pike (Esox lucius) is interesting. It is possible that pike (Esox lucius) were taken with hook and line immediately after spawning when they feed intensively and are less suspicious of baits and gear or under ice. Traditional fisheries take pike (Esox lucius) when it spawns in the shallows with leisters/spears. Lines and nets are generally not used due to the very sharp teeth of pike (Esox lucius) that can damage the gear. However, the groups inhabiting the Ob River in Siberia cover the lower part of the line in leather to prevent fish biting through the line (Zaliznyak 1997).

5. A correlation is also observed with simple points and Gadidae (grouping), pike (Esox lucius), cod (Gadus morhua), cyprinids (Cyprinidae), carp (Cyprinus carpio), Salmonidae and flatfish (Pleuronectidae) (grouping). The co-occurrence of short simple points at the Limfjord sites in Denmark was linked to eel (Anguilla anguilla) fisheries and the use of these forms as 'eel slitters' — see Section 6.3.4. It is possible that simple points were used for skinning a wide range of species but the correlation may be due to the multi-functional use of this implement, which would therefore be a category expected to occur on a large number of sites irrespective of economic emphasis.

6. Correlation studies of all European sites demonstrate a relationship between hooks/hook-related artefacts and Salmonidae. As there is a reduction in feeding in freshwaters of anadromous Salmonidae the correlation with hooks suggests trolling for these fish in marine waters, commonly practised in traditional fisheries or the line fishing of freshwater trout. Concentrations of anadromous species may be present in coastal waters throughout the year while waiting for opportune moments to ascend spawning rivers (determined by temperature, salinity gradients, water volume and weather conditions).

7. In the overall analysis of Mesolithic sites there is no correlation observed between any one category of artefact and cyprinids (Cyprinidae). This may be a consequence of the large number
of species that fall into this category and the relatively small representation of these species at most sites. There is a significant regional correlation between nets and cyprinids (Cyprinidae) reflecting the capture of large quantities of cyprinids (Cyprinidae) at the Iron Gates sites. This is consistent with the biology and behaviour of the identified species.

Co-occurrence of artefact type and fish species is also apparent in those instances where the type of fish or artefact was only present in small quantities. These relationships are discussed but cannot be taken as anything more than suggestive associations.

For example, there is a positive correlation between the occurrence of catfish (*Silurus glanis*) and bi-points in the Baltic region. However, the small number of sites on which this is based does not constitute conclusive evidence for the use of bi-points as gorges for the capture of catfish (*Silurus glanis*). The use of the gorge does correspond to the biology of the catfish (*Silurus glanis*). As a predatory fish it is susceptible to capture using hooks (although other methods can be used, it becomes increasingly difficult to take catfish [*Silurus glanis*] with nets or traps as size increases). However, the very tough skin around the mouth of the catfish (*Silurus glanis*) requires, in modern fisheries, the sharpest steel hooks and it is not certain that prehistoric hooks would have met this purpose. The manufacture of hooks with very sharp, narrow points from organic materials reduces resilience to mechanical stress. Traditional fisheries for catfish (Siluriformes) and other large predatory species (marine and freshwater) avoid the need for very sharp hooks by using circular hooks or gorges — Figure 7.10 (Worthington & Worthington 1933; Hickling 1961; Kroeber & Barrett 1960-1962; Timbrook 1991). The hook or gorge is entirely covered in bait and is inhaled by the fish, piercing the throat or upper digestive tract. The fish would then be hauled ashore or onto a boat and despatched using a club. Gorges operate in the same manner. The function of bi-points is controversial, as various functions have been ascribed to these artefacts. The evidence from the correlation analysis here and the biological make-up of catfish (*Silurus glanis*), together with ethnographic data, suggests that bi-points were used as gorges for the capture of these fish.

No credible explanation of the methods of capturing very large specimens of catfish (*Silurus glanis*), such as those recovered from Iron Gates sites, has been put forward to date. It is possible that wooden gorges were used for the capture of this species. The scarcity of fishing associated artefacts from the Iron Gates sites as a whole, owing, in part to preservation conditions and also to the lack of publication of site inventories (e.g. Padina), limits discussion on this matter. There is an additional weak correlation between catfish (*Silurus glanis*) and barbed points. Catfish (*Silurus glanis*) may have been taken with barbed points, which were recovered at Iron Gates sites in very small numbers (Table 6.3 and Figure 6.8b.1–3), but this method of capture is not observed ethnographically. The correlation may simply reflect the ubiquity of finds of barbed points at inland sites.
The number of finds of traps at sites with fish remains is too small to draw conclusions. It is interesting to note that eel (*Anguilla anguilla*) is found at all sites where traps (and fish remains) have been found. This is also the case for weirs and weir fences (again co-occurrence of fish fauna and weirs is limited). Use of traps in marine waters is also evident from the find of cod (*Gadus morhua*) in the Jonstorp example. Correlation analysis indicates a correspondence between finds of traps and flatfish (*Pleuronectidae*), reflecting the emphasis on flatfish (*Pleuronectidae*) at the two sites of Maglemosegård and Maglemosegårds Vænge. Baited traps may have been set to take flatfish (*Pleuronectidae*) at these sites. However, the majority of traps have been recovered from inland contexts. The co-occurrence of boats and paddles with the occurrence of eel (*Anguilla anguilla*) and flatfish (*Pleuronectidae*) corresponds to ethnographically known methods of capture — spearing with leisters from boats; in the case of eel (*Anguilla rostrata*) using torches as lures in night fishing.

The construction of the database detailed in the previous chapter has resulted in an easily accessible resource for the examination of sites of interest. However, the real strength of the database lies in the large number of sites included and the ability to group these sites according to shared properties. In this way, general trends in fishing practice have been inferred or examined in a more rigorous and objective fashion than is commonly the case. Moreover, the size of the sample set has permitted the more complicated issue of functional correlation between fishing implements and intended prey to be addressed. As such, the database analyses represent the final tool (along with fish behaviour, ethnographic analogy and fishing technology) that can be applied to the holistic appraisal of Mesolithic fishing. In the following Chapter this holistic approach is put to the test in a practical reassessment of the Tybrind Vig fishery (Section 8.4).

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1. Maori and other Polynesians groups are generally agriculturalists. The Maori of South Island subsisted predominantly by fishing and gathering due to the limited success of cultivation on poor arable soils (Metge 1976; Leach & Boocock 1993)
3. The high fat content of anadromous and catadromous species greatly increases rate of spoilage and decay – see Chapter 6.
4. Described by Gramsch (1992) as boards for winding bast cord
5. Benthic species are those that permanently inhabit bottom waters.
Chapter 8

Criticisms and Implications

8.1: Criticisms of Method

8.1.1: Artefacts

It is important to note that the

"vast majority of archaeological sites from the Mesolithic period does not contain preserved organic materials or any trace of food remains" (Price 1987:292).

It is accepted that the existing body of archaeological data (and the sub-set included in this study) may not be fully representative of Mesolithic fishing technology and practices. The large variations in preservation conditions apparent at Mesolithic sites on a Pan-European and regional scale may result in an over-emphasis of the variability of Mesolithic fishing practices. Differential preservation, resulting in the concentration of sites with organic remains along waterways and coastal Europe, may also over-emphasis the role that fishing played in European Mesolithic economies.

"The study of the Mesolithic has, for the best part of a century, been based completely on the results of settlement investigations, primarily of sites adjacent to the sea, or a lake" (Larsson 1988b:12).

The validity of the results of this study also directly depend on the veracity of the sources. The reconstruction of Mesolithic fishing activities is limited by the lack of detail and standardisation in publications and inaccessibility of data. For these reasons, this study makes no claims to be fully comprehensive.

Several major problems were encountered. Some of these problems were mentioned in the discussion of data base constructions (see Sections 6.1 & 6.3). The main drawback to the analysis of fishing gear is the lack of detailed description of finds. Often, gear is merely listed in terms of presence on a site, resulting in the loss of substantial quantities of evidence relating to fishing practice. The morphology of specific gear types can relate to mode of operation (e.g. the type of fishing ground in which the gear would be effective and suitable prey species). It is essential therefore for fishing gear, either to be described in detail (e.g. morphology, dimensions, raw materials used in construction), illustrated, or for comparison, to be drawn with well published finds. It would be desirable to produce a typological categorisation of fishing gear (in the manner of J G D Clark’s [1936] and Verhart’s [1989]...
classification of bone points) but for applicability this would have to be restricted to gross characteristics; accompanying descriptions of the specific attributes of finds would be necessary. Fishing gear is highly variable in form and size: relating to individual preference or culturally influenced methods of manufacture. No practical system of classification could account for this level of variability. If classification of finds and clarity in site publications is to be achieved, it is necessary to construct a standardised terminology for fishing gear. Interchangeable or erroneous use of terminology in archaeological reports (e.g., the variably use of the terms trap, weir and weir fences [Andersen, Enghoff]) hampers reconstruction of fishing practice.

8.1.2: Fish Assemblages

For the purposes of reconstruction and interpretation it has to be assumed that the recovered fish assemblage is representative of that originally deposited. However, it is acknowledged in this study that taphonomic processes, differential preservation, and excavation and recovery techniques may skew the relative economic importance of species within and between sites. A major problem encountered in this study is the lack of standardisation in reports on fish assemblages. This applies equally to the reporting of fishing related artefacts. This is, to some extent, understandable in the case of older studies. Many reports simply state that fish remains were recovered at a site, qualifying this with vague indicators of the number of remains found, e.g., numerous, abundant, few and rare. Some reports are still guilty of this. However, good methods of practice have been understood from the end of the 19th century (see Chapter 1). Desse & Desse-Berset (1996) point out that despite the publication of standardised approaches to osteometry in the 1970s, which permit accurate determination of fish length, this has seldom been systematically applied to archaeological assemblages.

The work of Enghoff has greatly advanced knowledge of the range of species fished by Mesolithic groups. Unfortunately, many other reports on fish assemblages from Mesolithic sites comprise little more than species lists, or worse, describe only the most commonly identified species or those considered to be most important to the economy of the site. However, the behaviour and habitat of the less important or accidentally caught species can give additional information on the fishing methods employed at a site. To obtain the greatest resolution of prehistoric fishing practices, fish assemblages need to be quantified, with species counts (preferably MNI and NISP) and estimations of size ranges reported. It is particularly important to report estimations of the size range or maturity of fish species in which the behavioural patterns of adults differ significantly from that of young (thus influencing methods of capture and timing of greatest susceptibility to capture). It is common practice, where recovered assemblages are very large, to analyse small samples. However, this may result in marker species (i.e., those that indicate or preclude the use of a specific gear type or indicate fishing in specific locations) not being identified.
Resource intensification may occur through technological development (Hayden 1981; Olsen & Hubbard 1984). The increasing use, through the Mesolithic, of large-scale gear indicated by the results of this study is suggestive of the intensification of fish exploitation. This can be attributed to an increase in dietary dependence on fish on a local or extra-local scale (with accompanying storage and trade) and/or population expansion. The use of large-scale gear such as nets and traps, which facilitate surplus production, and capture fish without causing internal damage or piercing the skin, are associated with the practice of storage. Fish that have been damaged (e.g. by harpooning, spearing or leistering) or are physically exhausted at death (e.g. line fishing) spoil more readily in storage (see Section 2.6). Storage of subsistence resources and population expansion are both phenomena widely acknowledged to signify increasing social complexity in the archaeological record (Schalk 1977; Testart 1982; Binford 1990, 1996; Yesner 1994). Other indicators of social complexity observed among Late Mesolithic groups include sedentism (often seen as a direct correlate of resource storage), territoriality, conflict, geographic restriction of artefact types, increase in settlement diversity, size and duration, status differentiation, long-distance trade or exchange of exotics, variation in mortuary ritual and formalised cemeteries (Bender 1985; Mellars 1985; Price 1985; Soffer 1985; Clark & Neeley 1987; Keeley 1988; Larsson 1988a; Voytek & Tringham 1989; Verhart 1990; Constandse-Westermann & Newell 1989, 1990; Blankholm 1992; Arnold 1995; Jacobs 1995; Radovanović 1996; Radovanović & Voytek 1997). Although there is no formal relationship between the exploitation of fish, the use of storage and increasing complexity, a statistical analysis of Murdock’s Ethnographic Atlas (1967) revealed that the more important fishing is to a group, the more compact and permanent the settlement and the larger and more stratified the group (Pálsson 1988). It is argued that the efficient exploitation of anadromous resources requires a certain level of organisation to schedule, not only fishing and processing of catches, but also off-season manufacture and maintenance of large-scale gear. However, the social complexity (manifested in social stratification) exhibited by Northwest Coast groups should not be taken as representative of that of European Mesolithic groups. Although there is relatively little ethnographic literature concerning East Coast Native American groups, archaeological investigations indicate that large-scale exploitation and storage of anadromous resources was practised by band organised groups in this region (Sanger 1995). The indicators of complexity mentioned above attest that the required level of organisation for the large-scale storage of fish and other resources existed in the Late Mesolithic.

Storage provides one means of coping with predictable seasonal scarcity by extending the temporal availability of resources (Testart 1982). Resource intensification may be seen as a direct consequence of increased territorial circumscription or population increase in the Late Mesolithic. Common sense dictates that an expanding population requires a greater quantity of subsistence resources. Large seasonal variations in photoperiod in temperate regions result in significant variation
in the availability of resources (Testart 1982, 1988; Binford 1990; Goland 1991). Thus, storage acts as a risk-reducing mechanism (Halstead & O'Shea 1989; Goland 1991), which is a characteristic of, though not exclusive to, groups inhabiting temperate regions (cf. Murdock 1967). Alternative strategies to reduce risk include trade, which may be viewed as a form of social storage, and residential mobility (Cannon 1996).

The territoriality observed in the Late Mesolithic, which presumably emerged some time before it is archaeologically identifiable, precludes residential mobility as a response to seasonal scarcity (Halstead & O'Shea 1989). The decreasing size of territories and increasing restrictions to movement may have created a need for the storage of resources. Populations dependent on fish for subsistence may have been less able to move to seasonal extraction camps. It is often assumed in anthropological and archaeological studies that seas and inland waters (and consequently, the resources therein), were perceived as common property freely exploited by all (Gordon 1954; Durrenberger & Pálsson 1987). However, close examination of ethnographic practices indicates that strict ownership and inheritance rules governed the exploitation of most stretches of water. Communities and individuals generally had rights to well-demarcated fishing grounds (Kroeber & Barrett 1960–62; Watanabe 1972a, b, 1977; Alexander 1980; Pálsson 1991; Zaliznyak 1997). Where waters are considered common property, groups restrict access through secrecy, gear ownership or destruction, intimidation and defence of territorial boundaries (Kroeber 1976; Durrenberger & Pálsson 1987).

It is possible that surplus production was required for the purposes of trade/exchange to obtain resources available only in neighbouring territories. This would further encourage subsistence specialisation and in turn reinforce trade alliances. In anthropological circles, recent theories on the development of storage and complexity have moved away from population pressure as a primary cause. Competition and the emergence of elite members of society are viewed as the motivator for change (Hayden 1990; Brumfiel 1994). The elite would encourage or perhaps even control the production of surplus for the purpose of self-aggrandisement. Emphasis is still placed on increasing population pressure in discussions of the changes observed in Mesolithic Europe. This may in part relate to the lack of archaeological correlates for competition but is also the result of the extensive ethnographic and ethnohistoric records available to North American anthropologists.

Technological development and the widespread adoption of large-scale capture techniques would have permitted the efficient exploitation of spatially and temporally concentrated resources such as migrating or shoaling fish species. Ethnographic records from California emphasise the importance of nets, weirs, dams and poisons in the large-scale capture of fish for storage purposes (Bennyhoff 1950). This would permit a larger population to be maintained or provide surplus for trade or exchange.
8.3: Storage in Mesolithic Europe

It is clear from caches of hazelnuts that food storage was practised in Mesolithic Europe (Mithen & Finlayson 1991; Denison 1995; Mason 1997; Kriiska & Lõugas 1999; Mithen et al. 2001). Similar caches of meat and fish have not or cannot be identified in the archaeological record because of biases in preservation and the nature of food processing techniques. The tenuous identification of the storage of fish may explain the relative lack of discussion in literature. The storing of a wide variety of resources is evident in ethnographic and ethnohistoric records, including all types of aquatic resources. Storage is identified from two categories of evidence in archaeological contexts; directly from the structure of faunal assemblages and by inference from artefacts and features.

Zvelebil (1989) suggests that migratory fish constitute the ideal storable resource. However, the variation in access to migratory fish across Europe should be taken into account. Availability varies both on a local and region scale, both in terms of fish species, abundance, concentration and predictability. This influences the level of dependence on, and storage of, fish in ethnographically observed groups. The storage of resources, and in particular fish, can be inferred from gross environmental factors. In the Varanger fjord region of Norway, extreme seasonal variation would have necessitated storage (Simonsen 1965; Renouf 1989). Darkness persists for eight weeks in the winter. Modern and recent groups inhabiting these northern latitudes do practice some sealing through ice holes at this time but subsist primarily on stored resources. In sub-Arctic regions, fish can be stored for winter by freezing. This leaves little trace in the archaeological record, either in terms of processing or storage features.

8.3.1: Identifying the Practice of Storage from Fish Assemblages

More usually, the storage or transport of fish can be inferred, in faunal assemblages, from the presence of a number of the following criteria: abundant fish remains, suitable trade species, varying skeletal element representation, size distribution of the assemblage, evidence for processing (e.g. cut marks or charring) and non-local species (Akazawa 1980, 1988; Brinkhuizen 1994; Matsui 1995; Barrett et al. 1999; Hoffman et al. 2000). However, none of these phenomena has been shown, or can be conclusively linked to, storage in Mesolithic contexts, even where it is assumed that the recovered assemblage is representative of the original deposition:

1. The abundance of fish remains at a number of European Mesolithic sites has been interpreted as evidence for the storage of fish, e.g. Mount Sandel and Lough Boora, Ireland, Montclus, Gard, France and the Vedbæk sites, Denmark, (Rozoy 1978; Woodman 1978a; Aaris-Sørensen 1980a). Abundance does not in itself provide conclusive evidence for storage. In the absence of detailed
data concerning the relationship of fish remains, settlement population and the time-scale of site occupation, such speculation should be avoided.

2. Fish species suitable for storage have been identified at Mesolithic sites. Again, this does not in itself imply storage. As discussed in Chapter 2, species considered suitable for storage and accepted levels of spoilage are in part culturally determined: most species and sizes of fish can be preserved for short-term storage or trade if desired.

3. Analysis of skeletal element representation has long been accepted as a method for identifying the preserving and storing of fish in archaeological contexts (e.g. Casteel 1976a; Enghoff 1986, 1991; Seeman 1986; Brinkhuizen 1994). This is often combined with the abundance of fish remains to determine storage practices. It is predicted that among groups practising storage, two types of site will be identified: processing sites that have fish faunal assemblages dominated by cranial elements, and base camps, with the predominant elements being vertebrae and other non-diagnostic elements (Matsui 1996; Hoffman et al. 2000). This model may be complicated by the immediate consumption of fish on processing sites and by the different processing methods applied, depending on whether the stored fish was for human or animal consumption, weather conditions, species, quantity and condition of the fish. The skeletal element representation of fish fauna from a number of Mesolithic sites is interpreted as processing for storage. For example, Mellars (1978) interprets the restricted distribution of fish and concentrations of branchial elements in the midden at Cnoc Coig as distinct fish gutting areas. It is possible, given the size of the island of Oronsay at the time of occupation and the likelihood that it was the focus of specialised extraction activities conducted on a seasonal basis (supported by otolith analysis), that fish were preserved for transport to home bases on neighbouring islands or the mainland. The dominance of cranial bones of pike (Esox lucius) in the Mesolithic assemblages from Svaerdborg, Præstelyngen and Tybrind Vig in Scandinavia and of eagle ray (Argyrosomus regius) at the site of Arapoouca, Portugal and the scarcity of cranial elements at the site of Ølby Lyng (0.5% of the total assemblage), have similarly been interpreted as evidence for transport or storage of fish (J G D Clark 1965; Noe-Nygaard 1983; Zvelebil 1989). Trolle-Lassen states of the Tybrind Vig remains that,

"presumably the Stone Age fishermen had been sitting in a boat or standing on a sort of pavement of stones just outside or in the periphery of the reed area. After the cod had been caught, the fish heads were cut off between the gill cover and the shoulder region, they were loosened from the vertebral column and dropped into the water – presumably among the reeds. In one case the three upper vertebrae were still connected to the cranium" (1984:140).

The myriad of problems (a consequence of differential preservation) associated with interpretations of skeletal element representation in archaeological assemblages has been discussed in Chapter 6. Skeletal element representation is not considered an appropriate or meaningful method for assessing the activities of preservation and storage in this study.
4. The size of the fish recovered cannot be linked to prehistoric storage practices. Groups dependent on aquatic resources preserve both large and small fish. Preservation techniques differ: medium and large fish are filleted prior to preservation whereas small fish are preserved whole. Cut-marks are rarely reported on fish bones from Mesolithic sites. However, there is convincing evidence for the processing of fish at Dietfurt Cave, Germany, where large numbers of fish rib bones with cut-marks have been recovered, implying the filleting of fish (Jochim 1998). It is possible that fish were cooked, preserved or consumed whole, *i.e.* unprocessed. Food residues from ceramic vessels at Tybrind Vig were found to contain gadid bones, scales and grasses, and may represent the remains of 'fish soup' (Trolle-Lassen 1984; Andersen 1987a). However, the absence of cut marks does not necessarily indicate that fish were not processed. Although all the fish brought to the camps of recent groups in the Lake Turkana region were processed with knives, only 4% bore cut-marks (K M Stewart 1991). Despite the abundance of fish remains at Danish sites there are few indicators other than the scale of the fisheries for storage (Enghoff 1986, 1991).

5. Non-local fish species have been identified in Mesolithic contexts. Their occurrence is generally thought to indicate prehistoric climatic variations rather than extra-local trade (Enghoff 1986, 1991) — see Chapter 7.

6. Charring of bones has been linked to the smoke curing of fish at sites such as Mount Sandel and Noyen, Siene-et-Marne, France (Woodman 1985b, Mordant & Mordant 1992). However, this may simply reflect cooking methods rather than processing for storage. It is interesting to note that the charred eel (*Anguilla anguilla*) vertebrae at Noyen were recovered from Early Mesolithic deposits at the site. In later Mesolithic deposits, where increased storing of resources might be expected, the eel (*Anguilla anguilla*) fishery had been replaced by pike (*Esox lucius*) fishing at this site (Mordant & Mordant 1992).

As with many other aspects of archaeo-ichthyology there is as yet no standard method for identifying the processing and preserving of fish from the remains identified in the archaeological record. It would appear that none of the above criteria are significantly diagnostic in the Mesolithic. Artefacts and archaeological features may provide an alternative approach for the identification of storage.

8.3.2: Identifying Storage from Artefacts/Features

Zvelebil (1989) states that the expected archaeological correlates of storage are, specialisation in exploitation, logistical base camps and mass capture technology. All of these criteria are known from Mesolithic Europe. Again, the question is whether these features can be related to the storage of fish. Ethnographic and ethnohistoric records suggest that a number of structures and implements are associated with the processing, preserving and storage of fish: *e.g.* storage baskets, structures and pits, roasting floors, smoking or drying racks, smoke houses, containers for rendering oils, knives and slitters. Baskets were particularly common (much more so than boxes or ceramic vessels) for the
storage of fish at Northwest Coast sites (Croes 1992). Unfortunately, in terms of archaeological recovery, many of these implements or structures would have been constructed from highly friable materials. Even where analogous artefacts/features survive they can be only tentatively linked to the storage of fish. There is the additional problem of offsite processing and preserving of fish. Fish that are intended for long-term storage must be processed and preserved within a narrow time-window (Chapter 2). For this reason it is common practice among the native groups of North America to process fish for storage at temporary fishing camps in the immediate vicinity of fishing grounds (Kvause 1956). These ephemeral sites leave little archaeological trace.

Certain archaeological features identified at sites are commonly related to large-scale preserving and storage of fish:

1. At Mount Sandel, Cnoc Coig and Morton small post-holes and mounds of pebbles are interpreted as supports for drying racks (J M Coles 1971; Mellars 1978; Woodman 1985b). Larger post-holes at Mount Sandel are suggested to have supported large storage frames (Woodman 1985b).

2. Thick lenses of ash at Newferry I and other River Bann sites are suggested to be the residue of smoking salmon for storage (Cutting 1962).

3. Pits are often linked to storage in the archaeological record (e.g. Woodman 1978b, 1985b; Renouf 1989). Ethnographically, groups inhabiting temperate regions more commonly use wooden structures built on stilts or baskets kept above ground for storing fish — see Figure 8.1 (Kroeber & Barrett 1960–62; H Stewart 1977; Zaliznyak 1997). This is a means of reducing the threat to stocks posed by scavengers and equally importantly, by infestations of insects. Where used, storage pits were lined with pine needles or maple leaves, which act to deter insects and also impart flavour to the fish (Kroeber & Barrett 1960–62). It is clear that pits were used for storage of fish at the Late Neolithic site of Rzucowo on the Polish Baltic coast where hundreds of thousands of fish remains were found in a single pit structure (Makowiecki & Van Neer 1996).

4. Clason (1980) speculates that the inhabitants of Padina probably had the technology to store fish (particularly in light of the anadromous resources that would have been available to inhabitants of the Iron Gates sites) and relates the character of the stone-lined hearths to the drying and smoking of fish. Fish remains are concentrated around the hearths at the Iron Gates sites (Srejović 1969; Prinz 1987). Prinz (1987) suggests that stone rings found in Vlasac II, traditionally interpreted as the foundations of temporary dwellings, may in fact be storage structures.

5. The ceramic vessels recovered from Ertebolle sites in Denmark could have been used for storage. Deith (1985) suggests a possible function in the storage of seal flesh, blubber and oil. In contrast, finds at Tybrind Vig with food crusts suggest domestic use (Nielsen 1987). It is possible that these vessels were used for the storage of fats. Ethnographically, this type of storage is commonplace and the dipping of foods into the fat would explain the various foodstuffs found in the Tybrind vessels (Andersen & Malmros 1984). The storing of fish is ceramic vessels is suggested in Middle Neolithic and possibly earlier deposits at Zvidze (Loze 1988a). It is probable, also on the basis of ethnographic analogy, that vessels constructed from less durable
materials were in widespread use for storage in the Mesolithic. Exceptional preservation conditions at Vis I and Friesack have permitted the recovery of birch-bark vessels. That from Vis I is an almost square container, 14.5cm in length, made from a single piece of birch-bark secured with wooden pegs (Burov 1998). The example from Friesack is similar, measuring 20.0cm, but has been moulded from a single piece of bark — Figure 8.2 (Gramsch 1992).

6. The exchange of fish may be inferred from the exchange of more durable goods (Hoffman et al. 2000). There is evidence for the long distance trade or exchange of exotics across Mesolithic Europe. Ethnographically, it is common practice to exchange like for like, i.e. rare and exotic goods would be exchanged for other high value or status items. The presence of exotics on Mesolithic sites in no way implies the preserving, storage or trade of fish or fish products. It is not certain to what extent there would have been movement of more mundane products.

Most of the features or artefacts could have served a number of different functions and do not therefore give definite evidence for storing of resources let alone the storage of fish. The case for storage of aquatic resources in Mesolithic Europe on the basis of the available evidence cannot be other than speculative. Storage of fish would be feasible only where there exists significant temporal concentrations of species. Storage would only be necessary where there is large seasonal variation in availability, i.e. regions where anadromy is pronounced, freshwater/marine resources are limited in abundance or availability and there is coincident seasonal scarcity in alternative, terrestrial resources. As discussed in Chapter 3, the pattern of fish behaviour in Europe would not have necessitated the development of storage (and consequent social complexity) on the scale seen among the Northwest Coast groups. Northwest Coast groups conduct subsistence fisheries predominantly with traps and weirs (Tables 3.1 and 3.2). The relative scarcity of stationary fishing structures and remains of anadromous/catadromous species at sites in Mesolithic Europe, may in part reflect preservation, but may alternatively be explained in terms of the different structure of fish as a resource in Europe when compared to that of North America. Among the Ainu of Japan, where runs of anadromous fish are extended throughout much of the year, trap and weir fisheries do not assume the importance observed in North America (Ohnuki-Tierney 1974; Watanabe 1977). Storage is practised by the Ainu but is limited to the autumn runs of salmon (Oncorhynchus spp.), with sufficient fish taken to provide part of the diet over the two to three months of winter (stored terrestrial resources also play a significant role in diet at this time). The relative ease of preserving lean species for long-term storage may have resulted in a preference for non-migratory species during the development and refinement of storage techniques (Chapter 2). The detailed stratigraphy and large faunal assemblage recovered at the Hoko River site and data from other coastal sites of the Locarno Beach Culture of the Northwest coast of North America suggest that marine species such as cod (Gadus macrocephalus) and halibut (Hippoglossus stenolepis), fished with long-lines, rather than migratory salmon (Oncorhynchus spp.), trout (Oncorhynchus mykiss) or eel (Anguilla anguilla) taken in traps and weirs, were the focus of the initial storage-based economies (Croes & Hackenberger 1988; Croes 1992). This indicates that the potential of fish as a stored resource should not be confined to migratory species. The temporal
analysis of fish species representation conducted in this study (Chapter 7) demonstrates a significant
decrease in the exploitation of eel (*Anguilla anguilla*) across all sites in the Late Mesolithic. Eel
(*Anguilla anguilla*), which has a very high fat content, is not easily stored without spoilage over the
long-term. This move away from eel (*Anguilla anguilla*) may correspond to increased storage of
resources, *i.e.* lean fish. However, despite clear specialisation in fisheries and the use of large-scale
gear, there is simply no conclusive evidence for the storage of any fish, lean or fatty, in Mesolithic
Europe. The use of large-scale gear by Mesolithic fishermen, though consistent with the practice of
storage, may simply indicate the increasing requirements for immediate consumption in an expanding
population.

8.4: Case Study — Tybrind Vig

The principal message of this thesis is that the varied information obtained from fish behaviour,
ethnographic analogy, fishing technology and correlation studies can and should be combined with the
artefactual and faunal evidence to reconstruct fishing strategies at a single site. To put this assertion to
the test, it is necessary to re-interpret a typical site using this ‘holistic’ approach and highlight the
additional or alternative conclusions reached. Tybrind Vig has been chosen as a case study because of
the range of fishing gear and fish species recovered from the site (a consequence of site submergence)
demonstrates the breadth and sophistication of Mesolithic fishing activities.

Information concerning the behaviour and habitat of the fish species identified from the site is used to
determine the most likely method, location and timing/season of capture. This data is then combined
with artefactual, technological and ethnographic information to provide a detailed picture of fishing
activities at the site. Ethnographic analogies are drawn from the databases of traditional fishing
practices — Tables 3.1 and 3.2. The fish assemblage from Tybrind Vig is reported as a species list —
the assemblage is not quantified (Table 6.2). This limits discussion of the relative importance of the
various species to the economy of the site. However, cod (*Gadus morhua*) is reported to be dominant
and flatfish (brill (*Scophthalmus rhombus*), dab (*Limanda limanda*) and plaice/flarender (*Pleuronectes
platessa/Platichthys flesus*), spurdog (*Squalus acanthias*) and three-spined stickleback (*Gasterosteus
aculeatus*) are described as common. It is therefore accepted here that Gadidae, flatfish
(*Pleuronectidae*) and a number of fatty species were the focus of fishing activities at Tybrind Vig.

Preliminary reports, by Trolle-Lassen (1984) and Andersen (1985, 1987a), which detail the
excavation and record the finds from Tybrind Vig provide little more than a list of the fish species and
the artefacts recovered. There is no interpretation of fishing patterns and the possible strategies
employed. Later reconsideration of the site has not redressed this except to speculate on the economic
importance of trap/weir eel (*Anguilla anguilla*) fishing by comparison with sites in the Limfjord
region of Denmark (*e.g.* Andersen 1995, Malm 1995, Pedersen 1995).
Stable isotope analysis of an individual from Tybrind Vig (Trolle-Lassen 1984) demonstrates the significant contribution of marine and/or estuarine resources to diet. Tybrind Vig was located, at the time of Mesolithic occupation, adjacent to a large bowl-shaped cove protected from the open waters of the Lille Bælt by a chain of small islands. Numerous freshwater outlets at the cove resulted in brackish waters. If marine resources were consumed a δ13C value of -15.7‰ implies that ca. 60% of dietary protein was obtained from aquatic resources. However, if brackish water resources were predominantly consumed the expected aquatic resource contribution to diet would be considerably higher (cf. Thornton & McManus 1994). The in situ recovery of a range of fishing artefacts adjacent to the settlement attest to the capture of fish inhabiting brackish waters.

The importance of trap fishing is claimed in interpretations of the economy at Tybrind Vig and at Danish sites in general (cf. Trolle-Lassen 1984; Andersen 1985, 1995; Enghoff 1995; Malm 1995). Malm even suggests that,

“Stationary fish traps presumably existed off all coastal Ertebolle Culture settlements” (1995:391).

This emphasis stems, in part, from Enghoff’s interpretation of Mesolithic fishing activities using the gear selectivity technique and its perpetuation in subsequent interpretations (see Section 4.11). Although trap fishing is an effective method of fish capture, there are many conditions and limitations to trap/weir use (see Sections 4.3.12 and 4.7.6). Other fishing techniques (attested by the wide range of artefact recovered at Tybrind Vig) may be equally, if not more, effective for the capture of fish depending on fish behaviour (and seasonal variation therein), and weather or hydrological conditions.

Two types of trap have been reconstructed from artefactual remains at Tybrind Vig. The first is a round, throated trap associated with a wattle fence — Figure 6.48.1 (Trolle-Lassen 1984). The form of the second type, a throated trap with a semicircular mouth — Figure 6.48.2, (proposed by Andersen [1995]) — was reconstructed from the recovery of a wooden rod with perforations at both ends (originally interpreted as a boat thwart) and by ethnographic analogy. The different morphology of these traps can be related to conditions of use (Best 1929; Dosedla 1984). The round trap is likely, on the basis of analogy, to have been used in soft substrates (supported by its association with a wattle fence). If Andersen’s inferred use of semicircular-mouthed traps is accepted (the evidence is entirely circumstantial), this form would have been most effectively used on coarser substrates. The form of the leisters found at Tybrind Vig further suggests the existence of two separate fisheries. Two types of wooden leister prong were identified; a long, slender type used in soft substrates and a shorter wider type used over coarse substrates (Andersen 1987a).

Fishing in more than one location (i.e. not just in the immediate locality of the site as proposed by Trolle-Lassen and Andersen) is supported not only by the two distinct forms of trap and leister prongs
recovered at the site but also by the salinity tolerance of the fish species identified (see Table 5.2). As mentioned above, the recovery of fishing gear in the offshore region of the excavation demonstrates fishing of the inshore waters at Tybrind Vig. Several of the marine species identified are euryhaline and as such could have been taken in the brackish waters of the cove, e.g. flatfish (Pleuronectes), young cod (Gadus morhua), black goby (Gobius niger), three-spined stickleback (Gasterosteus aculeatus), viviparous blenny (Zoarces viviparus) and pipefish (Syngnathidae). The other species identified at the site, e.g. herring (Clupea harengus), mackerel (Scomber scombrus), bullrout (Myoxocephalus scorpius) and cuckoo wrasse (Labrus mixtus), are less tolerant of reduced salinity and are unlikely to have been taken in the brackish inshore waters of the cove. These species suggest fishing activities in the more marine, outer reaches of the cove, or further afield in the Lille Bælt.

Mature salmon (Salmo salar) and eel (Anguilla anguilla), both of which have two major spawning runs (spring and autumn), may have been taken in the weir found at the shore next to the site or speared in coastal, estuarine or freshwaters during migration. The morphology of the trap recovered is analogous to those used in traditional Scandinavian eel (Anguilla anguilla) fisheries (Fischer 1993, Pedersen 1995). Suggesting the use of coastal weirs is the nearby recovery of a wooden structure interpreted as a wattle guiding fence. Immature eel (Anguilla anguilla), commonly known as elver, could also have been taken on a seasonal basis but are most effectively exploited with close-woven traps. During spawning migrations, traps of the type recovered at Tybrind Vig would have to be monitored and hauled at regular intervals to prevent damage to the trap. The weir fence may also have been used as a barrier to concentrate fish that can then be speared/leistered/harpooned or gathered in collecting baskets and dip-nets. Outside the spawning season, traps could be left largely unattended. Ethnographic records indicate that traps used in this manner are generally set with baits and hauled daily, usually at crepuscular periods in areas with little tidal action or at low tide in the tidal reaches of marine and estuarine waters.

The large number of short fire-hardened wooden points (>100), interpreted as the tips of fish spears may equally have served as the points of fish rakes (e.g. Figure 8.3). The rakes are set with up to 50 small wood or bone points. This type of implement is used by fishermen of Northwest coast groups and the Maori to rake large quantities of small fish concentrated in surface waters, particularly migratory or shoaling species such as eel (Anguilla spp.), eulachon (Osmerus spp.) and herring (Clupea harengus), directly into boats (Best 1929, Kroeber & Barrett 1960-62, H Stewart 1977).

The exploitation of salmon (Salmo salar) and eel (Anguilla anguilla) were not necessarily temporally restricted to spawning seasons. Significant numbers of mature salmon (Salmo salar) and eel (Anguilla anguilla) (generally males) are found in inshore coastal and estuarine waters throughout the year. This resource would be most readily exploited in shallow or surface waters with fish spears or leisters. Leister prongs constitute the largest single category of wooden implements at the site (Andersen 1987a). Eel (Anguilla anguilla), particularly brown eel, which lies buried in soft substrates when
resting, is often ethnographically observed to be fished 'blind' with long-pronged leisters analogous to the form recovered at Tybrind Vig.

The capture of a number of very small species (e.g. pipefish [Syngnathidae], black goby [Gobius niger] and viviparous blenny [Zoarces viviparus]) are possible incidental by-products of the weir/trap fishery at the site, originally intended for the capture of anadromous/catadromous species. However, several of these smaller species may have been actively sought. The three-spined stickleback (Gasterosteus aculeatus), which is described as common in site faunal remains, was the focus of a traditional fishery (documented from the 16th–19th centuries); exploited for its oil content, which was used as a fuel rather than as a food fish (Table 5.4). A number of fatty species, which are currently, or were historically, known to be taken primarily for the rendering of oil have been recovered at the site (cf. the occurrence of mackerel [Scomber scombrus], herring [Clupea harengus] and spurdog [Squalus acanthias]). Although it is possible that these species were taken solely for their flesh, the specialised exploitation of fatty species (such as eulachon [Osmerus spp.] and herring [Clupea harengus]) for oil rendering has been observed among several Northwest Coast groups including the Kwakuitl, Bella Coola, Haisla, Eyak and Coast Tlingit (Kvause 1956; Olsen & Hubbard 1984; von Brandt 1984a; Kirk 1986; Renker & Gunther 1990). The surplus production of oil allows these groups to trade with their neighbours for a number of terrestrial and aquatic resources (including fish considered to have more palatable flesh) which are not readily available within their territory (Kirk 1986). The identification of 'blubber' lamps at the site suggest a possible domestic use for fish oil.

Size estimations are given only for cod (Gadus morhua) recovered from the site: determined to be 25-60cm. Although it is suggested by Enghoff that small cod (Gadus morhua) such as this would have been taken by traps, they are more likely to have been taken with hook and line. This is supported not only by the results of correlation studies (see Section 7.4 ff.) but also by the overall species composition of the Tybrind Vig fish assemblage, the artefact inventory and by ethnographic analogy. For example, the capture of the solitary and relatively sedentary species, the cuckoo wrasse (Labrus mixtus), is most consistent with the existence of a line fishery at the site. Moreover, the habitat of these species (associated with rocky substrates) is inconsistent with weir capture. Cuckoo wrasse (Labrus mixtus), cod (Gadus morhua), and bullrout (Myoxocephalus scorpius) are most suited biologically, and most commonly observed ethnographically, to be taken with hook and line. Cod (Gadus morhua) are regularly taken in traps in recent commercial fisheries of East Canada, where very large shoals of cod (Gadus morhua) pass close inshore (in deep water) on a seasonal basis. There are no other known instances of cod (Gadus morhua) fishing with traps. Although cod (Gadus morhua) of the size identified at Tybrind Vig could have been taken at any time of the year in inshore waters, it is possible that cod (Gadus morhua) were fished along with other marine species at the edge of or outside the cove. The form of hook identified at Tybrind Vig (Figure 6.18), i.e. the absence of a barb, is consistent with active rather than set-line fishing.
Ethnographically, fishing is practised on two levels: the first uses large-scale, communally-owned gear for catches that are shared between participants or kin groups. Secondly, among all groups practising large-scale communal fisheries, fishermen will also fish on an individual basis with catches retained for individual households (Pålson 1991). Often this is done on days when weather conditions limit the use of large-scale gear or prevent fishing at sea. In these fisheries, passive gears are often avoided, particularly those methods that may reveal their location to other fishermen. This secrecy is necessary to prevent catches being stolen or good fishing grounds becoming over-fished (Kroeber 1976). The most common method used in these small-scale, individual fisheries is the hook and line. It is possible to conduct successful line fishing in most weather conditions. The cod (Gadus morhua) fishery evident at Tybrind Vig could reflect this form of activity. Cod (Gadus morhua) often enter shallow inshore waters in winter to feed along the edge of kelp beds. Large catches of small cod (Gadus morhua) are readily obtainable at a time of year when other species of fish may be less accessible.

Flatfish (Pleuronectidae) can be taken by a number of methods. They are vulnerable to hook fishing with baited bottom-lines and are commonly taken in this manner in traditional fisheries. Most species of flatfish can also be taken at low tide by hand or with leisters/spears/harpoons and are occasionally taken in traps that are set over night when swimming freely in search of food.

Herring (Clupea harengus), mackerel (Scomber scombrus) and spurdog (Squalus acantbias) are most effectively taken in encircling nets such as seines set out from the shore or between boats. Herring (Clupea harengus) and mackerel (Scomber scombrus) pass close to shore in seasonal migrations (the seasonal and diurnal vulnerabilities of the fish caught at Tybrind Vig are given in Table 5.3). This method of netting is consistent not only with species behaviour but also with the recovery of floats at the site. Although netting was not identified at the site, the textiles and cordage found on the site and the occurrence of nets at contemporaneous sites suggest that the practice of net fishing would have been known to the inhabitants of Tybrind Vig. Herring (Clupea harengus) and spurdog (Squalus acantbias) are more susceptible to capture at night, both species make diurnal migrations from bottom waters to the surface to feed. Concentrations of these species can be increased with artificial light sources set on the shore or on boats. Andersen (1987a) argues for the use of boats and artificial light sources in the night spearing/leistering of eel (Anguilla anguilla). This is based on the find of a clay hearth situated in the hull of one of the Tybrind Vig dugouts. It is equally likely that fires set in boats were used to concentrate shoals of herring (Clupea harengus) and spurdog (Squalus acantbias). Mackerel (Scomber scombrus) is most concentrated and can be fished in surface waters during the day. All three are fatty species, which are taken for flesh and oil in traditional fisheries. It is possible that sticklebacks (Gasterosteidae) were also taken in nets. The spines of the stickleback (Gasterosteidae) make it particularly vulnerable to tangling in small-meshed nets.
The use of passive gear set at dusk and hauled at dawn frees the rest of the day for other subsistence or social activities such as the hunting or gathering of terrestrial resources, fishing using more active methods and the manufacture and maintenance of gear. However, the species identified, their vulnerability and most likely method of capture is suggestive of active fisheries at the site.

Although a number of bows and arrows were recovered at Tybrind Vig it is not certain that they were used for the pursuit of aquatic species. It is possible that the bow and arrow was used for the capture of large salmon (Oncorhynchus/Salmo spp.) as seen among Amazonian and Northwest Coast groups but in the absence of size estimation of the salmon (Oncorhynchus/Salmo spp.), this is speculative.

As illustrated by the above case study, a tremendous amount of information can be inferred about fishing strategies, their scheduling and organisation by applying a holistic approach to the interpretation of data. This information paints a rich portrait of a society underpinned by its commitment to, and expertise in, the exploitation of aquatic resources. The greater understanding of their modus operandi provided by the results of this study highlights the complexity of social interactions necessary to maintain this lifestyle.

\*Eel is possibly the focus of specialised fisheries in the Limfjord region of Denmark in the Late Mesolithic (Ertebolle) period.
Chapter 9

Conclusion

The aim of this study was to provide an overview of fishing practices in Mesolithic Europe. Despite the accumulation of a wealth of new data since the publication of J G D Clark's (1948a) work, it was apparent that certain aspects of fishing practice and the use of fish as a resource had been neglected or incorrectly documented in the archaeological literature. Questions were posed in Chapter 1 concerning the importance of fishing to Mesolithic economy and society, on a Europe-wide and region-specific scale. Databases of anthropological, biological and archaeological information were constructed and analysed to address these outstanding issues.

9.1: Summary of Results

There is an apparent intensification in the exploitation of fish in the Upper Palaeolithic and throughout the Mesolithic. This is supported by the increased abundance and diversity of fish remains, apparent technological innovation and development, and the stable isotope analyses of human bone from Upper Palaeolithic and Mesolithic contexts.

Stable isotope analyses, which are the most accurate indicator of sources of dietary protein, indicate large variability in subsistence, both within and between populations (ranging from entirely terrestrial diets to those incorporating ca. 80-90% aquatic resources). In general, populations inhabiting the coastal regions and major waterways of Europe depended heavily on aquatic resources. Nitrogen isotope signals suggest that the primary aquatic resource was fish, although ethnographic analogy and faunal assemblages indicate that a range of other aquatic resources may have contributed to diet. This contradicts the original supposition of J G D Clark that fish and other aquatic resources constituted no more than a secondary resource for Mesolithic groups.

Since the work of J G D Clark (1948a, 1952), advances in recovery and identification techniques have greatly enhanced the number of fish species known to have been exploited in Mesolithic Europe. The fish species identified at Mesolithic sites indicate the exploitation of a minimum of 101 freshwater and marine species. The majority of these species could have been fished from inshore waters. However, a small number of the species recovered at Mesolithic sites must have been taken in offshore waters. The geographical distribution of these species implies fishing in open waters of the Mediterranean, the Skagerrak and, possibly, along the coastal regions of Norway.
An analysis of the geographic distribution of artefacts and fish fauna attests to two main areas with significant fisheries: coastal regions with riverine, estuarine and marine fisheries; and fisheries of the major inland waterways. This corresponds to ethnographic observations of the distribution of fishing grounds of traditional groups. However, an absence of evidence for smaller-scale fisheries in the inland areas of Europe may result from the use of expedient technology, bias in preservation or limited identification of sites.

The survey of artefactual remains provided evidence for the use of the four main gear types (hooks, spears/harpoons, nets and traps/weirs) across much of Mesolithic Europe. The find locations suggest active fishing of marine, estuarine, riverine and lacustrine environments. Methods of gear construction and raw material use are analogous to that of traditional fisheries. There are local and regional differences in the predominant types of gear used. Although this may, in part, reflect differential preservation, the chief cause is most likely regional variations in fish species and hydrology.

Ethnographic analogy applied to archaeological remains can be used to infer the range of gear used in Mesolithic Europe and suggest the location and season of specific fisheries. The variations in form and technological sophistication of this gear and other associated artefacts attests to a knowledgeable and skilled fishery paralleling, and possibly exceeding, the diversity observed in the native fisheries of North America.

Ethnographic records and the association of artefacts in archaeological contexts indicate that certain implements used in fishing can serve a number of other functions. However, the association of finds may indicate function. Correlation studies of the co-occurrence of potential fishing gear and fish species from Mesolithic contexts demonstrated a relationship between large predatory species and barbed points, between catfish (Silurus glanis) and pike (Esox lucius) and bi-points and between Gadidae and hooks. The use of these gear types (spears/harpoons, leisters, hooks and gorges) in specialised fisheries throughout Mesolithic Europe is therefore inferred. The correlation studies of the co-occurrence of fish species and fishing gear demonstrates the Mesolithic fisherman’s detailed knowledge of fish behaviour and habitat and is manifested in the development of specialist fisheries aimed at the efficient capture of a variety of species.

The analysis of geographical variation in Mesolithic fishing practice revealed significant regional differences. These differences were primarily related to the informed choice of gear by Mesolithic fishermen for the efficient capture of prime food fish under local hydrological conditions. The capture of fish with nets was the predominant fishing activity of the South European Atlantic coast and the Iron Gates region. Line fisheries were conducted on the exposed coasts of more northern latitudes of the North Sea Coast and throughout the Mediterranean. Ranges of fisheries operating various gear types are in evidence in the circum-Baltic zone. Trap and weir fisheries were prevalent only in the West Baltic and possibly in Ireland. Contrary to prevailing wisdom, stationary fishing structures (i.e.
weirs, barriers and traps) did not constitute the most efficient or even the most productive fishing method for all species across the entire region. A regional specialisation in fishing practices was confirmed by the correlation of fishing gear and fish species, which indicates the selection of specific types of gear for certain types of fish that varies according to local hydrological conditions.

From the recovery of certain fishing-associated artefacts it is possible to make very general statements about the waters that could have been fished with the gear, the most efficient spatial and temporal fisheries that could be conducted and a broad indication of type of species that may have been caught. However, fine resolution of fishing activities cannot be determined from artefactual remains alone.

A clearer picture of fishing activities can be drawn from the fish remains recovered from archaeological deposits than from artefactual remains. The types of waters that were fished can be determined from the biology, behaviour and habitat of the fish species identified. This information can be combined with the results of the correlation studies to suggest specific methods of capture for identified prey species. Detailed reconstruction of fishing activities, attributing the use of a specific gear type to the capture of an individual species, is possible only at sites where both fauna and artefacts are recovered.

A remarkable uniformity is exhibited in the fish species exploited throughout the Mesolithic. There is no difference in species exploitation across continental Europe that cannot be attributed to variation in available prey and regional topographic and hydrological conditions. Mesolithic fishermen demonstrate a preference for species today considered good food fish. They exploit the same species that have been the focus of more recent traditional and commercial fisheries for flesh and oil. The occurrence of large, voracious and deeper water species at Mesolithic sites may reflect the prestige value of such fisheries in addition to their economic role. There does appear to be regional variation in sophistication or scale of fisheries. For example, the evidence from the Atlantic coast of Scotland is limited to species or specific age groups of species that inhabit inter-tidal waters. The fish assemblages contain a similar range of species to those identified in the shell middens of Portugal and Ireland reflecting uniformity of hydrological conditions and species distribution. However, it has to be borne in mind that these observed differences in the scale of fisheries may simply reflect inter-regional differences in preservation.

There was a trend towards the use of larger-scale gear through time. This may be explainable in terms of preservation bias but the evidence is not entirely convincing. The relative quantity of the more durable artefacts such as net sinkers suggest that there was an increased use of large-scale gear. This may reflect an expanding population and an increasing use of storage (see Section 8.3). There is only evidence for temporal variation in the extent of exploitation for certain fish species at inland sites on continental Europe: eel (Anguilla anguilla) becomes less important in the Late Mesolithic and catfish (Silurus glanis) is increasingly exploited. Again, this may reflect increasing storage of resources.
This study illustrates the great increase in the archaeological evidence for Mesolithic fishing activities since the studies of J.G. D. Clark in the 1940s and 1950s. This has been largely brought about by the methodological developments of the ‘New Archaeology’ of the 1960s, the introduction of specialists in faunal identification and the expansion in archaeological survey and excavation. Despite this increase in data, there has been little attempt to draw together information concerning the identified species and fish biology and to then compare this to the artefactual record.

This thesis has addressed this issue bringing together numerous sources of information to provide a comprehensive overview of Mesolithic fishing activity across Europe. It has highlighted the detailed reconstruction of fishing strategies that can be achieved by applying a holistic approach to the reconstruction of fishing activities.
FIGURES
Figure 1.1 Fishing in Mesolithic Europe
Overview of Thesis Structure and Aims
Figure 1.2a Map of Mesolithic sites - north Europe

For site location see key to sites (Table 1.1) pp. 208-212
Figure 1.2 (contd) b Map of Mesolithic sites - south Europe

For site location see key to sites (Table 1.1) pp. 208-212
Figure 1.2 (contd) c
Map of Danish sites with Mesolithic finds included in study

For site location see key to sites (Table 1.1) pp. 208-212
Table 1.1 Key to Mesolithic Sites Included in Study

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Figure 2.1 Range of simple and barbed points recovered from the Semliki Valley sites, dated to c. 80,000 BP (after Brooks et al. 1995). The barbed points are analogous to European Mesolithic forms (see Figure 6.8).
Figure 2.2 Bi-points from Upper Palaeolithic contexts
1. Bi-point with central depression, Rochereil, Dordogne, France (after Feustel 1985)
2. Bi-point with central curve, Grotte d’Isturitz, Pyrénées-Atlantiques, France (after Feustel 1985)
3, 4, 5. Bi-points from the Dordogne, France; 6.4, 6.9 & 7.6cm respectively (after Rau 1885).

Figure 2.3 Possible crooks of composite hooks from Upper Palaeolithic contexts (after Feustel 1985).
Figure 2.4 Biserial barbed point of reindeer antler, Périgord, France ca. 7.1 cm (after Lartet & Christy 1875). Rau (1885) infers a function in fishing from the similarity of the barb morphology to fish fins.

Figure 2.5 Self-barbed point associated with remains of large fish at El Juyo, Santander (after Pokines & Krupa 1997).
Figure 2.6 Upper Palaeolithic spear thrower, Laugerie-Basse, France ca. 30cm (after Garrod 1955).

Figure 2.7 Reconstruction of fibre technology, Pavlov I, Czech Republic (after Adovasio et al. 1996)

a) fully flexible or semi-flexible fabric
b) semi-flexible fabric.
Figure 2.8 Hexagonal ‘mesh’ design engraved on mammoth tusk fragment, Eliseevichi, Desna Basin, Russia (after J G D Clark 1975).

Figure 2.9 Mobiliary artwork in clay, interpreted as representation of a sole, from mid-recent Magdalenian context at Lespugue, Haute Garonne, France (after Cleyet-Merles & Madelaine 1995).
Figure 2.10 Representations of fish from Upper Palaeolithic contexts:

1. Engraving of deer and salmon on deer antler, Lorthet, Hautes-Pyrénées, France (after Sollas 1911)
2. Engraving of fish on reindeer antler baton, La Madelaine, Ardèches, France (after Rau 1885)
3. Engraving of fish on reindeer antler, La Madelaine, Ardèches, France (after Rau 1885)
4. Cave drawing of flatfish, Le Mas d’Azil, Ariège, France (after Cleyet-Merle & Madelaine 1995)
5. Cave drawing of flatfish, Altexerri, Spain (after Cleyet-Merle & Madelaine 1995)
6. Pike engraved on drilled bear tooth, Duruthy Grotto, Landes, France (after Lartet & Christy 1875)
7. Outline of trout? drawn on the floor of Niaux Cave, Ariège, France (after Sollas 1911)
8. Engraving of Squalidae? on reindeer jaw, Laugerie Basse, Dordogne, France (after Rau 1885)
Figure 2.11 $\delta^{15}\text{N}: \delta^{14}\text{N}$ foodweb.

There is preferential uptake of $\delta^{15}\text{N}$ compared to $\delta^{14}\text{N}$ as the trophic level increases.
Figure 2.12a Carbon isotope values - Mesolithic humans
Typical bone collagen values for humans consuming marine fish, freshwater fish and $C_3$ terrestrial herbivores are indicated by the lines denoted 1, 2, and 3, respectively.
Figure 2.12 (contd) b Carbon isotope values - Mesolithic humans
Typical bone collagen values for humans consuming marine fish, freshwater fish and C₃ terrestrial herbivores are indicated by the lines denoted 1, 2, and 3, respectively.
Figure 2.13 Nitrogen isotope values - Mesolithic human

Typical bone collagen values for humans consuming C₃ terrestrial herbivores, freshwater fish and marine fish are indicated by the lines denoted 1, 2 and 3, respectively.
Figure 2.14 Carbon isotope values - Mesolithic dogs

Typical bone collagen values for dogs consuming marine fish, freshwater fish and C\textsubscript{3} terrestrial herbivores are indicated by the lines denoted 1, 2, and 3, respectively. Each value obtained at Ringkloster is given owing to the large variation in isotope signals at this site.
Figure 4.1 Bowyer terminology (after Bergman 1993)

Figure 4.2 Rock painting of recurved bow of stone age date from Alpera, Spain (after Feustel 1985)
Figure 4.3 Hook terminology

This terminology is applies for all hook types, illustrated here with a U-shaped bent-wood hook with recurved point (after Croes 1997).

Figure 4.4 Fishhooks manufactured from materials with natural barbs

1., 2. Neolithic fishhooks of pike dentaries from Saint Blaises, Switzerland (after Choyke & Bartosiewicz 1994)


Figure 4.5 Bi-point and single-point gorges of the Hupa, Northwest Coast (after Kroeber & Barrett 1960-62)
Figure 4.6 Dip-nets
Dip-nets used by the Central Coast Salish to collect fish concentrated at weirs and from fishing platforms built in the central flow of rivers (after Suttles 1990c).

Figure 4.7 Seine net (after von Brandt 1984a)
Figure 4.8 Lift net (after Brinkhuizen 1983)

Figure 4.9 Trawl set between two canoes (after H Stewart 1977)
Figure 4.10 Example of a set net with floats and sinkers
Gillnet with diamond shaped mesh, square wooden floats and perforated sinkers used in traditional fisheries of North west Coast (after H Stewart 1977).

Figure 4.11 Tangle net (after von Brandt 1984a)
Tangle nets consist of two or more layers of loosely-hung gillnet.
Figure 4.12 Cast net
Circular cast net constructed in triangular sections (after Brinkhuizen 1983).

Figure 4.13 Fish snares (after von Brandt 1984a)
Figure 4.14 A range of harpoons and spears used for fishing
1., 3., 4. Harpoons; 2. Self-barbed point. All used in traditional Californian fisheries (after Bennyhoff 1950)
7.-13. Fish spears, harpoons, leisters and rake of Northwest Coast groups (after H Stewart 1977).
Figure 4.15 Fish gaff
Most commonly used for the capture of salmon during spawning runs, (after Jenkins 1974).

Figure 4.16 Tubular traps
2. Open woven tubular trap used in traditional Scandinavian fisheries (after Fisher 1993).
Figure 4.17 Throated trap or non-return device (after Brinkhuizen 1983)

Figure 4.18 Trumpet traps
1. Putt, trumpet trap used in Severn Estuary (after Jenkins 1974).
Figure 4.19 Fish and crustacean pot or creel (after von Brandt 1984a)

Figure 4.20 Example of a trap constructed from netting set on a wooden framework.
Fyke net used in traditional Indian fisheries (after Hornell 1929b).
Figure 4.21 Salmon box
Set to collect fish at the base of waterfalls and natural obstacles to migration by Northwest Coast groups (after H Stewart 1977).

Figure 4.22 Cover pot (after von Brandt 1984a)
Cover pot of the Kerala, Southern India, used for fishing shallow waters.
1. Wattle weir with basketry collecting traps and fishing platforms
2. Barrier used to concentrate lamprey, which are collected with dip-nets
Figure 6.1 Bird bolts, Nizhnee Veret’e, Russia (after Oshibkina 1989)

Figure 6.2 Bow, Holmegaard, Denmark
(after Mathiassen 1948)
This takes the form of the majority
of bows recovered from Mesolithic
sites across Europe.
Figure 6.3 Bann flake (after Woodman 1978b)
1. Bann flake

Figure 6.4 Slotted bone points with flint inserts
4. Outline illustrating flint inserts of slotted point from Tlokowo
(after Sulgostowska 1996)
Figure 6.5 Simple bone points
1., 2. Hohen Viecheln, Germany; ca. 20.4 & 18.5cm respectively (Schuldt 1961)
3., 4. Tybrind Vig, Denmark; ca. 10.5 & 11.2cm respectively (Andersen 1987a)

Figure 6.6 Bone eel slitters
Eel slitters set in wooden handles used for skinning and gutting eel
Examples range from ca. 2-6cm in length.
Figure 6.7 Mesolithic fish leisters

1. Possible leister prongs from Brabrand, Denmark, analogous to leister prongs of Native American groups but originally interpreted as a throwing stick (after Rozoy 1978)

2. Barbed bone points found in association, Siretorp, Sweden (after J G D Clark 1936)

3. Three-pronged wooden leister with binding intact, Æro, Denmark (after Andersen 1995)
Figure 6.8a Barbed Points

1. Notched bone point, Hornsea, England; 25.3cm (after J G D Clark 1936)
2. Notched bone point, Leman & Ower Bank, North Sea; 21.8cm (after Burkitt 1932)
3. Barbed bone point (right) and method of hafting (left), Ulkestrup IV, Denmark; ca. 22.7cm (after J G D Clark 1975)
4. Hafted barbed point secured with resin and binding cord, Rabeløvsjon, Sweden (after J G D Clark 1975)
5., 6. Barbed bone points bearing traces of binding cord, Friesack, Germany; ca. 17.0 & 19.5cm respectively (after Gramsch 1992)
Figure 6.8 (contd.) b Barbed Points
1., 2. Fragment of barbed bone points from Vlasac, Serbia (after Letica 1969)
3. Possible harpoon head from Climente Cave, Romania (after Boroneant 1999)
4. Barbed point described as a harpoon head, Gudsø Vig, Denmark; 19.2cm
   (after Mathiassen 1948)
Figure 6.8 (contd.) c Range of barbed points from Hohen Viecheln, Germany possibly used for fishing (after Schuldt 1961)

1. Notched point; 12.1cm.
2. Single barbed point; 14.3 cm.
3. Simple point; 17.4cm.
4., 5. Medium barbed points; 22.2 & 15.3cm respectively.
6. Recurved barbed point fragment; 8.9cm
Figure 6.8 (contd.) Mesolithic barbed points - unusual forms
Figure 6.9 Barbed points, Star Carr, England (after J G D Clark 1954)
1. Barbed point of form consistent with hafting as a leister; 10.2cm
2. Grouping of points possibly originally forming a multi-pronged leister.
Size of barbed points: 28.0, 27.5 & 29.0cm respectively.

Figure 6.10 Multi-barbed bird spear (after Suttles 1990c)
Figure 6.11 Range of barbed points incorporated into fish spears, leisters and harpoons, California (after Bennyhoff 1950).
Figure 6.12 Two forms of leister prongs recovered at Tybrind Vig, Denmark (after Andersen 1995)

1. Short broad type, form is consistent with use over hard substrates
2. Long slender type, form is consistent with use over soft substrates.
Figure 6.13 Traditional Irish eel spear (after Went 1951)
The leister is used for the capture of brown eel buried in substrate

Figure 6.14 Composite barbed points
1. Suggested form of composite wooden barbed point with microlithic barbs
2. Composite hardwood barbed point used for fishing in the Amazon Basin
   (after Curwen 1941).
Figure 6.15 Wooden club from Holmegaard, Denmark
c. 31cm (Mathiassen 1948)

Figure 6.16 Fish clubs (after H Stewart 1975)

Clubs used to despatch large salmon and sturgeon by Northwest Coast groups.
Figure 6.17 Mesolithic bone fishhooks
1. Bloksbjerg, Denmark; 2.9cm (after Schwantes 1928); 2. Svaerdborg, Denmark (after Feustel 1985); 3. Tybrind Vig, Denmark; 3.1cm: illustrating method of line attachment (after Trolle-Lassen 1984); 4. Ertebolle, Denmark; 2.6cm (after Andersen 1995); 5. Aggersund, Denmark; 7.2cm (after Andersen 1995); 6. Sonderholm, Denmark; 1.4cm (after Andersen 1995); 7. & 8. Viste, Norway (after J G D Clark 1936) 9. Ageröd, Sweden; 4.7cm (after Larsson 1978b).
Figure 6.18 Fish hooks of the cod and halibut fisheries of the Northwest coast
1. Nootkan U-shaped bent-wood hook with composite crook (after Lartet & Christy 1875)
Figure 6.19 Mesolithic floated-fishhooks, Nyelv Nedre Vest
(after Renouf 1989)
The morphology of both hooks is consistent with float attachment at the bend.

Figure 6.20 Floated hooks or ‘samolovs’ of traditional European fisheries
1. Floated hook (after de Rohan Csermak 1963).
2. Method of floating hooks, ‘samolovs’ from a weighted bottom long-line
(after Brinkhuizen 1983).
Figure 6.21 Bone fish hooks, Varanger Fjord (after Renouf 1989)

Figure 6.22 Bone fish hooks used for marine fishing
Baited bone fish hooks of 1. Inuit and 2. Saami groups. These forms are analogous to Mesolithic examples from the Varanger Fjord (after de Rohan Csermak 1963).
Figure 6.23 Mesolithic composite fishhook crooks

1. Possible crook of fishhook from Bloksbjerg, Denmark (after Schwantes 1928)
2. Possible crook of composite hook or gorge from Bloksbjerg, Denmark (after Schwantes 1928)
3. Gorge from Nyelv Nedre Vest, Norway (after Renouf 1989)
4., 5. Possible gorges from Téviec, France; 8.2 & 6.6cm respectively (after Rozoy 1978)
6., 7. Possible crooks of composite hook from Gressbakken, Norway; 6.1 & 3.7cm respectively (after Renouf 1989)
8., 9., 10. Crooks of composite hooks, Gressbakken, Norway; 5.7, 5.7 & 3.6cm respectively (after Renouf 1989).
Figure 6.24 Composite bone hooks of traditional fisheries
1. Composite hook of Californian groups (after Bennyhoff 1950).
The crook is analogous to artefacts from Sønderholm (Figure 17.6).
2. Composite trolling hook demonstrating method of binding, from a tributary of the Oka River, Russia (after de Rohan Csermak 1963).
Figure 6.25 Composite trolling hook of Maori known as ‘pa kahawai’ (after Best 1929)

Figure 6.26 Composite fishhook of Greenland Inuit with microlithic crook (after Rau 1885)
Figure 6.27 Unmodified line sinker

Method of securing sinker to fishing line so that the catch can be hauled without the weight of the sinker (after H Stewart 1977)
Figure 6.28 Mesolithic plummets
1. Possible line or net sinker from Hohen Viecheln, Germany (after Schuldt 1961)
2. Perforated plummet from Ostrovul Mare, Romania (after Boroneant 1999)

Figure 6.29 Floated bottom-line, Northwest Coast (after Croes 1997)
Bottom-floated V-shaped hooks used for flatfish fishing.
Figure 6.30 Sheet-bend knot (after Stjernquist 1952)

Figure 6.31 Fragments of net from Friesack, Germany

1. Knotless netting: the mesh is held secure by twisting rather than knotting the cord (after Gramsch & Kloss 1989).
Figure 6.32 Bark floats from Antrea, Finland (after J G D Clark 1936)

Figure 6.33 Inuit set net with float analogous to the Antrea examples (after E W Nelson 1899).
Figure 6.34 Bark floats, Hohen Viecheln, Germany (after Schuldt 1961)
An illustration of the two types of float recovered at the site.
1. Diameter 9cm. 2. Maximum 7.9 x 5.0cm.
Figure 6.35 Sinkers of traditional fisheries

1. 19th century, Denmark (after Rau 1885).
2, 3, 4. 19th century, Co. Down & Co. Westmeath, Ireland (after Rau 1885).
5. Native American, Susquehanna Valley (after Rau 1885).
7., 8. Notched sinkers, Susquehanna Valley, USA (after Rau 1885).
9. Gravel filled bark sinkers from Neolithic contexts at Zvidze, Latvia (after Loze 1988a)
Figure 6.36 Possible notched stone sinker from Birsmatten, Switzerland (after Bandi 1963)

Figure 6.37 Possible perforated sinkers
This type of artefact is generally interpreted as a mace-heads but takes the same form as the perforated sinkers of traditional fisheries (Figure 6.38)
1. Friesack, Germany (after Gramsch & Kloss 1989).
2. Hohen Viecheln, Germany; maximum 9.1cm diameter (after Schuldt 1961).
Figure 6.38 Polished, perforated stone sinkers of Northwest Coast groups
This form of sinker (after Kroeber & Barrett 1960-62), used to weight set nets is analogous to the 'mace-head' artefacts recovered at European Mesolithic sites (see Figures 6.35 and 6.36).

Figure 6.39 Perforated sinker, dredged from Storefiske Bank, North Sea; ca. 3.1cm (after Bjerk 1995)
Figure 6.40 Sinkers from Schela Cladovei, Romania

1. Pecked grooved sinker
2. Notched sinker.

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Figure 6.41 Possible wooden frame of dip-net from Vis I, Russia (after Burov 1992)

Figure 6.42 Mesolithic decorated bone ‘netting needles’
1. Limhamn, Sweden (after J G D Clark 1936)
2. Fünen, Denmark (after J G D Clark 1936)
3. Los Azules, Cantabria
(after Fernández-Tresguerres Velasco 1979)

Figure 6.43 Net spreaders of Northwest Coast groups
(after Kroeber & Barrett 1960-62)
Figure 6.44 Artefacts analogous to Northwest Coast net spreaders, Hohen Viecheln, Germany (Schuldt 1961)
1. 42.0cm. 2. 41.8cm.

Figure 6.45 Mesolithic fish pulses
1. Wooden disc interpreted as a fish pulse, Vis I, Russia; 7.8cm diameter (after Burov 1992)
2. Wooden disc, possible fish pulse, Bloksbjerg, Denmark; 13.6cm (after Schwantes 1928).
Figure 6.46 Wooden spindle whorl, Northwest Coast
(after H Stewart 1975)
The spindle whorl is analogous to wooden floats and fish pulses
Figure 6.47 Examples of Mesh designs engraved on Mesolithic artefacts
1. Engraving of mesh on bone fragment, Bohuslän, Sweden (after J G D Clark 1975)
2. Engraving of mesh on antler tine, Sjoholmen, Sweden (after Larssen 1978a)
3. Engraving of mesh on antler adze, Sjoholmen, Sweden (after Larssen 1978a)
4. Engraving of mesh on bone fragment, Mullerup, Denmark (after J G D Clark 1975).
Figure 6.48 'Mesh' designs on lithic artefacts

1. Sandstone slab with 'mesh' design, Ageröd I, Sweden (after Althin 1950)
2. Flint core with 'mesh' design, Ageröd I, Sweden (after Althin 1950).
Figure 6.49 Mesolithic fish traps
1. Reconstruction of Tybrind Vig, Denmark, trap based on recovery of 2. wooden ‘thwart’; 94cm long (after Andersen 1995)

Figure 6.50 Basketry fragment recovered at Vis I, Russia, interpreted as a close-woven trap (after Burov 1992)
Figure 6.51 Trumpet fish trap, Villingebæk, Denmark (after Rozoy 1978)
Figure 6.52 Throated fish trap fragment, Nidløse, Denmark (after Mathiassen 1948)

Figure 6.53 Throated fish trap, Lille Knabstrup, Denmark (after Andersen 1995)
Figure 6.54 Traditional Scandinavian eel weir
This type of eel weir with fyke-net is analogous to a reconstruction of the Tybrind Vig, Denmark, weir proposed by Pedersen (after Pedersen 1995; Fischer 1993).

Figure 6.55 Reconstruction of fish weir at Neolithic site of Oleslyst, Denmark (after Pedersen 1992).
Figure 6.56a dugout from Pesse, Netherlands (after Rozoy 1978)

Figure 6.56b dugout from Tybrind Vig, Demark (after Andersen 1987a)

1. Plan of dugout illustrating hearth and ballast stone
2. Reconstruction of dugout.
Figure 6.57a Mesolithic Paddles

Figure 6.57 (contd.) B Blade morphology (after Burov 1992)
Figure 6.58 Bullhide coracle of the Minnetarees, Dakota (after Rau 1885)
This type of coracle was used in traditional fisheries in the coastal regions of Europe.

Figure 6.59 Boat thwarts
1. Magleø, Denmark (after Mathiassen 1943)
2. Tybrind Vig, Denmark (after Andersen 1987a)
Figure 7.1 - Fish species from Mesolithic sites

Quantitative

Graphical representation of the quantitative analysis of faunal remains recovered from Mesolithic sites. As discussed in the text, for each site, numerical fish species abundance was converted into percentage abundance in order to facilitate inter-site comparison. Sites were grouped according to the criteria of site location and period of occupation as follows; a) all Mesolithic sites, b) inland sites, c) coastal sites, d) Early Mesolithic inland and e) Late Mesolithic inland. For each grouping the sum of percentage abundance of each fish species were calculated (vertical axis) and fish species ranked along the horizontal axis. Only the most frequently occurring species are included in the graphs.
Figure 7.1 Fish species from Mesolithic sites (quantitative)
Inland Early Sites

Inland Late Sites

Figure 7.1 (contd)
Figure 7.2 - Fish species from Mesolithic sites

Qualitative

Graphical representation of the qualitative analysis of fish species recovered from Mesolithic sites. As discussed in the text, for each site, the presence or absence of a particular species was assessed. Sites were grouped according to criteria of site location and era of occupation as follows; a) all Mesolithic sites, b) inland sites, c) coastal sites, d) Early Mesolithic inland and e) Late Mesolithic inland. For each grouping the number of sites, positive for each fish species were calculated (vertical axis) and species ranked along the horizontal axis. Only the most frequently occurring species are included in the graphs.
Figure 7.2 Fish species from Mesolithic sites (qualitative)
Figure 7.2 (contd)
Figure 7.3i - Artefact occurrence at Mesolithic sites

Quantitative

Graphical representation of the quantitative analysis of fishing-related artefacts recovered from Mesolithic sites. As discussed in the text, for each site, numerical artefact abundance was converted into percentage abundance in order to facilitate inter-site comparison. Sites were grouped according to criteria of site location and period of occupation as follows; a) all Mesolithic sites, b) inland sites, c) coastal sites, d) Early Mesolithic, e) Late Mesolithic, f) Early Mesolithic inland and g) Late Mesolithic inland. For each grouping the sum of percentage abundance of each artefact were calculated (vertical axis) and artefacts ranked along the horizontal axis.
Figure 7.3i Artefact occurrence at Mesolithic sites (quantitative)
Figure 7.3i (contd)
Early Mesolithic Inland Sites

Late Mesolithic Inland Sites

Figure 7.3i (contd)
Figure 7.3ii - Artefact occurrence at Mesolithic sites

Quantitative

Graphical representation of the quantitative analysis of fishing-related artefacts recovered from Mesolithic sites. In contrast to Figure 7.3i, sites with unassociated or isolated finds of barbed points were excluded from this study to lessen the bias of sites where points were used for terrestrial hunting. As discussed in the text, for each site, numerical artefact abundance was converted into percentage abundance in order to facilitate inter-site comparison. Sites were grouped according to criteria of site location and era of occupation as follows; a) all Mesolithic sites, b) inland sites, c) coastal sites, d) Early Mesolithic, e) Late Mesolithic, f) Early Mesolithic inland and g) Late Mesolithic inland. For each grouping the sum of percentage abundance of each artefact were calculated (vertical axis) and artefacts ranked along the horizontal axis.
Figure 7.3ii Artefact occurrence at Mesolithic sites (modified quantitative)
Figure 7.3ii (contd)
Early Mesolithic Inland Sites

Late Mesolithic Inland Sites

Figure 7.3ii cont.
Figure 7.4 - Artefact occurrence at Mesolithic sites

Qualitative

Graphical representation of the qualitative analysis of fishing-related artefacts recovered from Mesolithic sites. As discussed in the text, for each site the presence or absence of a particular artefact was assessed. Sites were grouped according to criteria of site location and era of occupation as follows; a) all Mesolithic sites, b) inland sites, c) coastal sites, d) Early Mesolithic, e) Late Mesolithic, f) Early Mesolithic inland and g) Late Mesolithic inland. For each grouping the number of sites positive for each artefact were calculated (vertical axis) and artefacts ranked along the horizontal axis.
Figure 7.4 Artefact occurrence at Mesolithic sites (qualitative)
Early Mesolithic Sites

Late Mesolithic Sites

Figure 7.4 (contd)
Figure 7.4 (contd)
Figure 7.5 Netting needles of Northwest Coast groups
1. Expediently produced wooden netting needle, Coast Yurok (after Gifford 1939)
2. Expediently produced wooden netting needle, McCloud River (after Rau 1885)

Figure 7.6 Possible wooden netting needle, Friesack, Germany (after Gramsch 1992)
Figure 7.7 - Regional variation in identified fish species

Graphical representations of the regional differences in the quantitative abundance of fish species. Sites were grouped into the nine geographical regions shown and the sums of the percentage abundance calculated for each species of fish within each grouping. Some species were grouped into a single family such as 'salmonids' or 'cyprinids' in order to compensate for the lack of species-level identification for certain families of fish. Species were ranked in order of abundance and displayed in pi-chart form.
Figure 7.7 Regional variation in identified fish species
Figure 7.7 (contd)
Figure 7.7 (contd)
Figure 7.8 - Regional variation in artefact occurrence

Graphical representations of the regional differences in the quantitative abundance of fishing-related artefacts. Sites were grouped into the eight geographical regions shown and the sums of the percentage abundance calculated for each type of artefact within each grouping. Some artefacts were grouped into a single category such as 'net-related' or 'hook-related' in order to compensate for the variety of forms observed. Artefacts were ranked in order of abundance and displayed in pi-chart form.
Figure 7.8 Regional variation in artefact occurrence
Figure 7.8 (contd)
Figure 7.8 (contd)
Figure 7.9 Fish: artefact correlations
Figure 7.10 Circular fishhooks (after Timbrook 1991)
Circular bone and shell fishhooks of this form were used in the traditional fisheries of Africa, North America and Polynesia for the capture of large predatory fish in marine and freshwaters.

Figure 7.11 Fish hooks, Cyclops Cave, Youria, Greece (after Sampson 1996)
Interpreted as tuna trolling hooks these artefacts are analogous to the trolling hooks of Northwest Coast and Polynesian groups.
**Figure 8.1** Above-ground fish-storage structures set on piles or in trees (after H Stewart 1977).

**Figure 8.2** Bark storage vessel from Friesack, Germany (Gramsch 1992)

**Figure 8.3** Fish rake

Rakes are used by Maori and Northwest Coast groups to collect migratory species (after H Stewart 1975).