The scope of Strategic Environmental Assessment of Continental Shelf Area SEA 4 in regard to prehistoric archaeological remains

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Executive Summary

Prehistoric submarine archaeological remains back to a date of about 9000 years ago, Mesolithic and Neolithic, could occur in the SEA4 area between the northern mainland coast and out to a depth of the order of 150m on either side of the Orkney-Shetland Ridge. The combination of post-glacial sea level rise which terminated about 5000 years ago, and the continuing subsidence of the shelf, with uplift of the mainland, creates a complex sequence at coastal sites which may have been dry land over 5000 years ago, then covered by the rising sea, and are now uplifted again. Coastal sites in the Hebrides, St Kilda, Orkneys, and Shetland show that human cultures with seafaring and advanced constructional techniques occupied northern Scotland at least 9000 years ago. Known submerged prehistoric sites in Orkney, Shetland, Viking Bank, and Denmark, show that prehistoric sites from the last 5-10,000 years can survive marine transgression. The strong current conditions in the SEA4 area, the exposure to full North Atlantic storm conditions, the thin sediment cover in many places, and the large areas of exposed bedrock, make the exposed areas of the shelf statistically poor prospects for the survival of prehistoric deposits *in situ*, other than in submerged caves. Within the sheltered sea lochs and enclosed bays of the archipelagos, in submerged gullies, and locally thick sediments, survival is quite likely. Deposits in open shelf gullies are likely to have been transported and re-deposited. Evidence from the northern North Sea suggests that some prehistoric peoples may have occupied the exposed shelf area during late glacial periods utilising Inuit-style survival methods, and butchering marine mammals. If this proves to be the case, there may be unexpected occurrence of earlier prehistoric sites, Late Palaeolithic, on the north-west shelf. Pipe entrenching is the process in the oil and gas industry which is most likely to disturb prehistoric archaeological deposits. Commercial site investigation using acoustics and coring could provide beneficial new archaeological data. The paper concludes with tentative suggestions for discussion of protocols and a reporting regime.

Contents

1. Overview of the legislation and agreements (Scottish, UK, EU and international) that apply to marine and maritime prehistoric and archaeological remains off the coast of Scotland.

1.1 UN Conventions, European laws and directives, UK legislation, Scottish legislation, and non-statutory codes and procedures all apply to coastal and offshore marine, maritime and submarine archaeology. Historic Scotland for Scottish Ministers has responsibility for archaeology within the 12 nautical mile Territorial limit, and SEA4 is thus partly within Scottish Waters. Outside the Territorial limit the continental shelf is UK jurisdiction, but Historic Scotland is necessarily extending its interest in this area, in the same way that English Heritage is taking some responsibility for submarine archaeology beyond the 12 nm limit off the English coast.

1.2 In this report there will be no analysis or discussion of the state of shipwreck archaeology. There are an estimated 26,500 historic losses over 100 years old and 13,500 wrecks in UK Territorial Waters (English Heritage 2002, para. 4.3), and in Scottish waters the Protection of Wrecks Act (1973) is administered by Historic Scotland. There are many more wrecks in deeper water further offshore. Many of the same international legislative documents apply to all types of marine archaeology, whether of shipwrecks, abandoned single artefacts, or submerged sites of previous human occupation. However, the emphasis of the present report is entirely on the subject of submerged sites where human beings and early hominids previously lived or hunted on terrain which was at that time dry land, or where they exploited fish and shellfish on the coast which is now submerged. Sites discussed are all older than 2,000 years, and mostly older than 4,000 years. It must not be assumed that the comments made or conclusions reached in this paper would apply in exactly the same way to shipwrecks on the sea bed.

1.3 Legal regimes will be reviewed from the global and UN level successively downwards in scale to the regional and local, and non-statutory agreements or codes. When reporting the status of legislative documents which may or may not have been signed on behalf of the UK Government or UK agencies I will not comment as to the reasons, nor as to likely changes in policy. All terms such as "underwater cultural heritage", "maritime archaeology", "marine archaeology", "submarine archaeology", "nautical archaeology" etc., will be deemed to have equivalent meaning. Nothing stated in the following discussion should be interpreted as an attempt to define strict legal obligations. It is an attempt to show by analogy, and in plain language, how prudent anticipation of future events leads to a consistent view of the responsibilities of regulatory authorities and operators.

1.4 The United Nations Convention on the Law of the Sea (UNCLOS) was negotiated continuously from 1968 through to 1982 when the Convention document itself was agreed. The Convention became recognised international law when it had been ratified at national level by 65 states, and was ratified by UK on 25 July 1997. Although UNCLOS entitles the coastal state to declare an Exclusive Economic Zone out to about 200 nautical miles from a coastal baseline, and to declare an extra 12 nautical mile Contiguous Zone outside the traditional 12 mile Territorial Sea, the UK has decided not to opt for either of these legal rights.

1.5 The Articles of UNCLOS directly concerned with marine archaeology are 149 and 303 (See Annexe 1). Article 149 applies only to archaeology in the International Area outside national jurisdiction. Since, by definition, SEA4 defines a part of the UK Continental Shelf these circumstances do not apply. Article 303(1) stipulates that all states have the duty and right to protect archaeological resources found at sea "and shall co-operate for this purpose". This Article is completely open-ended, with no geographical boundaries or distinctions between different economic or jurisdictional zones. Since the UK has signed UNCLOS, and has a designated Continental Shelf which includes SEA4 which is periodically licensed for the exploitation of both hydrocarbons and aggregates, it follows that Article 303 applies in a general sense to SEA4.

1.6 The UNESCO Convention on the Protection of the Underwater Cultural Heritage (UCPUCH) (General Conference, 31C, 2001) is an international and globally applicable document which has been passed by UNESCO General Conference, but has not been ratified by sufficient countries to become international law. It has not been ratified by the UK. It is probable that the necessary number of signatories to make the Convention into agreed International law may never be obtained.

1.7 There is considerable tradition, at least in the field of international legal conventions concerning the sea, for complex documents to be discussed for many years, and for those draft clauses or principles which have consensus acceptance to become the guidelines by which people act, while other principles are neglected, ignored, or rejected, long before agreement or ratification of the final document. Thus the UNESCO Convention should prudently be considered in terms of the "going rate" for the levels of national regulatory control which the coastal state might be obliged to assert on its Continental Shelf, and similarly for the obligations of operators exploiting or utilising the resources of the Continental Shelf.

1.8 The Preamble to UCPUCH states that UNESCO is conscious "of the need to respond appropriately to the possible negative impact on underwater cultural heritage of legitimate activities that may incidentally affect it". This is the situation which applies to SEA4 and to this Report. Underwater cultural heritage is defined, as in most other documents, as traces of human existence which have been partially or totally underwater for at least 100 years. UCPUCH is designed to be compatible with UNCLOS (UCPUCH, Article 3)

1.9 UCPUCH (Article 4) states that underwater cultural heritage shall not be subject to the law of salvage, unless this is authorised by the competent authorities, and the cultural heritage materials have maximum protection. UK Salvage Law only applies to shipwreck, including articles associated with shipwreck, and so salvage law does not apply to prehistoric material on the UK Continental Shelf whether outside or inside Territorial Waters, even if the raised material is landed at a British port.

1.10 UCPUCH (Article 5) states that signatories should use the "best practicable means" to prevent or mitigate adverse effects to underwater cultural heritage caused by legitimate activities under their jurisdiction. Again, although UK has not signed, the general indication of this Article is clear. A point of uncertainty and ambiguity regarding this clause is the extent to which it is completely open-ended, requiring apparently unlimited commitment to ensure that no damage is done, and to what extent a common-sense judgement should be applied regarding the chances of an unknown site lying in the path of some legitimate commercial activity. This obligation is dealt with more specifically in UCPUCH (Article 10.4) which applies directly to the Continental Shelf

1.11 The UNESCO Convention concludes with a set of Rules Concerning Activities Directed at Underwater Cultural Heritage. The preferred means of protecting cultural heritage sites is protection *in situ*. For prehistoric sites this is sensible, provided there is no erosion, since only a few sites need to be excavated, and it is sufficient in most cases to document the type of site for research purposes. In the southern and central North Sea the volume of Pleistocene terrestrial mammal bones recovered by bottom trawlers is sufficient to support a modest trade in sorting and dispersing the bones to museums, research groups, collectors and fossil shops (Post and Kompanje, 1995; van Kolfschoten and Laban, 1995; Post *et al.*, 2001). Some of the bones have been adapted as tools by humans (Louwe Kooijmans, 1970-71; Post, personal communication 2002). The flow of material recovered by fishermen in Scottish Waters is likely to be much smaller, but not zero. Since the bones and fossils are inevitably disturbed by bottom trawls (van Kolfschoten and Laban, 1995) it is better that the disturbed and recovered material should be monitored by palaeontologists and archaeologists than simply lost. The combination of erosion and disturbance by trawling needs to be assessed fully before deciding that an archaeological site can be safely left *in situ*. Most of the remaining Rules refer to the planning and conduct of projects conducted by specialist archaeologists to study or excavate sites of underwater cultural heritage.

1.12 The European Convention on the Protection of the Archaeological Heritage (Revised) (The Valetta Convention) was agreed by the Member States of the Council of Europe in 1992, and became law on 20 March 1992. It has been ratified by the UK, and in Scotland the lead body is Historic Scotland. Most of the Articles concern archaeology on land, control of the trade in antiquities and the prevention of looting. The Valetta Convention (VC) applies "underwater" (Article 2.ii). Historic Scotland implements VC, and has programmes for coastal archaeology, analysis of erosion and its impact on archaeology (Historic Scotland Archaeological Procedure, Paper 4, 1996) and offshore submarine archaeology, which is covered by the Policy Paper "Conserving the Underwater Heritage" (Historic Scotland, 1999). The latter paper mentions "...remains of structures which were originally built wholly or partly underwater, such as fishtraps and crannogs and also the remains of human activity which originally took place on dry or marshy land which has since been inundated, either by water levels rising relative to land or by marine or fluvial erosion." This clearly includes submerged prehistoric sites inundated by rising post-glacial sea level. The legally stated limit at present is out to the 12 mile limit of

Territorial Waters, but serious research concern is applied to the problems of marine archaeology in deeper water out to the shelf edge. The Ancient Monuments and Archaeological Areas Act 1979 gives powers to schedule monuments within the Territorial Seas. The Protection of Wrecks Act (1973) is administered in Scotland by Historic Scotland for Scottish Ministers, and this applies out to the 12 mile limit. However, HS takes a pragmatic interest in submarine archaeology throughout the continental shelf area, as would be required by the Valetta Convention.

1.13 In VC the archaeological cultural heritage is also linked with the concept of "historical and scientific study" (Article 1.1) and "research into mankind and the related environment" (Article 1.2.i). This suggests an analogy with the many Articles of UNCLOS relating to scientific research. Article 1.3 of VC states that it applies whether on land or under water.

1.14 VC (Article 2) provides for "archaeological reserves" on land or under water. VC (Article 5) spells out at length the consultation which should take place between planning authorities and developers to avoid damage to archaeological remains. The implications are relevant, by analogy, to procedures which may be recommended on the UK Continental Shelf in SEA4.

1.15 The terms of reference for this report require consistence and compatibility with the Guidance Notes on protecting the offshore heritage produced by BMAPA and RCHME (Wessex Archaeology, 2001). In practice there is no aggregate dredging in SEA4, and the authority of RCHME does not apply in Scotland. Nevertheless, it is reasonable that the principles established in that document should be taken into account, as, equally, the policy statement of English Heritage in response to its formal appointment as the body responsible for implementing the Valetta Convention in England (EH, 2002, Taking to the Water). These documents are discussed in the DTI report on SEA3, and will not be further analysed in this report. To all intents and purposes, on pragmatic grounds, the policy of HS itself indicates compliance with VC, with no inconsistency between Scottish and English sectors.

1.16 Three components of UK law apply directly to marine archaeology in Scotland: The Ancient Monuments and Archaeological Areas Act 1979; the authority of the Receiver of Wrecks, which applies only to shipwreck (Coastguard and Maritime Agency, Department of Trade, Merchant Shipping Act (1995)); and the Protection of Wrecks Act (1973) administered by Historic Scotland in Scottish Waters.

1.17 The Royal Commission for Ancient and Historical Monuments for Scotland (RCHAMS) maintains an archival record service documenting all archaeological sites, and this is accessible to the public and scholars through an internet search system known as CANMORE and CANMAP. RCAHMS runs a Maritime Project of the National Monuments Record of Scotland (NMRS) which seeks to document maritime sites, defined as ships, boats, and crashed aircraft, but not built structures or prehistoric sites. (Unpublished paper issued by MP of NMRS, 2002). The University of St Andrews has created a data base and GIS system analysing all coastal archaeological sites which are, or could be, threatened by coastal erosion. The contents of this data base in the SEA4 area have been reviewed in summary for the present report, and the prehistoric sites will be discussed in Section 3.

1.18 HS grant aids the Nautical Archaeology Society in Scotland. The Archaeological Diving Unit at the University of St Andrews has conducted survey work on a range of wrecks in Scottish Waters. This group has held for many years the contract for inspecting wrecks throughout the UK under the Protection of Wrecks Act (1973), but this contract has been terminated in early 2003. Heriot Watt University runs diving courses at Scapa Flow which include training for marine archaeology. Most organisations concerned with marine archaeology in the UK meet through the activities, conferences, workshops, and projects of the Nautical Archaeology Society

1.19 The Protection of Military Remains Act (1986) has the principal concern to protect the sanctity of vessels and aircraft that are military maritime graves. In 2001 the Secretary of State for Defence announced that 16 vessels within UK jurisdiction would be designated as Controlled Sites, and 5 vessels in international waters would be designated as Protected Places. The purpose of this safeguard is not primarily archaeological, but MoD liaise closely with DCMS and Historic Scotland in the process of site designation.

1.20 The previous paragraphs have reviewed a range of international and national documents which pertain to UK Territorial Sea and Continental Shelf. The SEA4 area abuts on the Median Line with Norway and Faeroes. The northern North Sea is bordered by Norway, Denmark and Germany. A prehistoric marine archaeological programme within the SEA4 area is likely to require collaboration with some of these states. Some of these states may have signed and ratified the same documents, or documents which the UK has not ratified, and collaborative projects in the North-West Approaches and northern North Sea should be based on adequate preliminary consultation on these matters.

1.21 It is good practice for government agencies, planning authorities, and industry representatives to develop non-statutory guidance, recommendations, or codes of practice for the protection of archaeological sites which may be disturbed. Consultation may take place through scholarly organisations such the Council for British Archaeology (CBA), or the Nautical Archaeology Society. For example the consultation phase of the Mineral Planning Guidance for On-Shore Oil and Gas and Coalbed Methane Development included circulation of the relevant archaeological paragraphs to the CBA in 1999-2000. Discussion of the draft specifically referred to the importance of wetland and inter-tidal archaeology, and the importance of Mesolithic activity on the Dogger Bank. The British Marine Aggregate Producers Association (BMAPA) has collaborated with the Royal Commission on the Historical Monuments of England (RCHME) to produce a Consultation Document (Wessex Archaeology, 2001).

1.22 The BMAPA/RCHME code discusses Environmental Impact Assessment (EIA) which should include a description of the measures envisaged in order to avoid, reduce, and if possible remedy significant adverse effects on the historic environment. By analogy, broadly equivalent principles may be applied to monitoring and managing the archaeological impact of the offshore Oil and Gas Industry. There is reference to prehistoric sites from Palaeolithic to Mesolithic. Pre-dredge surveys and evaluation may be needed. Dredging exclusion zones can be implemented around areas where the presence of prehistoric assemblages has been confirmed. Although it may be possible for a suitably experienced archaeologist to visit onshore screening plants periodically to carry out a visual search for stone tools and other human artefacts, such procedures appear unlikely to be productive. Copies of reports on any sites located and the measures taken should be lodged with the appropriate Curators and the NMR and NMRS as appropriate.

1.23 Summary of legal situation and the prudent practices to adopt in the Scottish Waters of the UK sector

No Government agency in the UK has been formally allocated the responsibility to monitor, manage, or protect the prehistoric cultural heritage on the UK Continental Shelf outside Territorial Waters. Within Territorial Waters the responsibility rests with Historic Scotland in Scottish Waters, and both Historic Scotland and English Heritage are concerned to protect the cultural heritage beyond that limit in their respective adjacent areas of the UK Continental Shelf. Through signing UNCLOS, the UK is duty bound to observe the stipulations of UNCLOS Article 303, while the draft UNESCO Convention indicates the responsibilities which are, by general consensus, deemed to be reasonable in regard to prehistoric cultural heritage on the Continental Shelf. The principles of the Valetta Convention, broadly interpreted, might apply on the Continental Shelf since it does apply underwater, but no UK agency has been statutorily designated to implement it outside Territorial Limits. It is therefore prudent, though not legally binding, for all parties, government agencies, regulatory authorities, commercial operators, and voluntary bodies to act as if their standards of conduct were to be judged, in broad measure, by the standards of those documents.

2. Overview of known and likely areas with prehistoric archaeological remains, with mapped indications of relative likelihood of the presence of remains (sensitivity mapping) and with hotspots identified

2.1 The earliest occupation of the British mainland by hominids, *Homo heidelbergensis*, occurred about 500,000 years Before Present (BP) (Pitts and Roberts, 1997). and recent evidence suggests that it could be as early as 700,000 years BP. Human and proto-human artefacts may therefore have been deposited in sediments or caves on the continental shelf at any time in the last half million years whenever the glacial control of world sea level caused the floor of Scottish UK continental shelf, to be dry, and outside the limits of the ice. In practice, most of the Scottish UK continental shelf was covered by successive ice sheets, and so early archaeological deposits are unlikely. However, some archaeological deposits are known to have survived over-running by ice sheets (Ashton *et al.,* 1992) at the southern edge of the ice, where river valley sediments were displaced in blocks, but retained their integrity, permitting palaeoecological studies and artefact retrieval. This was at High Lodge, Mildenhall, Wiltshire. If artefacts can survive ice sheet impact in unconsolidated deposits, there is a greater chance that deposits within caves could survive, which might be more typical of the Scottish shelf. This argument may apply also to the cave at Creag nan Uamh (see next para.).

2.2 The generally accepted earliest date of human occupation in Scotland after the last, Devensian, glaciation, is at about 9000 years (Wickham-Jones, 1994, p.46-47). This means that we are dealing almost entirely with the periods known as Mesolithic, and Neolithic (after 5500 years BP), and passing into the Bronze Age at about 3800 years BP, and Iron Age at 2800 years BP (Turner, 1998b, p.20). Older human artefacts than this have not been found on the Scottish mainland coasts, or on the islands, with incontrovertible dates. However, poorly dated remains of accumulated reindeer horns from about 900 antlers were found in 1926 in the cave of Creag nan Uamh, Inchnadamph, Sutherland, along with a possible ivory spear point (Wickham-Jones, 1994, p.43). The antlers have been studied more recently, and date over a period from 44,000 to 22,000 BP, and it is not at all certain that their accumulation was caused by man. These deposits, whatever their precise origin, show that there were ample supplies of reindeer, a basic food commodity in the Palaeolithic, in northern Scotland just before the peak of the last glaciation, the Devensian.

2.3 An extraordinary richness of cultural remains and very advanced complex Neolithic and Mesolithic structures have been found on many of the islands, off the west and north coast, and, for the present paper, it is worth postulating that there may be earlier materials on the sea floor. That is, the first occupiers of Scotland could have arrived on the outer shelf while the sea level was still tens of metres lower than at present, and that, as the sea level rose, and the ice retreated, the sparse population migrated landwards and upwards, finally occupying the mainland of Scotland, and the residual upper peaks on the shelf which became the outlying islands, including St Kilda, Orkney, and Shetland. A small component of this retreat is already proven, since the sea level was about 40-50m lower relative to the land around the Western Isles and Shetland when the first documented sites were occupied about 9000 years BP. The question is, how much earlier could people have arrived in Scotland? Also, where did the first people after the Devensian Ice Age come from?

2.4 The occurrence of human remains in southern Britain is mainly south of the southernmost extent of the multiple succession of ice sheets which grew and waned about 6 times across northern Britain in the last half million years The sequence of such multiple glacial indicators is best detected at the edge of ice sheets, where the successive ice limits may differ and not overlap. Near the centre of a thick ice cap, such details are usually very indistinct. All the ice caps centred on the Scottish Highlands, and the ice sheets extended to the edge of the continental shelf to the north and north-west. Thus, off the north coast of Scotland only two distinct phases have been detected. The earliest is broadly equivalent to the so-called Anglian glaciation about 0.4 million years BP, and the younger is equivalent to the Devensian, which had a maximum extent about 22,000 years BP, (Stoker *et al.*, 1993).

2.5 Figure 1 shows the extent of the Devensian ice, shortly after its maximum extent (Stoker *et al.,* 1993, p.114). The 5 parallel ridges on the edge of the shelf are late Devensian submarine lateral moraines (Stoker, 1997). Each ridge consists of sediments of glacial origin, probably formed during stillstands during the retreat of the ice sheet. The moraines are up to 50m high, 8km wide, and as much as 60km long. Coring reveals sands and gravels which were deposited in about 50m of water. Thus the ice fronted directly onto the Atlantic water at this stage. Iceberg ploughmarks occur in a band along the shelf break (Fig. 2, from Stoker *et al.*, 1993, p.120), consistent with this picture, and with the later drift of deep water icebergs against the shelf edge.

As the main ice retreated, small valley glaciers may have advanced and retreated. A small radial ice transport existed over Shetland. The Papa Basin (Fig. 1) is probably a glacially over-deepened valley or sub-glacial tunnel.

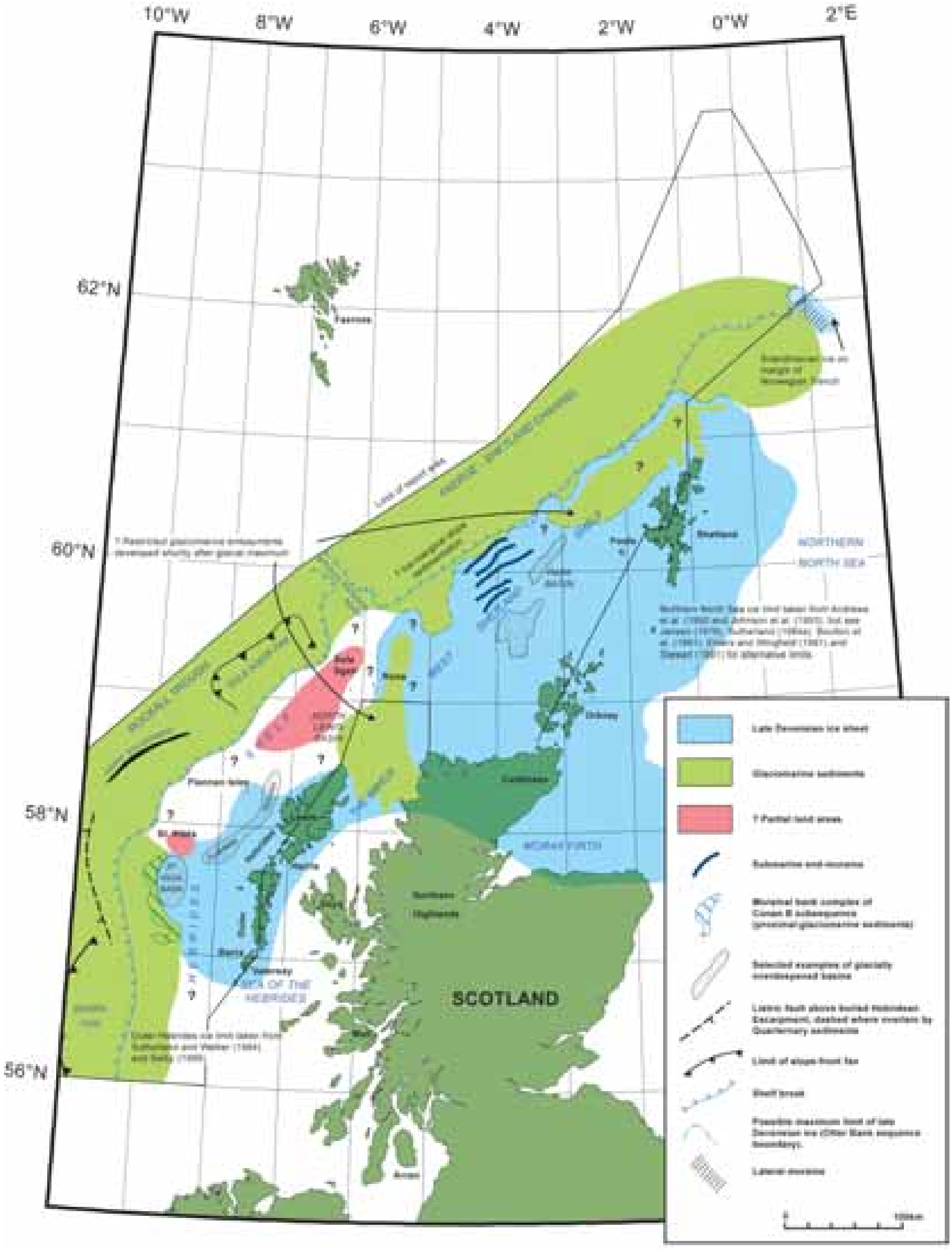


Figure 1 *Schematic palaeogeographic reconstruction showing the inferred extent of the late Devensian ice sheet at, or shortly after, the glacial maximum. (From Stoker et al. 1993). Note position of St Kilda west of the Hebrides, and the moraine complex west of Shetland (IPR/40-3C British Geological Survey. (C)NERC. All rights reserved).*

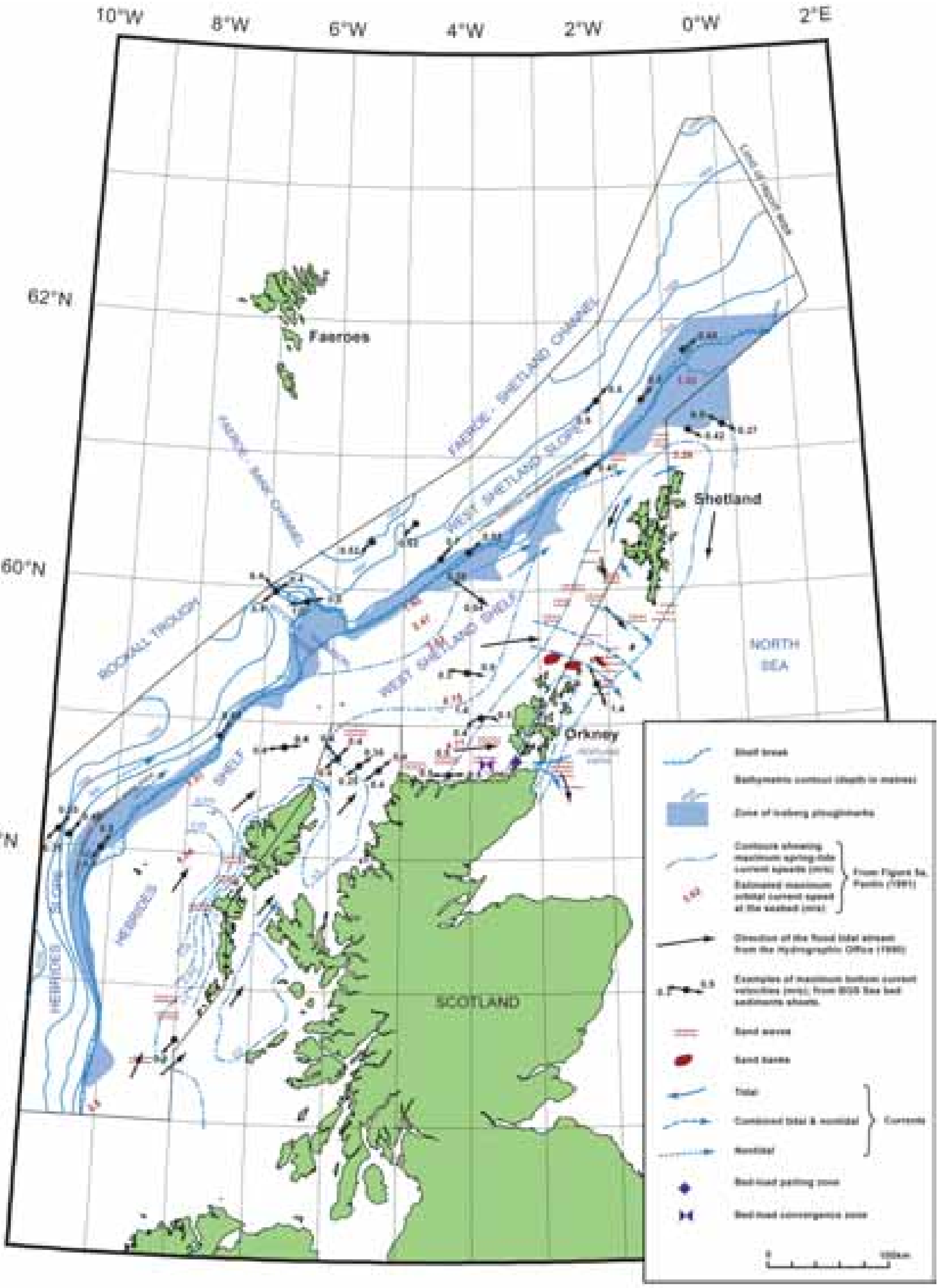


Figure 2 *Tides, bottom currents, sedimentary bedforms, sediment transport and iceberg ploughmarks in the area of SEA4 and the Western Isles. Note strong currents over the Orkney-Shetland ridge. (From Stoker et al., 1993)(IPR/40-3C, British Geological Survey.(C)NERC. All rights reserved).*

2.6 Smith *et al.* (1999, p.1) (see Fig. 3) show the most recent analysis of the uplift of the Postglacial Shoreline around the Scottish coast. The contours can be derived for almost the whole landmass of Scotland because of the intensely indented coastline, and the long sea lochs (Flemming, 1982). From the point of view of the prehistory of SEA4 it is fundamental that the zero isobase coincides almost exactly with the northern coast of Sutherland, and curves round to the west along the eastern shore of the Hebrides. It follows that archaeological sites on the northern Sutherland coast have experienced a rising sea level during the Flandrian transgression, and that the coast is now stable relative to modern sea level The Hebrides, St Kilda, Rona, the Orkneys, and Shetland are all subsiding slowly relative to present sea level, and have also experienced the continuous rise of eustatic sea level due to the final melting of the global ice sheets after 20,000 years BP.

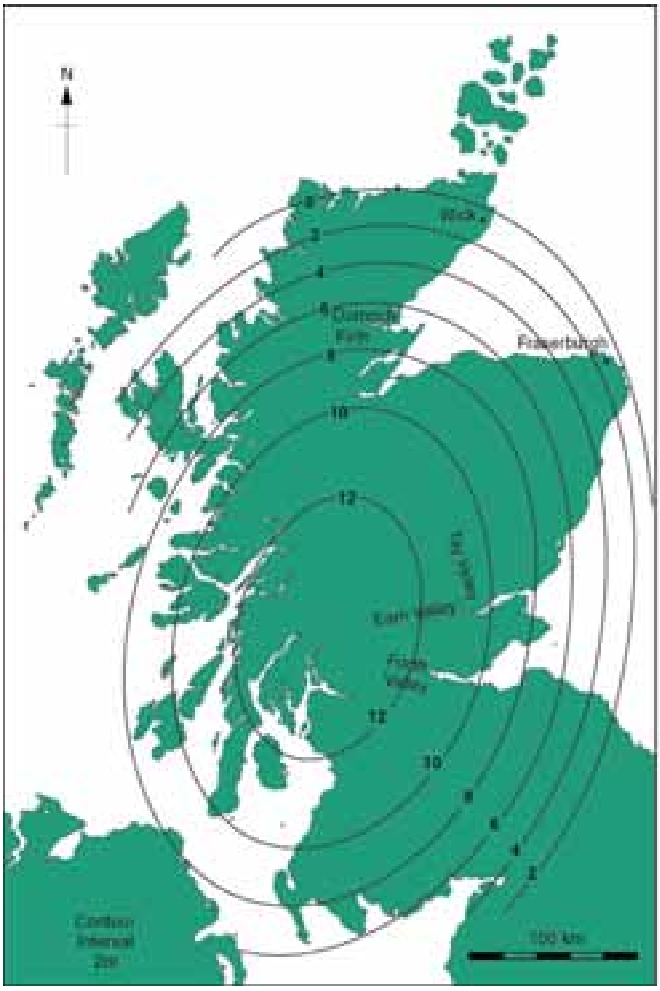


Figure 3 *Isobases showing the uplift of the post-glacial shoreline on the Scottish mainland. Because the sea lochs penetrate so far inland it is possible to determine the uplift near the centre of the zone of isostatic uplift. (From Smith et al., 1999).*

2.7 Figures 4 and 5 (Lambeck, 1995, Shennan *et al.*, 2000b) show the sequence of ice sheet limits, coastline, and the impact of rising sea level on the British Isles, including the northern islands. At 22,000 BP Scotland and the western Isles are covered by the ice sheet, with Orkney just on the edge, and small ice sheet on Shetland (Woodcock and Strachan, 2000). By 18,000 the extended Orkney-Shetland shelf is dry land, with a glacial sea area linking that shelf to the main North Sea exposed shelf. This sea would have been covered in floating ice. By 14,000 the ice cap has retreated almost completely to the modern coastline of Scotland, and by 12,000 BP the ice has entirely melted, although there is a brief period of renewed ice cover, the Loch Lomond stadial, around 10,000 BP. Since humans are certainly present in northern Scotland and the islands by 9,000 BP, it is clear that they may have been present for several thousand years earlier, and would probably have been exploiting sea mammals as the food base (Wickham-Jones, personal communication, 2003). Coastal human habitations have been found submerged off the coast of Denmark as early as 12,000 BP (Fischer, 1991, 1995, 1997).

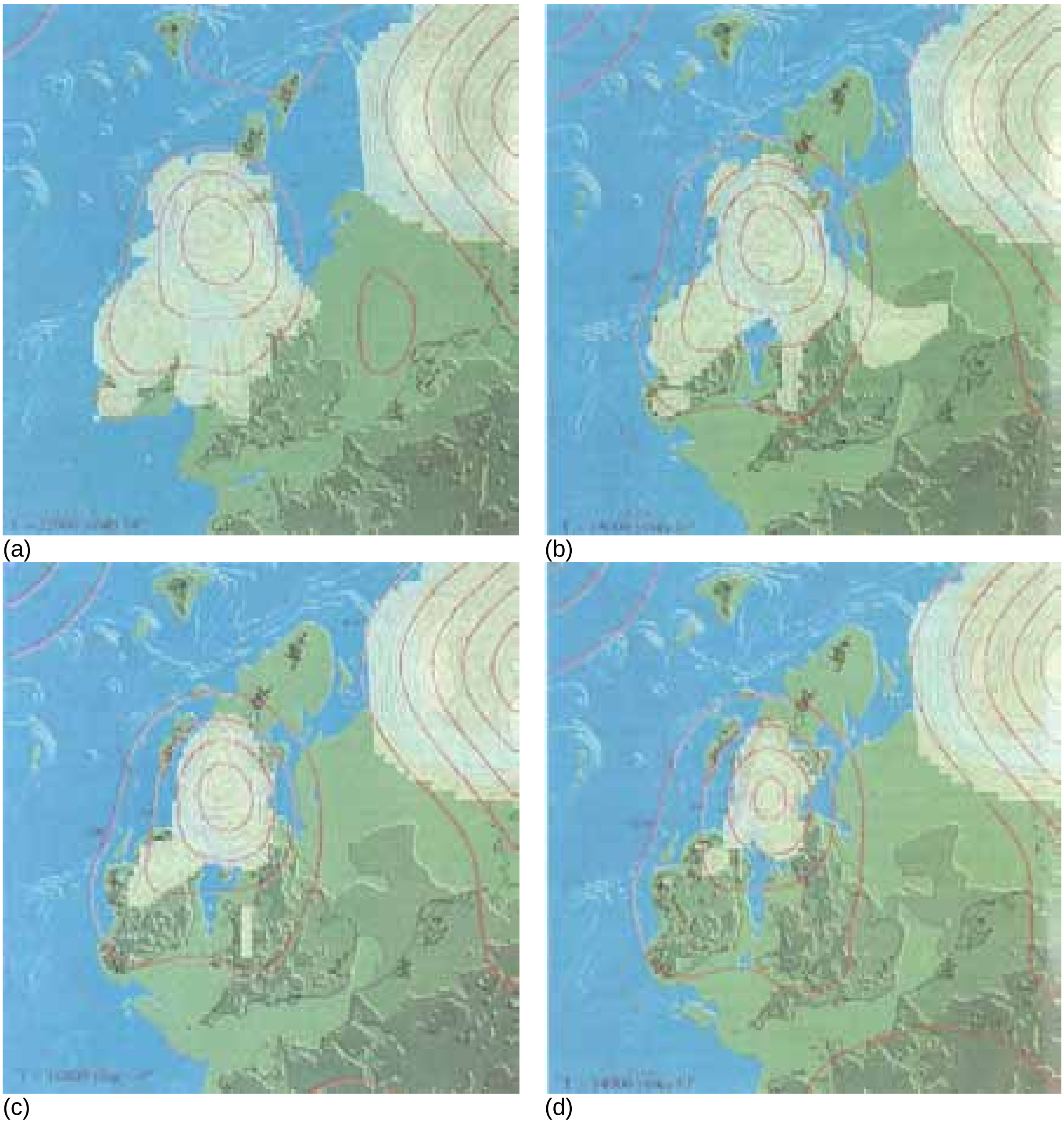
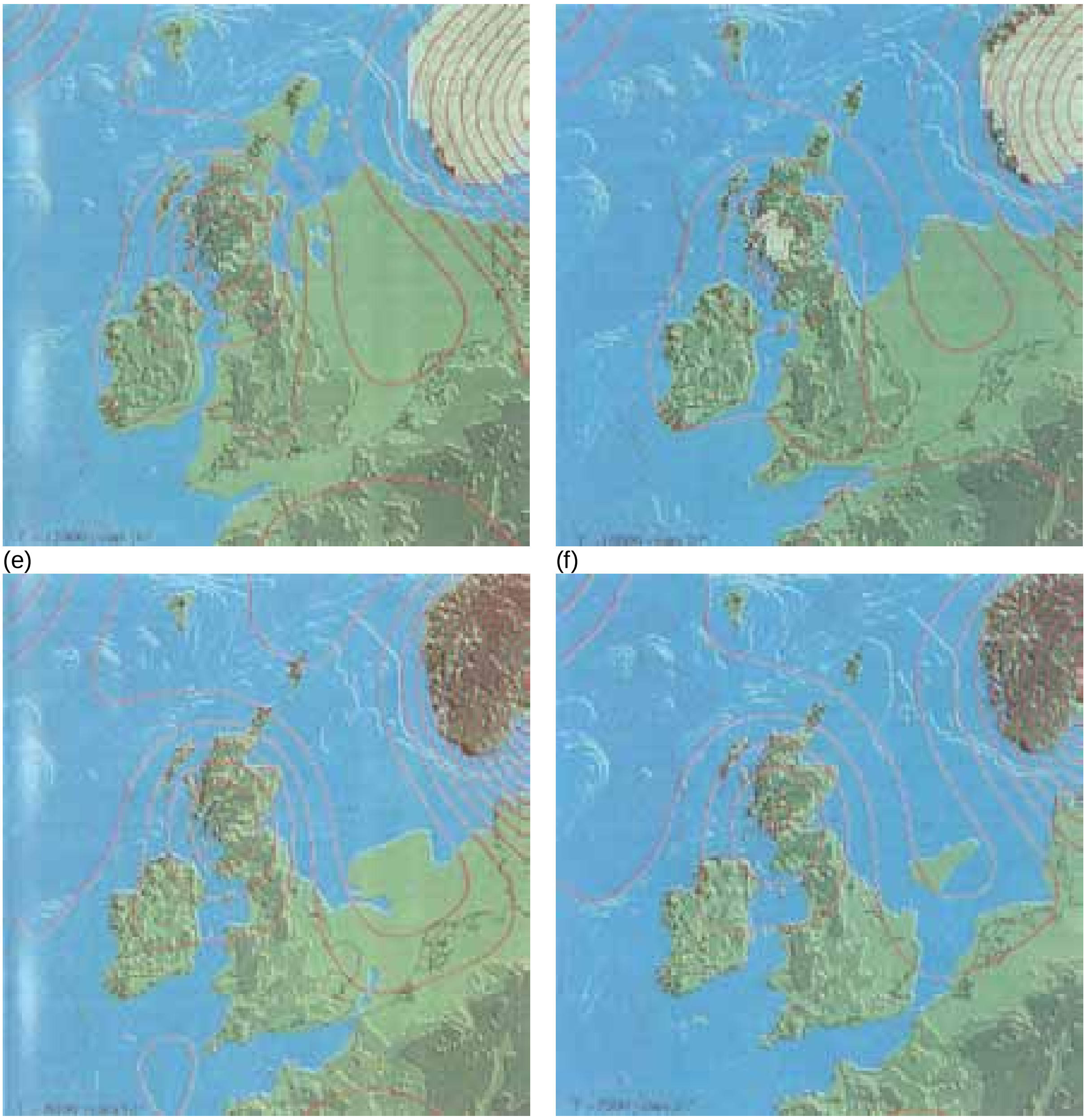


Figure 4 *Isobase maps of predicted shorelines, shoreline locations and ice sheet limits for selected epochs. (a) 22,000 years BP corresponding to the adopted time of maximum glaciation over the British Isles, (b) 18,000 years BP corresponding to the time of the onset of deglaciation of the large ice sheets, (c) 16,000 years BP, (d) 14,000 years BP.*



(e) (f) (g) (h)

Figure 4 continued (e) 12,000 years BP, (f) 10,000 years BP, (g) 8,000 years BP, (h) 7,000 years BP. The maximum ice heights for these epochs are: 1,500m at the time of the glacial maximum at 22,000 years BP, 1,400m at 18,000 years BP, 1,300m at 16,000 years BP, 1,000m at 14,000 years BP and 400m at 10,000 years BP. Palaeowater depths are also indicated with contours at 50, 100, 150 and 200m. Isobase contour intervals are 50m for (a) to (d), 25m for (e) and (f) and 10m for (g) and (h). (After Lambeck, 1995).

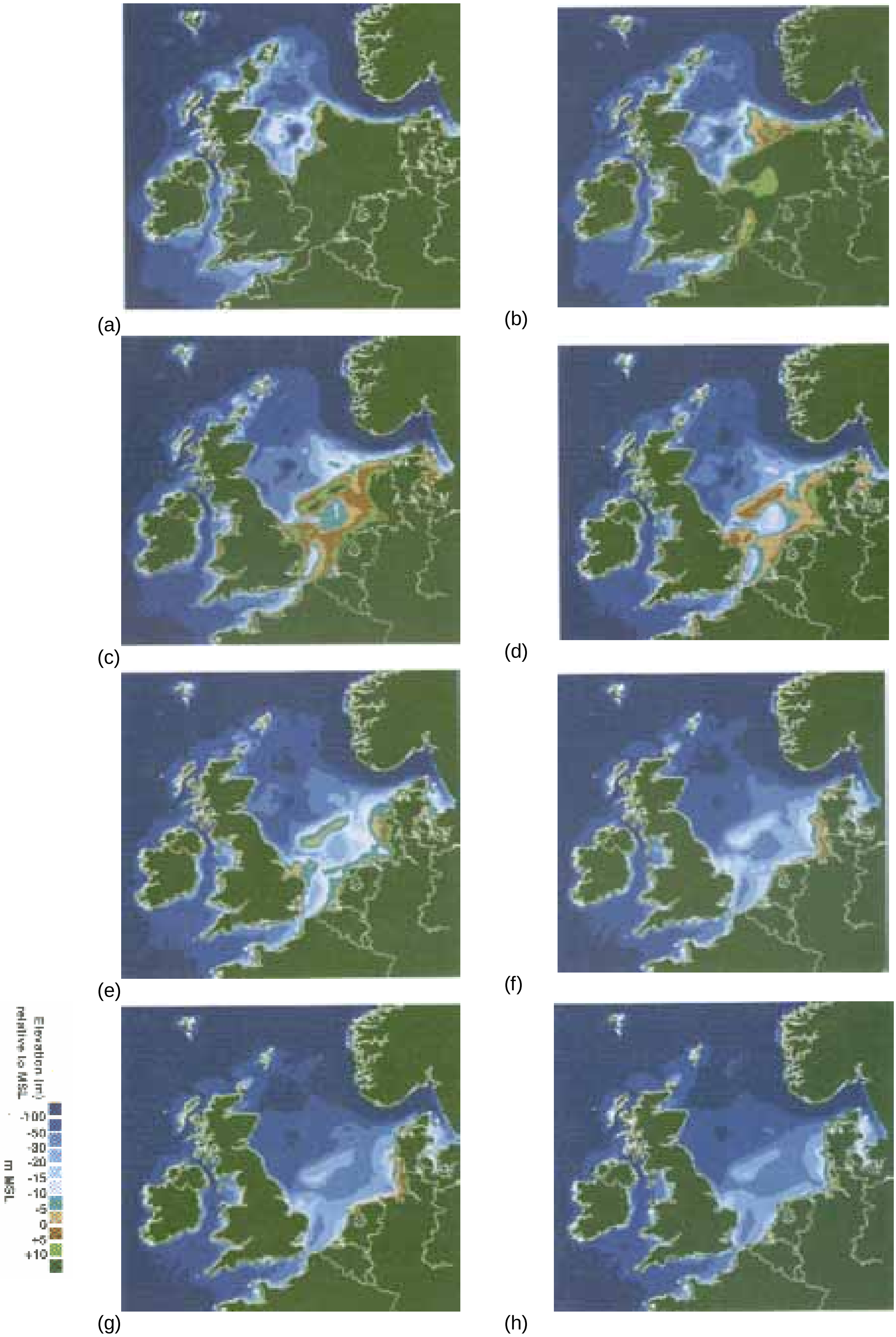


Figure 5 Palaeogeographic reconstructions of Northwest Europe (a) 10,000 years BP, (b) 9,000 years BP, (c) 8,000 years BP, (d) 7,500 years BP, (e) 7,000 years BP, (f) 6,000 years BP, (g) 5,000 years BP, (h) 4,000 years BP. Elevations (metres) relative to MSL, depths below MSL are given as negative. (After Shennan et al, 2000b).

2.8 Lambeck (1995) and Shennan *et al*. (2000a, 2000b) have produced models which combine the compensation for the addition and removal of the weight of ice (Glacial isostatic correction) and for the removal and addition of weight of water (Hydro-isostatic correction) during the rising sea level (see Figs 4 and 5). In Figures 4(a)-4(d) we see the north British ice cap melting rapidly from 22,000 to 14,000 years ago. As the weight of ice is removed the land rises faster than the global sea level, so that the area of dry land increases throughout this period, both northwards and south-westwards. By 12,000 years BP the sea is beginning to overflow the land (Fig. 4(e)) and, although a small ice cap forms briefly around 10,000 years BP, the sea continues to rise faster than the land, forming deep bays and gulfs penetrating into the North Sea, isolating Dogger Bank, and separating the Straits of Dover about 7,000 years BP (Fig. 4(h)). Figure 5 shows the final inundation of the north west shelf separating all the islands, and the progressive flooding of the North Sea area, from which people may have migrated along the coast into Scotland.

2.9 The north-west Scottish shelf has a shelf-break close to 150-200m, and these two isobaths are within a few km of each other over most of their length (Admiralty Chart 219; and see also Fig. 7), with an extensive area of low gradient up to 50-100m, and then relatively short, steep, irregular topography up to the modern coast. Around 14,000 BP the area of dry land exposed, and not covered by ice, is a maximum. As the sea inundates the shelf the largest area is flooded by 7,000 BP, and there was only a relatively narrow strip, steep and rocky, which was inundated after that date. However, as shown in Fig. 6 (Lambeck, 1991, p.38), the composite sea level curve for Lerwick shows slow continuous inundation up to the present day. As central Scotland continues to rise (Fig.3) the outer islands and shelf margin continue to sink as the peri-glacial bulge collapses. In the absence of more detailed information, the Lerwick curve will be used as a proxy for the relative land-sea boundary throughout the SEA4 region, other than close to the Sutherland coast itself, where land subsidence now is almost zero. Because much of the coastline of northern Scotland (that is, the islands) is still subsiding, Historic Scotland has an active programme of documenting coastal erosion and the risk to identified archaeological sites on or close to the water (Dawson, 2003). These data will be used later in this report.

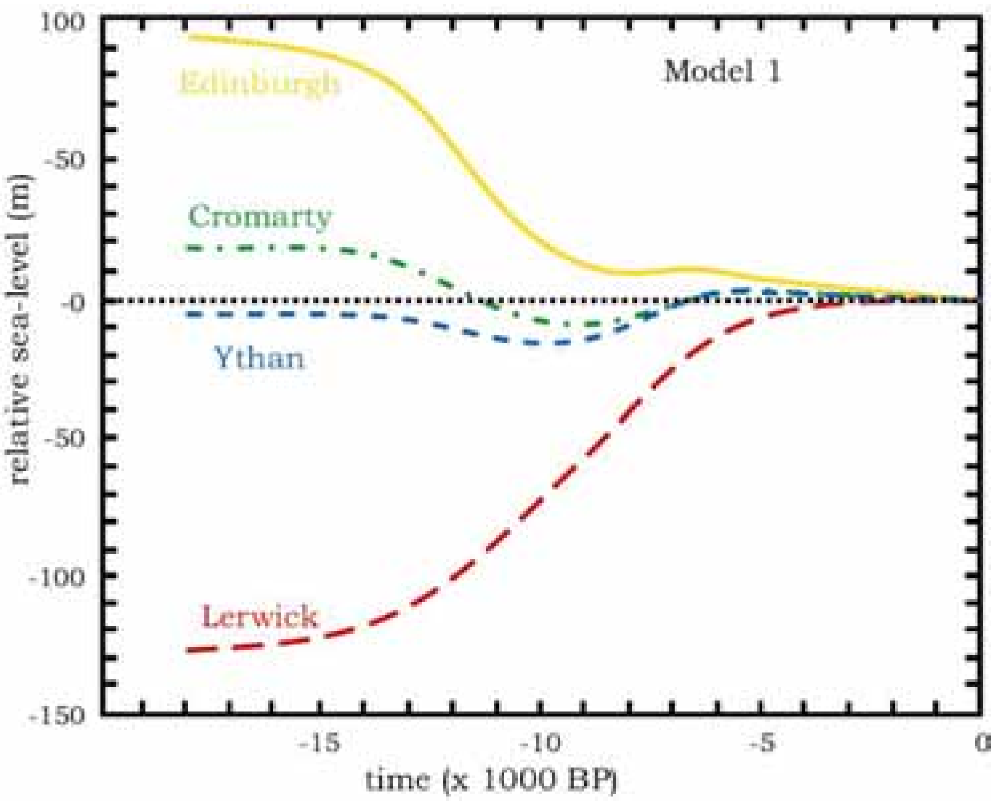


Figure 6 *Predicted relative sea level curves for the last 20,000 years based on ice model ARC3(BRI) at four sites in Scotland. Note Edinburgh and Cromarty are uplifted by post-glacial isostatic rebound creating a relative drop in sea level. Lerwick in Shetland is exposed to continuous relative rise of sea level. (After Lambeck, 1991).*

2.10 While humans may have exploited floating sea ice and the peri-glacial tundra for terrestrial and marine mammals, they cannot have existed very close to the ice cap itself, or in the land areas actually covered by ice. Thus determination of the limit of the ice sheet at different dates is critical (Fig.1). This model suggests that the ice was continuous across Orkney and Shetland at the peak of the Devensian glaciation, about 22,000 years BP. An area of dry land may have been exposed close to the shelf edge to the north and west of the Hebrides. The moraines described by Stoker (1997) are thus critical in showing that the ice sheet did reach very close to the present shelf break. As the ice sheet terminated close to the shelf edge the finely ground glacial debris was transported almost directly into the Rockall Trough and the Faeroe-Shetland Channel.

2.11 In northern peri-glacial conditions the availability of protein for prehistoric peoples close to the shore was higher than in the hinterland (Momber, 2000, 2001; Fischer, 1995). At glacial maximum when the sea did not penetrate into the North Sea area any inhabitants would have depended on large mammals such as mammoth and reindeer. Typical maps and discussions of the food base tend to emphasise the availability of terrestrial mammals on the continental shelf (e.g. Barton, 1997, p.134). Fischer (1995, 2002) has added the importance of coastal fish and shellfish. Later, Mesolithic peoples would have benefited from the resources of wetlands and estuaries. Flemming (1996) summarises the reasons for prehistoric peoples being attracted to the coast, and estimates that, as sea level fell, vegetation and fauna would colonise the exposed land close to the shoreline within a few decades. Bailey, (2003) has recently summarised the strong case for coastal dwelling during prehistoric times. Human remains in south Wales have been found a few km from the ice front (Woodcock, 2000, p.404), so cold itself was not a deterrent. Primitive hunters required fresh water, food supplies, a supply of flints, bone and wood to make weapons and tools, some timber, shelter, skins for clothing, and a secure position which might have to be defended, with good routes of access, and the option to move or migrate with the seasons, or with changing supplies of fish, shellfish, or mammals. Mesolithic settlements were often positioned so as to be convenient to fish traps and fish weirs on the coast. Knowledge of these requirements has been used with great success by archaeologists in the UK and Denmark to predict and interpret submerged Mesolithic sites (Andersen, 1980; Pedersen *et al.,* 1997; Momber, 2001; Coles 1998, 1999, 2000). Hunting kill sites, flint quarries, flint-knapping sites, settlements, camps, shell middens, charcoal from fires, and shelters, tend to cluster round shorelines, estuaries, lagoons, headlands and promontories.

2.12 An additional factor, which has usually been omitted from these analyses is evidence for early humans living in Arctic polar conditions. Fitzhugh (2002) sets out the strong evidence for early human exploitation of the food resources of the circum-polar zone, using life-strategies similar to modern Inuit or Eskimos. Zhokhov Island, north of Siberia, in the Laptev Sea, is the northernmost Arctic site occupied at 8400 years BP (Pitulko, 2001). Excavations at the Mamontovaya Kurya site on the Usa River, inside the Arctic circle, revealed stone tools and carved mammoth tusks nearly 40,000 years BP (Pavlov *et al*., 2001). The exploitation of marine mammals, especially seals, walruses, and cetaceans must be considered for peoples living in circum-polar conditions. Anyone who has seen a walrus haul-out will know how clumsy the animals are on the beach. They would have been the most attractive prey for any peoples who chose to live on the northern or north-west margins of Europe during peak glaciation, or as early as, say, 12-14,000 years BP. The reported recovery by Dutch fishermen of walrus bones showing signs of cut-marks and butchery from 56^{o} North in the central North Sea (Klaas Post, personal communication) strongly suggests this possibility. This type of culture may correlate with the otherwise curious retrieval of a lithic artefact off the Viking Bank from a depth of 145m (Long *et al.,* 1986). Wickham-Jones has pointed out (2003, personal communication) that the availability of large quantities of fat from marine mammals is an important component of a glacial climate diet, since the hunter-gatherer diet inland tends to be too lean to support human survival in extreme cold.

2.13 This places a premium on identifying accurately the ice limits, shorelines and rivers at each date, and especially those shorelines where the sea level was locally constant for hundreds or thousands of years, relative to the local land. Under these conditions rivers would tend to create stable estuaries, and perhaps barrier bars or lagoons and wetlands, waves would erode substantial rock terraces, cliffs, and caves, and shallow water sediments or peat could accumulate. Because of the doming of central Scotland the previous shorelines with terraces and caves have been uplifted in many areas, and several occupied caves are known on raised terraces around Oban (Wickham-Jones, 1994 p.71-73). Off the coasts of the islands, one would expect to find submerged caves. Various combinations of floating sea ice, rocky shelters, ample terrestrial mammals such as reindeer, or marine mammals such as seals, walrus, otter, and cetaceans, depend on the exact local topography. We now consider the question of how and when human artefacts deposited in caves, rock shelters, rocky gullies, beach gravels, river beds, or lagoonal sediments or peat, would survive sea level transgression.

2.14 Taphonomy is the study of the changes which occur to deposits after primary burial. Archaeological materials may be covered by metres of sediments which protect them indefinitely, or eroded by ice, eroded by rivers, eroded and scattered by surf action on a beach, eroded by bottom action of storm waves in shallow water, eroded by tidal currents, chemically altered, or disturbed by trawling, dredging, entrenching, or drilling. There is insufficient space in this report to discuss all the processes, conditions, and topography which are most favourable in every combination of circumstances for the survival of an archaeological artefact *in situ* which is submerged for at least part of its existence. The typical conditions for the survival of known submerged archaeological prehistoric sites are presented in a table by Flemming (1983a, p.161-163) classified as Ria, Lagoon, Estuary, Sheltered alluvial coast, Exposed accumulating beach, Submerged sea caves, Karstic caves, and Islands and archipelagos. Each site is classified in terms of depth, age, tidal range, current, wind fetch, and estimated wave action. Peat and submerged forests are important indicators, and Figs 19 and 20, in Louwe Kooijmans (1970/1), illustrate the widespread occurrence of peat on the floor of the North Sea. (See also the analysis of the SEA3 area, Flemming, 2002). Earlier analysis of North Sea peat is provided by Jelgersma (1961). Submerged peat has been reported in Shetland (Mykura, 1976, p.110-111; Turner, 1998a, p.67), while the rocky terrain is suitable for the preservation of submerged caves. Occupied prehistoric caves are known on land in the area of Oban, and on the island of Ulva (Wickham Jones, 1994, p. 71-73). R. Forbes (2003, personal communication) describes high resolution swath bathymetry indicating a submerged cave with a fallen or collapsed roof at a depth of 20m off Orkney (see Fig. 12).

2.15 Although other factors also apply, for example ice scour, glacial erosion, frost shattering, and normal subaerial erosion processes, the critical period for survival of an archaeological deposit is the time when the surf zone starts to impact on the site, and the ensuing few hundred years as the sea level rises over the site, and coastal shallow water waves are breaking over the site, or washing into a cave mouth. Favourable factors for survival in the deposit area include:

- Very low beach gradient and offshore gradient so that wave action is attenuated and is constructional in the surf zone.
- Minimum fetch so that wave amplitude is minimum, wavelength is short, and wave action on the seabed is minimum.
- Original deposit to be embedded in peat or packed lagoonal deposits to give resistance and cohesion during marine transgression. Drowned forests and peat are good indicator environments.
- Where deposits are in a cave or rock shelter, roof falls, accumulated debris, concretions, breccia, conglomerate formation, indurated wind-blown sand, all help to secure the archaeological strata.
- Local topography contains indentations, re-entrants, bays, estuaries, beach-bars, lagoons, near-shore islands, or other localised shelter from dominant wind fetch and currents at the time of transgression of the surf zone.

2.16 This brief analysis demonstrates that survival or destruction of an archaeological deposit, whether originally inland or on the coast, depends acutely upon the local topography within a few hundred metres or a few km of the site. Generalised coarse resolution maps tend to omit the details which show the necessary local topographic clues. The BGS 1/250,000 maps, although they are primarily designed to present sediment data, provide a much more accurate representation of topography, with isobaths at 10m intervals, than the Admiralty Charts. Additional high resolution swath bathymetry would be enormously valuable in detecting probable sites. It is no coincidence that the most prolific area of proven submerged Mesolithic sites is between the islands of the Danish archipelago, where many hundreds of sites have been mapped and sampled by the National Museum Maritime Archaeological Institute, and the National Forest and Nature Agency, assisted by amateur divers. Further submerged Baltic sites have been discovered in sheltered waters off the coast of northern Germany (Lubke, 2001, 2002). The Bouldnor Cliff site in the lee of the Isle of Wight on the Solent is protected in the same way. Off Gibraltar a hook-shaped submerged promontory contains caves facing inwards towards the land which would be protected from waves while the sea level rose (Flemming, 1963; 1972), and similarly protected sea caves have been found in the Bay of Villefranche (Flemming, 1972).

2.17 The factors in the previous paragraphs are those which promote survival of the original deposit *in situ*. However, if an archaeological deposit is buried under 5-10m of mud or sand it will not be discovered, except in very unusual circumstances. Thus the final requirements for survival and discovery are:-

- Low net modern sediment accumulation rate so that the artefacts are not buried too deeply.
- No fields of sand waves or megaripples over the site.
- Ideally, a slight change in oceanographic conditions so that the site is being gently eroded to expose deposits when visited by archaeologists. (This factor is sufficiently common in known sites to be a serious factor, and should not be regarded as an unlikely fluke).

2.18 The previous paragraphs describe how prehistoric archaeological remains can be deposited and preserved as the sea level rises once over the site; how the remains can survive on the seabed; and how they may subsequently be sufficiently exposed or eroded to permit discovery. The great majority of known submerged prehistoric sites globally fall in the age range of 5,000-45,000 years old (Flemming 1998), and thus, even if they were formed before the last glacial maximum at 22,000 years BP, the sea level was falling at the time, and they only experienced one subsequent marine transgression during the Flandrian rise of sea level. Only one submarine prehistoric site has been reported with an age which implies multiple marine transgressions. Werz and Flemming (2001) describe 3 Acheulean hand-axes found at a depth of 8m offshore Table Bay, South Africa, covered by several metres of marine sand, and embedded in red earth on bedrock. The offshore gradient seaward of the site is 1:400, which is extremely low, and so the Atlantic swell was both attenuated and constructional in action when breaking. The tools are of a type which was in use between 300,000 and 1.2 million years BP. The report analyses the tectonic stability of the coast to check whether the land may have subsided since the tools were deposited. The conclusion is that the tools have survived *in situ* and have experienced between 3 and 8 marine transgressions of glacio-eustatic origin. The hand-axes each weigh just over 1kg, and are about 21cms long. This example, which is unique so far, demonstrates that, given suitable oceanographic conditions, hominid and human artefacts can survive multiple marine transgressions over many hundreds of thousands of years.

2.19 Potential discovery "hot-spots" in the SEA4 cannot be listed exhaustively at this stage. The steps needed to create high resolution local sensitivity maps can be identified, and are discussed later in this section. In principle the key factors are:-

- "Fossil" estuaries and river valleys.
- The flanks of banks and ridges which have been proven to have peat layers, or which are likely to have peat layers.
- Valleys, depressions, or basins with wetland or marsh deposits.
- Nearshore creeks, mudflats, and peat deposits.
- "Fossil" archipelago topographies where sites would have been sheltered by low-lying islands as the sea level rose.
- Niche environments in present coastal zones, wetlands, intertidal mudflats, lochs, and estuaries.
- Caves and rock shelters in re-entrant bays, fossil erosional shorelines, submerged rocky shores protected by other islands, or in archipelagos.
- Deposits of sediments formed within, or washed into rocky gullies and depressions.
- Coastal sites comparable by analogy to modern Inuit migratory sites, adjacent to sea ice, giving access to marine mammals as a food resource.

2.20 Basic topography can be obtained from Admiralty hydrographic charts 219 and 245. BGS Sheets discussed in para.2.16 show the positions of production platforms and pipelines. Fig. 7 shows the topography of SEA4 at 20m vertical resolution and with high horizontal resolution. At first sight there are many features close to the coast and the offshore islands and archipelagos which provide locations comparable with the features required in previous paragraphs The outer shelf deeper than 80m in general is a rather low prospective area, although the intermingled hummocks, moraines and troughs suggest a periglacial wetland topography which may have supported considerable wildlife.

2.21 The changes in and survival of a site, and the chances of discovery, depend also on the present conditions of winds, waves, and currents in the area, and the water movements on the seabed. The 50-year extreme maximum winds in SEA4 are of the order of 45-46m/sec 1-minute mean, that is, approximately 165 km/hr wind speed (Blackham *et al.,* 1985, p.44). Fifty-year extreme maximum wave height is of the order of 30m, with a period of 20 seconds (Blackham *et al.,* 1985, p.45). Such conditions are, by definition unusual, and a more general description of winter conditions is obtained by considering the percentage occurrence of Significant Wave Heights of a given magnitude. For 10% of the time in winter the Significant Wave Height exceeds 6 to 7m (Draper, 1991, Map 5). Wave observations at Stevenson, 60 miles NE of Shetland, show a highest Significant Wave Height of 10m, and a maximum period of 14 seconds (Draper, 1991, p.9). Tidal streams in the area are substantially less than 1.0m/sec over most of the area, but much faster, of the order of 1.0-2.0m/sec over the Orkney-Shetland ridge, and through the Pentland Firth.

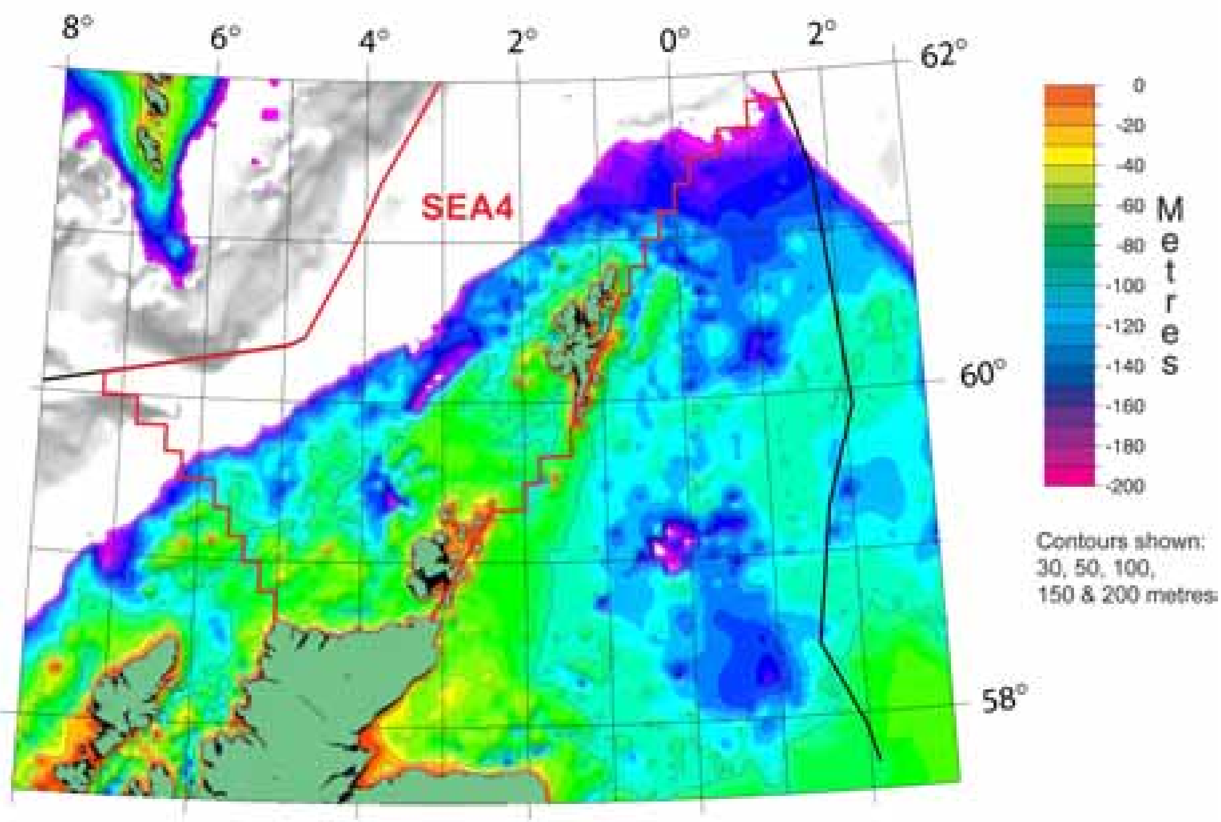


Figure 7 *Bathymetry of the North and Northwestern Shelf shallower than 200m. The heavy black line is the boundary of the UK Sector in the map, and the red line is the boundary of SEA4.*

2.22 The depth at which waves can disturb sediments on the seabed is a function of the wavelength, which is related to period. Thus waves of period 10s have a wavelength crest to crest of approximately 156m, 13s produces a wavelength of 263m, and 20s would have a wavelength of about 620m. The depth at which the wave interacts with the seabed is about half the wavelength, with significant force to move sediments at one quarter the wavelength. Thus the typical winter waves in the SEA4 area can influence the seabed at a depth of the order of 70m-120m, and move sediments significantly at 35-60m depth. The most extreme waves influence the seabed at a depth of 300m, and move sediments strongly at a depth of 150m. Sediments which have been stirred up by waves are then displaced by tidal currents. The seabed in SEA4 is thus depleted of fine sediments in many areas, leaving lag deposits of gravel and coarse sand, while parts are swept down to the bedrock. Where there are cohesive Quaternary deposits, these resist erosion, and could contain archaeological materials. Similarly, bones and flints could remain within coarse gravels, or trapped in gullies in bedrock. Fine sediments have accumulated in depressions such as Papa Basin. For a more detailed discussion and analysis of the sediment distribution and sediment bedforms see the DTI Strategic Environmental Assessment Area 4, Technical Report by Holmes et al. (2003).

2.23 Interpretation of archaeological prospectivity depends on separating modern bedforms and banks of mobile sand and sand waves from earlier Devensian gravel, clay, moraines, drumlins, or peat, eliminating areas of bare rock or extremely thin modern marine sediments over bedrock, and identifying erosional features associated with fossil cliffs and caves. Since the earliest inhabitants of the Scottish continental shelf may have been living in a culture similar to that of the Inuit peoples of Greenland and northern Canada and Alaska, we also need to search for the traces of sheltered sea bays and gulfs which may have been covered by sea ice. In these environments marine mammals would have prospered. The irregular hummocky shelf topography in SEA4 at depths greater than 50m is reminiscent of the present landscape of marshes and kettle holes in southern Alaska or the gravel spits, bars, and islands on the coast of Spitzbergen. It would be salutary to compare the archaeological site characteristics of Alaska with the terrain in SEA4 to see if one could find parallels.

2.24 The British Geological Survey (BGS) collaborated with its opposite numbers in Netherlands and Norway during the 1980s and 90s to produce a series of seabed sediment maps for the UK Continental Shelf at a scale of 1:250,000. These maps, and the associated cores, are an essential tool for assessing the archaeological potential and sensitivity of areas of the sea floor, providing classification of surface sediments by grain size, thickness of active marine sediments, thickness of Holocene deposits, standard cross-sections, information on tidal currents, sand waves and sand ripples, carbonate percentage, and other items of information which vary from sheet to sheet. Some sheets, but not all, include copious technical notes, sections, core profiles, and analysis of sources, references, and comments on the various facies. All sheets show positions of platforms and pipelines at date of publication. The Schiehallion-Clair pipeline across to northern Shetland, terminating at Sullom Voe was constructed recently, and the survey data and video record of the terrain would provide excellent background for prehistoric research. Notes on some of the most relevant sheets follow (from north to south). This analysis refers only to the geological, sedimentary, and taphonomic conditions relevant to primary occupation in the area, and the preservation of sites. Many of the sheets also contain islands where archaeological remains are known on shore, or in the intertidal zone, and these features, where relevant, are described in Section 3.

2.25 Each BGS sheet covers an area 2^{o} of longitude and 1^{o} of latitude. Within the SEA4 area 5 sheets (Wyville Thomson, Judd, Flett, Horne, and Sedgwick) chart seabed which is entirely deeper than 200m. The remaining sheets are reviewed below in north-south sequence. The 200m and 150m isobaths are within a few km of each other along most of the shelf break, except in the extreme north of SEA4.

Miller: BGS, 1990. 61^{o} - 62^{o} N; 0^{o} - 2^{o} W. The south east half of this sheet is shallower than 200m, but most of this area is deeper than 150m, and all of it is deeper than 120m. Most of this area has been disturbed by iceberg ploughmarks. The shelf break is deeper and more gradual than further south, and the shelf surface is smoothly undulating with sand and gravelly sand. There appears to be relatively little Holocene modern sediment accumulation. The extreme depth of this area, the low relief, and the extreme exposure to Atlantic and Arctic storms during marine transgression, make this a relatively low prospective area for prehistoric archaeology.

Cormorant: BGS 1984. 61^{o} - 62^{o} N; 0^{o} - 2^{o} E. A massive gravel-sand ridge trends NW-SE at a depth of 170-180m, on the edge of the shelf. Core logs show clay and sand with shells. This is the extreme northern margin of land at the maximum extent during Flandrian transgression, when the land was rising faster than the sea level. Iceberg ploughmarks occur at the shelf edge. Recent marine sediments are very thin, less than 1m over much of the area, overlying patchy and variable deposits of clays, sand and gravel, with shell fragments and pebbles. Only the south west corner of this sheet refers to seabed shallower than 150m. This does not appear to be a prospective area archaeologically, although it is quite close to the Viking Bank, where a single flint tool was found (Long *et al.*, 1986). It is important to note that such chance finds could occur almost anywhere.

Foula: BGS, 1990. 60^{o} - 61^{o} N; 2^{o} - 4^{o} W. The 200m and 150m isobaths traverse SW-NE across this sheet so that only the SE half is relevant. The rocky island of Foula is in the extreme SE, consisting mostly of Lewisian albite gneiss and foliated granites. The shelf edge is a zone of iceberg ploughmarks. The shelf-edge end moraines described by Stoker (1997) do not appear at all clearly in the bathymetry of this sheet. An elongated depression extending SW-NE between Turbot Bank and Otter Bank descends to a depth of 230m, and is known as Papa Basin (Fig. 1). This trench, probably a sub-glacial tunnel or over-deepened basin is interesting as a trap for archaeological deposits, but the thick accumulation of sand would make discovery difficult. At the centre of the sheet is a broad shallow depression on the shelf undulating between 160-180m with a sandy bottom, sloping SW into Papa Basin. The area of this sheet deeper than 100m is generally a poor archaeological prospect because of the relatively low gradient terrain, lack of relief, and hence no localised protection from waves and currents after marine transgression. While much of the area is probably 10-20m too deep compared with the Lerwick curve (Lambeck, 1991) and also compared with the Viking Bank flint (Long *et al.*, 1986) to have been exposed as dry land, the large area with gradients lower than 1/500 to 1/1000 also means that wave energy during marine transgression was attenuated over a very wide shallow shelf.

Wave action would thus have been constructional, and artefacts could have been preserved within a few metres of sand. Additionally, wave action may have piled up large gravel ridges or gravel islands.

Shallower than 50-100m there are outcrops of Lewisian granitic and metamorphic rocks, and Devonian sedimentary beds. Isobaths suggest a rugged terrain with re-entrants, outcrop ridges, and gullies which might protect archaeological deposits, even if they have been transported before final deposition.

Shetland: BGS, 1998. 60^o - 61^o N; 0^o - 2^o W. The Shetland islands consist of largely Devonian Old Red Sandstone and Precambrian Lewisian metamorphic rocks and granite. Archaeological prospects within the archipelago, in the sea lochs and intertidal areas will be considered in Sections 3 and 4. The West Shetland Shelf is largely underlain by Old Red Sandstone, some Permo-Triassic rocks, and Precambrian Metamorphics. The area west of Shetland covered by this sheet is shallower than 150m, and the bottom mostly consists of a thin patchy veneer of gravel and sand over bedrock. Out to a depth of 100m the isobaths indicate irregular topography with re-entrants and small valleys, although the upper surface is often classified as "smooth featureless rock platform". The most prospective areas would be those where echo-sounding or swath-bathymetry show a pattern of submerged headlands, valleys, or steep terrain which could be penetrated by caves. There are some scattered sand waves with a height of up to 4m approximately along the 100m isobath.

Rona: BGS 1987. 59^o - 60^o N; 4^o - 6^o W. To the north-west corner of this sheet the seabed drops away into the Rockall Trough. To the south east is the island of Rona consisting of garnitiferous amphibolite and acid gneiss, with nearby the islets of Stack Skerry and Sule Skerry. Multiple gaciations have left tills and glaciomarine sediments, consisting of sandy gravel and gravely sand. The islands drop away steeply to 50m, and the deeper seabed slopes gently out to the shelf edge with hummocky highs at 50m, and depressions at 80m. As with other parts of the SEA4 shelf there are no identifiable drainage channels or river beds. Storm waves and tidal currents have winnowed out much of the finer sediment leaving the lag gravels. Modern sand bedforms are usually less than 1m thick.

Orkney: BGS, 1984. 59^o - 60^o N; 2^o - 4^o W. Over the Orkney-Shetland Platform, Papa Bank and the North Shoal the till-like Quaternary deposits are usually less than 5m thick. Currents are often greater than 1.0m/sec in the open sea and greater than 2.0m/sec in the channels between islands. Archaeological prospects within the archipelago, in sea lochs, and intertidal areas will be considered in Sections 3 and 4. To the west of the Banks the Quaternary beds are 20-80m thick, and BGS Borehole 49 reveals a sequence of clays and pebbly clays. Modern sediments are largely biogenic carbonate sands. The 50m isobath hugs the cliffs on the west side of Orkney, with a more extended shelf gradient out to 50m over a distance of 3-5 sea miles to the north of the islands. From 50m out to the 80m and 100m isobaths to north and west the gradient is about 1/1000. There are scattered highs rising to 80m and lows dropping to 160-180m. With the seabed and Quaternary deposits being largely gravels, sandy gravel, and gravely sand, it is probable that there is a strong lag effect, with the possibility of stone tools and bones being embedded. The low gradients generally mean that wave action during transgression will have been heavily attenuated, and the depressions in the shelf are interesting as possible traps for slowly moving large particles.

Fair Isle: BGS, 1990. 59^o - 60^oN; 0^o - 2^o W. The sea floor over the Fair Isle Ridge consists of gravel and sandy gravel in a thin layer over bedrock. Tidal currents are typically 1.0- 1.5 m/sec. Quaternary deposits are very thin or absent, except close to the west side of Sumburgh Head, where the Witch Gravel Formation occurs. Sand waves exist to the west and south west of Fair Isle. In view of the minimal sediment cover and the strong currents, archaeological prehistoric materials are only likely to occur close to Sumburgh Head or Fair Isle, or trapped in rocky gullies.

Sutherland: BGS, 1989. 58^o - 59^o N; 4^o - 6^o W. The underlying geology is Permo-Triassic with some Lewisian. The Quaternary deposits vary from 0-40m thick, and are mostly less than 10m thick. There are patchy outcrops of bedrock. Much of the seabed sediment is clay and sand to a depth of 1m, or sand over dimicton. Large areas of fine clay with small pebbles, or very thin silty clay, sandy, with pebbles. The seabed drops away steeply from the mainland shore to a depth of 30-50m, and then undulates with highs and lows in the range 50-80m. Currents mostly in the range 0.5-0.75m/sec, with greater than 1.5/sec round Cape Wrath. The submerged landscape consists of Late Devensian moraines overlain by Flandrian marine cold water deposits.

Caithness: BGS 1987. 58^o-59^o N; 2^o - 4^o W. The sill of the Pentland Firth is at a depth of 70m, and the channel is 25km wide. Currents through the Firth are 1.0-1.5m/sec. The bottom of the Firth is bare rock, with an extensive area of active sand waves in the western approach to the Firth. To the east there are Quaternary deposits 10-20m thick, while the Quaternary thickness to the west increases gradually to the order of 50m. Modern sediments are generally less than 1.5m thick. The Quaternary deposits consist of pebbly clays, glacial till, and patches of sandy gravel, indicating early Flandrian, just after deglaciation, with a date of 12,400BP.

Summary of logical analysis of site potential

2.26 The discussion throughout this section on site occurrence, preservation, and discovery is based on the analysis of known prehistoric submerged sites off the coasts of many countries. It is not a speculative theory without field evidence. A selection of the key sites providing the basis for this analysis are described by the following documents: Godwin (1941); Blanc (1940); Fischer (1995); Galili and Nir (1993) Galili *et al*. (1993); Momber (2000, 2001); Flemming (1962, 1972, 1983a; 1983b; 1998; and 2002); Prigent *et al.* (1983); Hayashida (1993); Harding *et al*. (1969); Cockrell and Murphy (1978); Wreschner (1977, 1983); Clottes and Courtin (1996); Wilkinson and Murphy (1995); Andersen (1980); Scuvée and Veragué (1988); Werz and Flemming (2001); Josenhans *et al*. (1997); Stright (1990); Louwe Kooijman (1970-71); Verhart (2001); and Lubke (2001,2002).

2.27 Possible null zones and prospective submerged archaeological sites

Null zones

Fischer (1991) shows a series of plots of the ice front retreating from the north of Denmark, and the positions of the northernmost prehistoric sites at the same dates. The correlation suggests that there were no permanent settlements within about 100km of the ice front, that is, the edge of the permanent land-based ice sheet. Settlements do move north continuously following the ice, and there may have been hunting or fishing excursions closer to the ice front, and onto floating sea ice.

The tops of banks and ridges would usually not have been inhabited, and would tend to be scoured by wave and current action during inundation, if not under present conditions. Late Palaeolithic and Mesolithic people were not stupid, and probably had the same IQ as modern humans, combined with the migrant hunter's understanding of the landscape, weather, and the seasonal movements of animals. In near Arctic conditions settlements would have been in the lee or shelter of ridges and headlands, not on top. If they had adopted an Inuit life-style, they would have been happy living on exposed coasts, and travelling over sea ice, plus using kayaks or canoes. The ice caps had melted completely by 9,000 years BP, but even as the climate ameliorated and vegetation and forests covered the land, the attraction of the coast would persist into the Mesolithic.

Bare rock with gently sloping or horizontal surfaces swept by waves and currents would have a minimal chance of providing shelter for humans, or for preserving artefacts. However, where such surfaces have been exposed after the erosion and removal of late Quaternary deposits or post-Devensian material it is possible that artefacts may have been trapped in cracks and gullies. Artefacts from shipwrecks have frequently been found in such locations. Steep surfaces and caves will be reviewed below.

Prospective sites, to be considered for high resolution sensitivity mapping

Fossil estuaries and river valleys.
Owing to the nature of the terrain it is not possible to identify continuous submerged river valleys from the topography at present.

The flanks of banks and ridges which have been proven to have peat layers, or which are likely to have peat layers.
The moraines on the outer shelf edge were deposited by grounded ice in contact with the sea, and are therefore not likely to contain artefacts. Many of the other smaller banks and hillocks could provide evidence of a terrestrial landscape and vegetation at a depth of the order of 50m, which may have been compatible with human occupation.

Valleys, depressions, or basins with wetland or marsh deposits.
This is the other half of the previous paragraph. Depending upon evidence from other regions as to how people lived and exploited resources in this kind of terrain, it is possible that the numerous pits and

depressions, which were probably associated with small lakes, would have been attractive hunting areas.

Nearshore creeks, mudflats, and peat deposits.
These environments are already associated with intertidal and shallow water archaeological sites in the area. Research aimed at tracking these occurrences into slightly deeper water would reveal whether the same environments were exploited in the past. Evidence from Denmark, East Anglia, and the Solent suggest that this is a very favourable class of site.

"Fossil" archipelago topographies where sites would have been sheltered by low-lying islands as the sea level rose.
Wave exposure is extreme to the west, north, and north east. For islands to provide reasonable protection there have to be several of them in a close group. Close analysis of the topography may reveal groups of high ground consisting either of Quaternary deposits, or bedrock, forming patterns of islands which could provide shelter from many different directions. In making these calculations the change of gradient of the shelf through time should be calculated as accurately as possible, to allow for post-glacial rebound.

Niche environments in present coastal zones, wetlands, intertidal mudflats, lochs, and estuaries
Micro-topography on the scale of 100-1000m can determine both the location of an occupation site, and its survival. Some sites in this category are already known, and will be discussed later. Study of the typology of sites will indicate how further sites could be discovered in shallow water.

Caves and rock shelters in re-entrant bays, fossil erosional shorelines, submerged rocky shores protected by other islands, or in archipelagos.
This type of submerged site has not so far been identified anywhere in northern Europe, but is relatively common in the Mediterranean, and potentially in other parts of the world. A large submerged cave occupied in the Palaeolithic is described by Clottes and Courtin (1994), and archaeologically prospective caves are being investigated off Gibraltar (Finlayson, personal communication), Malta, and Greece. A small Palaeolithic submerged deposit in a cave on the Italian coast was surveyed by Riccardi *et al*., (1987). The steep rocky topography of the Scottish coast, and the occurrence of rock outcrops offshore, suggests that submerged erosional rock terraces could be located by sonar or swath bathymetry, and caves identified. (See Fig.12).

Deposits of sediments formed within, or washed into rocky gullies and depressions.
A number of Armada shipwrecks have been discovered by divers around northern Scotland, Fair Isle (Stroms Hellier), and northern Ireland (Martin, 1975). Though most of these wrecks occurred on exposed rocky shores, many artefacts have survived because they fell into cracks and gullies in the rocks. I am not aware of any prehistoric materials having been found in exactly similar locations, but it is probable that thin layers of Quaternary deposits have been washed away from bedrock in some locations, and that archaeological components could have fallen into protected depressions as the sea rose. The closest comparison would be with the site of Aghios Petros, in the Northern Sporadhes (Flemming, 1983b), where a stratum of earth several metres thick over bedrock, and containing an archaeological component, was inundated to a depth of 10m by the post-glacial rise of sea level, and a concentrated layer of archaeologically rich materials was left as a lag deposit on the sea bed. This was in a very sheltered situation. Search for such materials in SEA4 might be productive close to the coast in shallow water, but it would be a very difficult environment to detect in deep water.

Coastal sites comparable by analogy to modern Inuit migratory sites, adjacent to sea ice, giving access to marine mammals as a food resource.
Stanford and Bradley (2002) have suggested that during the Devensian glacial maximum Palaeolithic peoples could have migrated along the edge of the permanent Atlantic sea ice from the European continental shelf to North America. While this model is still highly speculative it draws attention to the fact that the cultural patterns and technological devices needed to survive at the ice edge are very well known, and that the necessary ingredients have existed for tens of thousands of years in other parts of the world. The absolutely necessary component of this hypothesis is the ability of Late Palaeolithic or Mesolithic peoples to slaughter and butcher marine mammals. Adequate tools certainly existed. An analysis of Devensian and post-Devensian marine mammal bones recovered by bottom trawlers would provide much of the necessary evidence. Additionally, analysis of prospective sites should be focused on known areas of post glacial maximum coastal sea ice, and areas of gravel suitable for walrus haul-outs.

3. Human occupation of the Scottish Shelf

3.1 There is a strong appreciation amongst scholars and research workers at Historic Scotland, RCHAMS, and various university groups in Scotland and elsewhere, of the importance of submarine prehistoric occupation sites on the Scottish shelf. For several decades crannogs have been surveyed and excavated in freshwater lochs, and in recent years prehistoric structures in the intertidal zone, and immediately offshore have been located and documented. Submarine peat and other indicators have been identified within the archipelagos (Turner, 1998a). Wickham-Jones (1994) and Spikins (AHRB grant proposal, University of Newcastle upon Tyne) have addressed the problem of early occupation of the Scottish continental shelf. The discovery of a single flint tool off the Viking Bank at a depth of 145m (Long *et al*., 1986) confirmed that people could have been living this far north on the exposed continental shelf very soon after the ice retreat, and before complete declaciation of the Scottish Highlands. Wickham-Jones (1994, p.54) has suggested that the re-occupation of the northern shelf during the melting of the Devensian ice sheet was by a combination of migratory movements up the west coast from England and Ireland, up the east coast from England and mainland Europe, including from the occupied areas in the central North Sea, and from the east or north-east, where people may have been living on the ice edge, or had recently re-occupied the margins of Norway and Denmark below present sea level.

3.2. The date range of the different periods of prehistory in Scotland has been summarised in para. 2.2. The only deep water prehistoric site known close to the SEA4 area is the flint found on the Viking Bank, already mentioned. However, on the modern coast there is an extraordinary variety of prehistoric structures, making this one of the richest areas in Europe for prehistoric archaeology. It is almost inconceivable that this rich technological achievement should not have deeper roots offshore, and possibly a few thousand years earlier. Structures and relics include promontory forts, tower-like forts known as brochs, fortified residences built on artificial (or sometimes natural) islands known as crannogs, cairns, tombs, elaborate burial sites, multi-roomed houses, standing stones, stone circles, occupied caves, shell-middens, burnt-mounds where fires were burnt repeatedly for hundreds of years, stone tools, stone knives, bronze axes and blades, carved and decorated stones. These objects all testify to an intensely complex and energetic culture. The use of boats in the later prehistoric periods is obvious, since the people were living on islands. However, the earliest date of seafaring in the region is completely unknown at present.

3.3 In this section I will consider very briefly the information on coastal archaeological sites which indicates the probable occupation of the northern and north western shelf at different periods. In order to bracket the sea areas I will discuss St Kilda, on the shelf edge, Rum, Orkney, Fair Isle, and Shetland. Figure 8 shows the distribution of the larger prehistoric sites in Scotland. In the next paragraphs I will consider the statistics of the distribution of prehistoric sites on the coast, based on an inventory of many smaller sites than those shown in Fig.8.

3.4 Dawson (University of St Andrews, personal communication) has compiled an extensive coastal data base of archaeological sites within a few metres of the beach, or situated on the intertidal foreshore. This has been done under contract for Historic Scotland. Because of the tendency to subsidence of the coast the risk of erosion is severe, and this is the primary reason for the survey. Although this data base does not include any data from below sea level (some features are on rocks or artificial mounds built in the water), the statistics of the occurrence of prehistoric features immediately on the coastline are impressive.

3.5 The coastal site classification provided by Dr Dawson is not exactly standard from file to file, and therefore the following statistics are not exactly comparable. Prehistoric sites include promontory forts, cairns, shell mounds and middens, Mesolithic cave sites, hut circles, field walls, enclosures, standing stones, burial sites, walled islands, and stone alignments. The general picture of intense development right up to the waterline, and beyond, is perfectly clear.

Shetland: 845 recorded coastal archaeological sites on or extremely close to the shore of which 181 are prehistoric (earlier than 2000 years BP) and 37 sites date to 6000-5000 years BP. The percentage of prehistoric sites is 21%.

Orkney: 744 total recorded coastal sites, of which about 150 are classified as belonging to various ranges of early millennia such as "4th to 3rd millennium BC" etc. Because of the overlap of these brackets, there is a risk of double counting. Approximately 40 sites date to the 1st millennium BC, 20 to the 2nd millennium, 70 to the 3rd millennium, and 20 to the 4th millennium. The percentage of coastal sites which are prehistoric is about 20%

North Sutherland: On the mainland north coast there are 498 recorded coastal sites in total, of which only 13 are recorded as prehistoric, with promontory forts, cairns, shell mounds, and some cave sites. The percentage of coastal sites which are prehistoric is about 3%.

Lewis: With 1907 recorded coastal archaeological sites, of which 19 are Iron Age, 8 Bronze Age, 10 Neolithic, and 202 broadly classified as Prehistoric. This makes a total of 239 prehistoric sites, or 12%.

One should not try to deduce anything detailed from this very rough calculation, but it does illustrate that comparing one length of coastline with another, the proportion of prehistoric sites to more modern sites is much higher on the islands than on the Sutherland coast, and Orkney and Shetland are similar to each other.

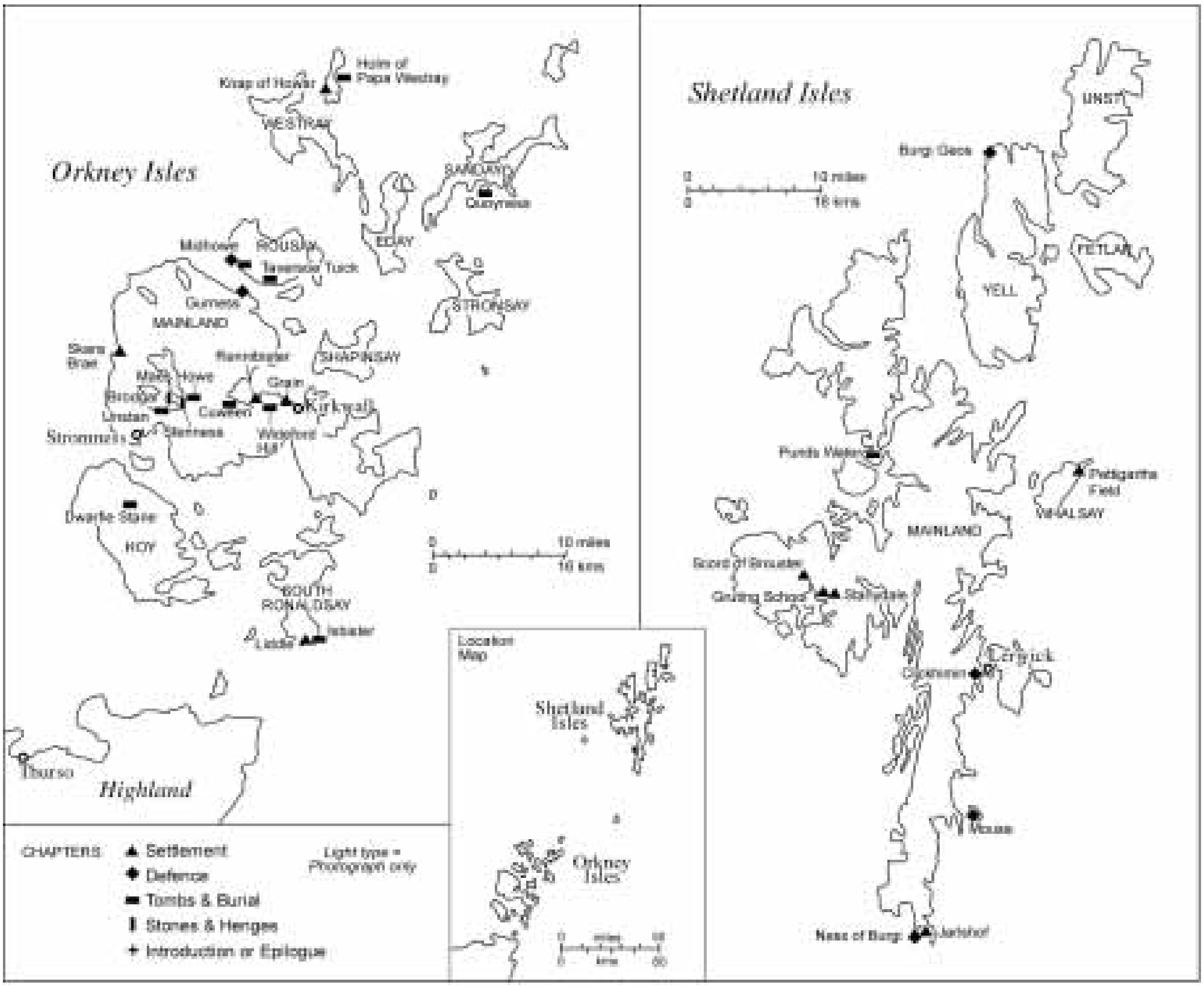


Figure 8a *These maps show in very general terms the distribution of the major prehistoric sites in Scotland. Databases quoted in the text indicate that there are many more small sites, often concentrated very close to the modern shoreline. (From MacSween and Sharp, 1989).*

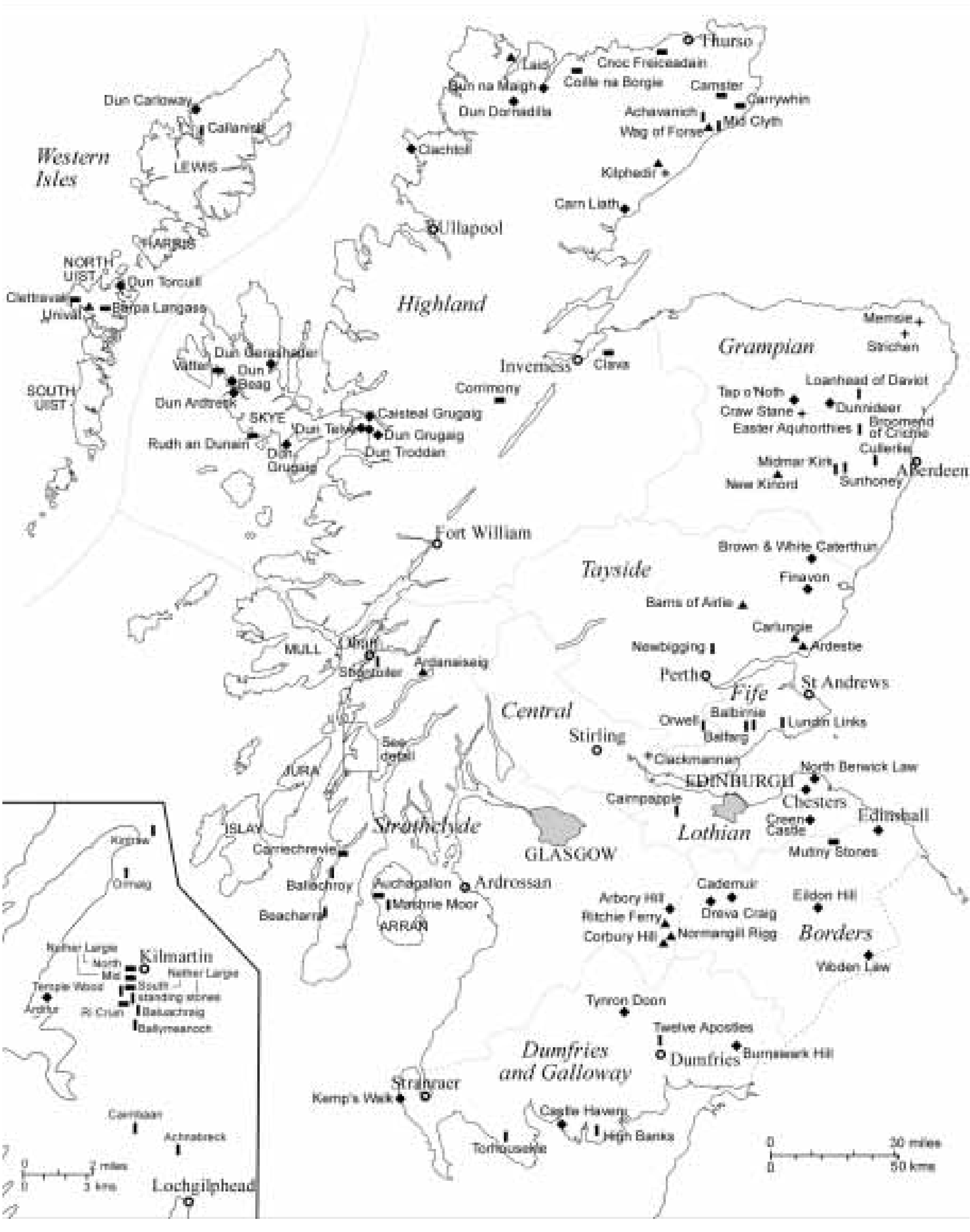


Figure 8b *These maps show in very general terms the distribution of the major prehistoric sites in Scotland. Databases quoted in the text indicate that there are many more small sites, often concentrated very close to the modern shoreline. (From MacSween and Sharp, 1989).*

Figure 9 *Illustration of some typical coastal prehistoric structures in Orkney, Shetland and Hebrides. (a) Knap of Howar, on the island of Papa Westray, Orkney. This Neolithic structure is about 5,500 years old. (b) Broch Mousa on the island of Mousa, Shetland. The broch is the most complete in Scotland, and is 13m high. (c) Dun Torcuill in Loch Duin, which is a tidal loch near Lochmaddy, North Uist. The broch is on a small island connected by a causeway. (d) Burgi Geos, on the west coast of Yell, Shetland, is a blockhouse or fort built on a headland, and protected by a wall of stones across narrowest point. (Graphics adapted from MacSween and Sharp, 1989).*

3.6 These statistical data, combined with the site maps in Fig. 8, establish a number of points

a) The sophistication of construction techniques at least as early as 6,000 years BP, and probably older.

b) The large number of structures now on the coast, and, in view of the known subsidence and past sea level rise, the number which must have been inundated in the last 6000 years. The sea level was at approximately 20m below present (Fig. 6) relative to the land at this date and so many Neolithic and Mesolithic sites built on the shore then must be below sea level.

c) The number of constructions which exploit the terrain, such as headlands and small islands. In spite of the sea level change it is apparent that these locations, where the terrain is steep, were deliberately on or close to the shore, often for defensive purposes.

d) Because many small islands were inhabited when the sea level was approaching present sea level, it is obvious that boats were being used to communicate between settlements at an early date. Evidence from the Mediterranean, south east Asia, and Australia show that people were using boats or rafts to cross sea channels at least 50,000 years ago. It is therefore reasonable that people were using boats or canoes in north west Europe in the Late Palaeolithic.

3.7 St Kilda

St Kilda is a World Heritage Site 64km west of Harris in the outer Hebrides. The 100m isobath almost joins it to the Hebrides, so that it was linked to the mainland and continuous with the Devensian ice sheet at the peak of the glaciation, and became a separate island, or group of islands, shortly before 12,000 years BP. There are 8 small islands, the largest of which is Hirta. On a clear day Lewis is visible from Hirta. The islands were glaciated, and contain exotic transported rocks, moraines, and glacial till (Emery, 1996, p.1). Emery (1996, p.179) considers that Neolithic occupation is possible. Pollard (1999) summarises archaeological finds during the last 100 years, and current excavations, indicating Neolithic and Bronze Age activities on Hirta, although settlement may not have been continuous. He notes "... erosion of the raised beach cliff may indicate that this low lying area, ideal for agriculture, may have been much more extensive in the past, but we have little idea as to how much of this has been lost to the sea since the Neolithic." And later in the same document " It is not beyond the bounds of reason to suggest that people were visiting St Kilda as early as the Mesolithic, between around 9000 and 6000 years BP."

Fleming (1995) reports a project to analyse thousands of flaked stone, dolerite, implements, from quarries to the west of Village Bay. These are typical of Neolithic and Bronze Age. He concludes that a viable community may have lived on the island, with contacts to the Hebrides, and that relevant sites may lie beneath the ocean. Turner (2003) reports Iron Age pottery There is now considerable evidence that St Kilda was occupied at least as early as the Neolithic, and, given the extensive quarrying, that the settlement was more or less permanent.

3.8. Rum

Wickham-Jones (1990, 1994, p.84-88) describes excavation of a Mesolithic site on the island of Rum. Three seasons of work from 1984-86 were sponsored by Historic Scotland at the Kinloch site at the head of Loch Scresort, where Mesolithic deposits were threatened by agricultural development. Excavation revealed post-holes for dwellings, traces of fire, and over 140,000 pieces of bone, stone tools, and waste materials. The stone tools included arrowheads, scrapers, awls, blades and flakes. The location is very sheltered, with a nearby beach for boats, and the site could have been occupied year-round. Hazelnut shells found in hearth sites dated to 8500 radiocarbon years BP, older than any other site in Scotland. The relative sea level was slightly lower at this time. Materials found at Kinloch and other islands indicates that people were transporting tools and possibly other goods such as hides or venison between the islands.

3.9 Orkney

Recent work in Orkney has shown that several Mesolithic sites exist which pre-date the better known Neolithic farming sites (Wickham-Jones, 1994, p.74). There are about 40 large islands and many small ones in the archipelago, and most of the land consists of Old Red Sandstone, with a covering of boulder clay. Most of the islands would be joined together by a relative lowering of sea level of 20m, and the sea level was several metres lower than at present in the early Neolithic. Erosion is still cutting back the cliffs, and the relative sea level is rising slowly. The western and northern coastlines consist of towering cliffs with the highest at 300m. Orkney was separated from mainland Scotland by about 13,000 years BP, (Ritchie, 1995, p.19), and several small mammals already lived on the islands. Fish, shellfish, seals, and whales were abundant. Search for Mesolithic flint tools of types known to be associated with fishing elsewhere have so far been inconclusive (Ritchie, 1995, p.21). Scattered Mesolithic artefacts have been found at a number of sites, and in earlier collections which have been re-classified (Turner, 1998b, p.19). Mesolithic sites are known on the coast of Caithness just across the Pentland Firth, and the oldest documented settlement site on Orkney at Knap of Howar in Papa Westray dates from 4600 years BP, and is a fully fledged Neolithic farm complex. It therefore seems necessary that there were earlier pioneering settlements.

Given the small dimensions of the individual islands of Orkney, often 5-10km across, with the exception of the larger Hoy and Mainland, it is inevitable that many settlements are close to the sea. Nevertheless, the extraordinary number of complex prehistoric buildings either on the shore, or even partly eroded, is so impressive that one must conclude that the occupants were professional users and exploiters of the sea. Amongst the most dramatic structures are two houses at Knap of Howar on Papa Westray (Fig. 9a), Skara Brae on the Bay of Skaill, the Broch at Midhowe (See cover picture), and the burial tombs on Holm of Papa Westray. At Skara Brae the debris and middens showed that the diet was based on farming cattle, pigs, sheep and goats, with domesticated dogs, and cultivated barley and wheat. Some deer were hunted, and stranded whales were butchered. The midden contained enormous quantities of limpet shells and fish bones, mostly cod and saithe.

This is not the place to attempt a summary of the full scope of prehistoric archaeology on Orkney. It is sufficient only to demonstrate the importance of the archaeological remains on the shore, the probability that some components of Neolithic and Mesolithic archaeology are probably surviving in shallow water, and to propose the hypothesis that earlier Mesolithic sites may exist out to a depth of 10-20m.

3.10 Shetland

The islands of Shetland were heavily glaciated, resulting in wide fertile valleys, and over-deepened hollows now containing lochs. Sea lochs penetrate far inland, and are called voes. The curve of relative sea level through time for the last 20,000 years is shown for Lerwick in Fig.6. Submerged peat is common in sheltered voes and sounds, and in shallow water peat is often visible below a layer of pebbles (Mykura, 1976. p.110-111). The submerged peat illustrates the result of recent marine transgression. Archaeological evidence shows that peat was used as a fuel at least as early as the Neolithic (Turner 1998b, p.15). By 8000 years BP the air temperature had reached that of today, and a light covering of woodland was beginning to cover the Shetland islands below an altitude of 200m. The most common trees were hazel, willow, rowan, and juniper.

In deposits dating to about 7500 years BP there is an increase in microscopic particles of charcoal, suggesting that fires were quite common, but dated kill sites have not been found. Mesolithic peoples lived a nomadic live, usually close to the coast, sleeping in caves or temporary shelters. The coast of the Shetland islands was at least 20-30m below present sea level at a date of 7500 years BP, and so it is possible that Mesolithic sites of that date are now completely submerged.

By 5500 years BP there is evidence for farming on Shetland, and the extensive field wall patterns at that date suggest that the development started considerably earlier. Overall there are 180 prehistoric house sites for this period (Turner, 1998b, p.27). At the beginning of the Iron Age, around 2500 years BP, people were building forts and brochs, and the most dramatic fortified structures of this date are at Clickhimin and Jarlshof, both on the coast. The tallest standing broch is at Mousa, where the circular tapering tower survives to a height of 13m. It also is on the coast.

As in the case of Orkney, it is not the purpose of this section to summarise the prehistoric archaeology of Shetland, which would require hundreds of pages. The purpose of these notes is only to demonstrate that highly sophisticated structures were built on the present shoreline between 7000 and 2000 years BP, and that almost certainly similar structures were built on land which is now submerged by tens of metres.

3.11 Summary

This section has shown that northern Scotland and the outlying islands were occupied by sophisticated people at least as early as the Mesolithic, starting around 9000-8500 years BP, at a time when the sea level in the outer islands was about 40-50m lower than at present relative to the land. Although the evidence of occupation is still tenuous at this earliest date, the most important materials might now be underwater. While there is no archaeological evidence at all for occupation before these dates, that is in the Late Palaeolithic, any such human presence must have been on land which is now submerged. It would take many years of slowly accumulated evidence to prove or disprove the presence of such early occupation, but it is worth collecting the relevant data in a low key but systematic way. Early occupation would almost certainly be based on exploitation of marine mammals.

4. Known submerged sites

4.1 Introduction

In order to illustrate the potential for submerged archaeological sites within the SEA4 area we will consider some submerged sites in the adjacent Northern North Sea, in Denmark, and a suspected submerged cave site off the coast of Orkney. As explained in Section 2 the submarine environment in SEA4 is somewhat different from the known areas of the North Sea and English Channel, many of which were described in the review for SEA3 (Flemming, 2002). Close to shore the seabed is much more rocky and steep than the sites described in SEA3, and in deep water the SEA4 environment is the sub-glacial and peri-glacial assemblage of moraines, hollows, kettle holes, and depressions, with very little modern marine sediment. The latter is broadly comparable with the topography of Denmark, which was itself glaciated, but the SEA4 area was subsequently exposed to extreme storm wave attack, while the Danish archipelago was very sheltered.

4.2 West Viking Bank

Vibrocore number 60+01/46 obtained as part of a BGS programme in the UK shelf produced a worked flint from a point 150km north-east of Lerwick, near Viking bank, in a water depth of 143m (Long *et al*., 1986) (Fig.10) . It is inside the UK sector. The artefact has been submitted to the National Museum of Antiquities of Scotland. This artefact is unique on a global scale, both in terms of its water depth, and its distance from the present shore. The unusual statistical chance of its discovery arises because the BGS programme required many hundreds of cores to be taken over a wide area of the continental shelf at standardised spacing, and the laboratory analysis of the core revealed the flint. Out of the hundreds of cores examined, no other flints were detected.

The location of the core was 60^o 42.3' N, 1^o 40.3'E. The core location appears on the BGS sediment map for Halibut Bank. The artefact is made of fine, dark grey patinated flint, and is 21mm long, weighing only 2.6g. It has been retouched to make a steep face, and may also have been broken by accident. Scrapers of this kind exist at a number of sites, and it can be attributed to the Upper Palaeolithic (Long *et al.* 1986, p.59). The core was 1.7m long, and consisted of 50cm of silty sand overlying 10cm of pebbly muddy sand with many shell fragments and frequent whole shells. Beneath this is 1.0m of clay with shell fragments, and a basal layer of poorly sorted pebbly sand. The flint was found 28cm below the surface in the Holocene silty sand. Long *et al*. (*op.cit.*p.57) conclude that the layer is a lag deposit formed when the marine transgression reworked sediments in shallow water, and the flint comes from a nearby archaeological site on land exposed prior to the transgression.

The lowest indicators of sea level on the present seabed are at depths of the order of 180-190m, dating from approximately 15-16,000 years BP (Carlsen *et al.* 1984). Ice caps from Norway and Shetlands did not meet across the North Sea. The model of Lambeck (1995) provides a set of plots showing the limits of the ice caps and the shorelines from 22,000 years BP onwards (See Figs. 4 and 5). As the local ice caps retreat the land comes up faster than the global sea level so that the dry land area is at a maximum around 16,000 to 14,000 years BP. Peacock (1995,p.1040) dates the gravel and shell-hash layer below the Holocene sands in the core to about 11,000 years BP. Around this time band the flint tool could have been lost on the continental shelf at the observed location. The isobases on the Lambeck figures indicate the depth of the contemporary shoreline as it would be found now. The flint lay in the depression about half way between the two isobases showing -100m, suggesting that it should be found now at about 150m. The actual depth at the find site was 143m. The BGS map shows a gentle east-west gradient of the present seabed at the core site, suggesting that the source could be to the east.

By 11,500 years BP a sea level stand caused a wave-cut platform to the north of the sample area, and the Viking and Bergen Banks existed as islands (Rise and Rokoengen, 1984). The sea level subsequently rose rapidly, and there was little subsequent deposition, although there was reworking of shallow sediments. Popular discussion often focuses on cut off islands, and imagines massive disasters, floods, and many deaths. More realistically people hunting and living in a near arctic environment, fishing and hunting, would avoid wind-swept high ground and thus the location of the tool close to a palaeo-shoreline is to be expected.

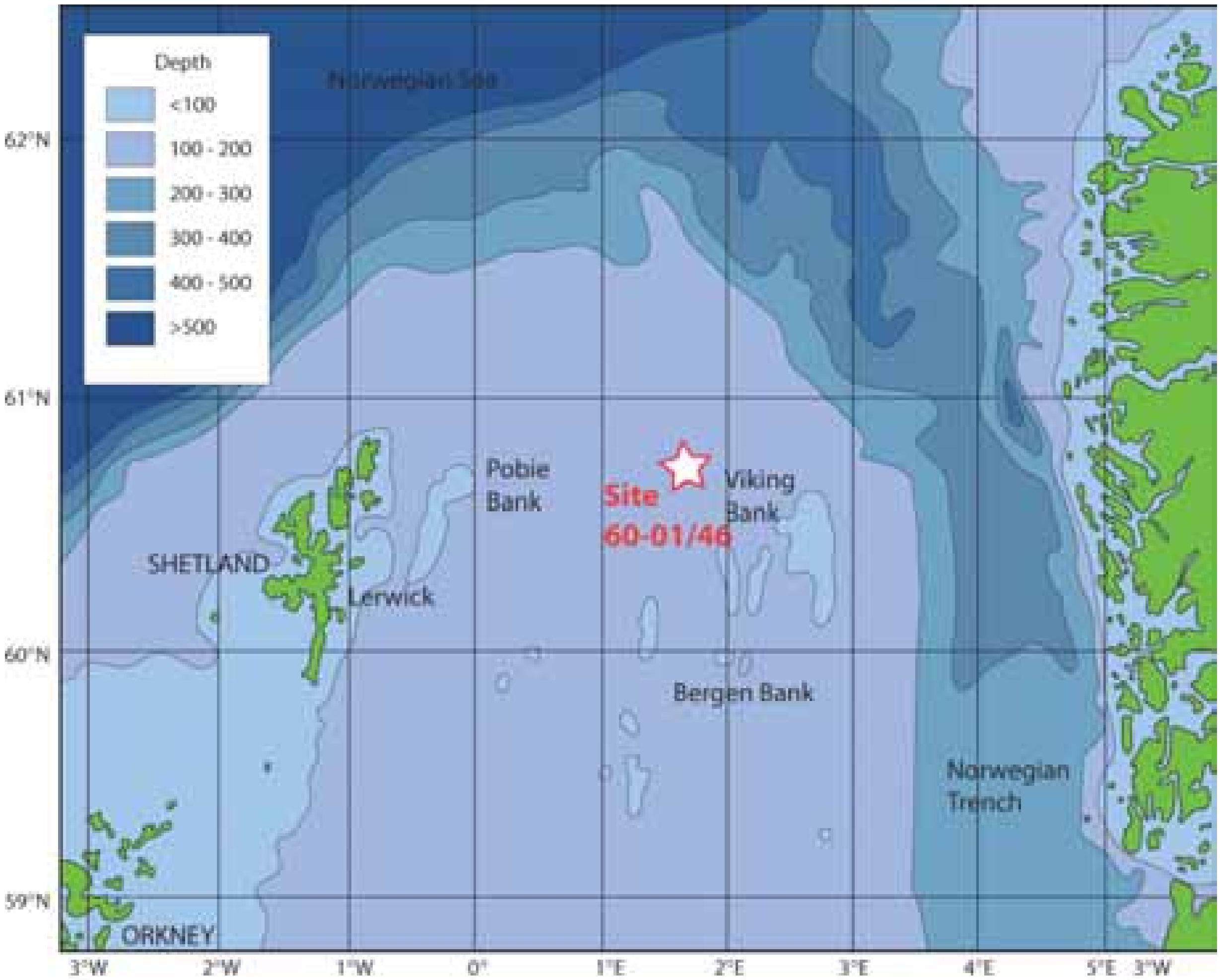


Figure 10a *Bathymetric map of the Northern North Sea showing site 60+01/46 and localities referred to in the text. (Contours in metres below sea level).(From Long et al.1986).*

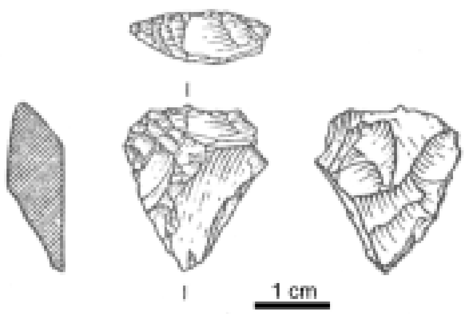


Figure 10b *The flint artefact (From Long et al. 1986).*

4.3 Denmark Archipelago and Storebaelt

Since the late 1970s several groups of divers have been finding Mesolithic settlement sites in the waters of the Danish archipelago. Skaarup (1980, 1983), Fischer (1991, 1995, 1997), Fischer and Sorensen (1983), Fischer and Thomsen (1987, 1988), and Andersen (1980) through a wide range of publications give an overview of the many hundreds of Upper Palaeolithic, Mesolithic, and Neolithic sites found underwater amongst the islands of the Danish archipelago. It is undoubtedly the richest and most extensive continuous area of underwater prehistoric archaeology in the world. Sites have been found at predicted locations to a depth of about 30m, using environmental models from the shoreline to a maximum predicted depth of 60m. Although the great majority of sites are within the Baltic, a few artefacts have been recovered from as much as 10km offshore the Danish North Sea coast (Fischer, personal communication, 2002). The analysis of the complex cultures which evolved in the Danish archipelago has changed the whole picture of how people moved northwards from about 14,000 years BP onwards, following the retreating ice front. It is now obvious that the basic source of food, health, comfort, and prosperity was the sea, and that the combination of seafaring with coastal foraging and fish trapping indicates a sophisticated community with skills to cope with all the risks and dangers of the seafarer's life.

A seminal excavation which attracted much interest in the early stages of Danish underwater prehistoric archaeology was that by Andersen (1980) describing a submerged settlement discovered in 1978 at Tybrind Vig. The water depth was 2-3m, and finds occurred in a strip about 50m long and 10m wide along the original shoreline. Finds included fish traps, stakes, food waste, bones of mammals and fish, and many small fur-bearing animals. Seals and porpoises were caught at sea. Fifteen oars for canoes were found, and bows for shooting arrows. In 1980 a dugout canoe was found, cut from a lime tree trunk, 9m long and 65cm wide. The boat included a small fireplace, possibly to create flares to attract fish or eels, but also suggesting that sea trips may have lasted more than a few hours. The remains have been dated to 6,000-5,700 years BP.

A unique factor in the Danish situation is that the land masses making up the archipelago are all small, compared with the UK or the main European continental area, and are very low lying. The greatest altitude is of the order of 300m, and most of the land is below 100m. The result is that the sediment load transported by rivers or direct coastal runoff is very limited. Sea currents then winnow away the finer sediments, leaving the archaeological material as surface lag deposits.

The winter storms of 1999-2000 caused damage to many underwater prehistoric sites. Amateur divers gave reports to the National Museum's Institute of Maritime Archaeology. While damage and loss undoubtedly occurred, the storms also revealed many new artefacts, many kilograms of flints, bones, antlers, a harpoon, and one human skull. Anders Fischer (personal communication, 2002) states that similar erosive exposures occur each winter, and are usually reported by sports divers.

When planning the Fixed Link Bridge-Tunnel joining the islands of Fyn and Sjaelland, a survey of the route of the bridge was very carefully made first for archaeological relics. The Fixed Link across the Storebaelt is about 15km long, from Nyborg to Korsor. The decision to build the Link was taken in 1987, and, since the route of the various bridges, cuttings, and tunnels had not yet been fixed, the divers searched a much wider area than was finally influenced by the construction. In 1997 a massively complete survey and analysis of the archaeological results was published under the editorship of Pedersen, Fischer and Aaby (Pedersen *et al*. 1997). The report is probably the most thorough and complex document available on all aspects of a submerged prehistoric site, or rather area of sites. As the introduction says (Pedersen *et al.* 1997, p.62) "The contributions to this chapter may therefore be taken as inspiring examples of the world-wide archaeological potential of the sea-bed".

It is almost impossible to summarise here the scope of this work, which revealed a range of Mesolithic and Neolithic sites, skeletons and skulls, extensive submerged forests with the trunks of oak trees from 9100 years BP, and a pine forest at a depth of 30m dating to 10,100 years BP. There were sufficient tree trunks to construct a local dendrochronology. Worked flints, organic materials, fish- traps, fish weirs, wattle fencing, fence stakes, arrowheads, ornaments of carved antlers, and trade- goods from central Europe, all provided testimony to the vigorous settlements which resided on the ancient coast from about 8,000-4,000 years BP. Archaeologists have concluded that the coastal sites contained many families living together, and that the sites already known inland were only the outposts where small groups foraged the hinterland, and then returned to the shore. The probable location of sites was predicted in advance using a model based on the best sites for the construction of fixed fishing traps made of long wattle fences. The predicted sites often turned out to be so rich that divers found worked flints within minutes of reaching the seabed, and on average would find 41 flints per hour at these sites (Fig.11).

During the Mesolithic, the surrounding land was covered in dense forest of lime, oak, elm and ash, with an under-forest of hazel. Fireplaces and charcoal were found, as well as dugout boats. From the skeletons the health and age structure of the population can be assessed, and the diet. Sea food, not surprisingly, was the dominant component.

Figure 11 *Divers inspect fresh flints raised from the submerged Mesolithic site at Stavreshoved, during the Danish Storebaelt project. (From Pedersen et al. 1997).*

4.4 Orkney

The detection of proven submerged Neolithic or Mesolithic sites in Orkney is in its earliest stages. The following notes and illustration (Fig 12) are provided by Dr Robert Forbes, Director of the Orkney Diving Centre operated by Heriot Watt University. The first site is a fossil shoreline in the cliff coast on the west coast of Mainland Orkney. The red circle locates a deep hole in the bedrock which appears to be a collapsed sea cave. Dr Forbes comments: "The problem is the available information I have would tend to suggest that the sea level did not remain at this height for a sufficient period to cut a structure like this. We had hoped to dive on this site but as yet have not got around to it. There is what seems to be a similar feature further up the coast but the "roof" for the cave isn't quite as collapsed."

Given multiple glaciation and multiple sea level changes a cliff-terrace-cave feature is not necessarily the result of a single concentrated period of erosion. Thus the cave feature could have been formed at a relatively early period, and occupied much later. The site does need investigation by divers, if only to confirm that submerged caves do exist, and can be found.

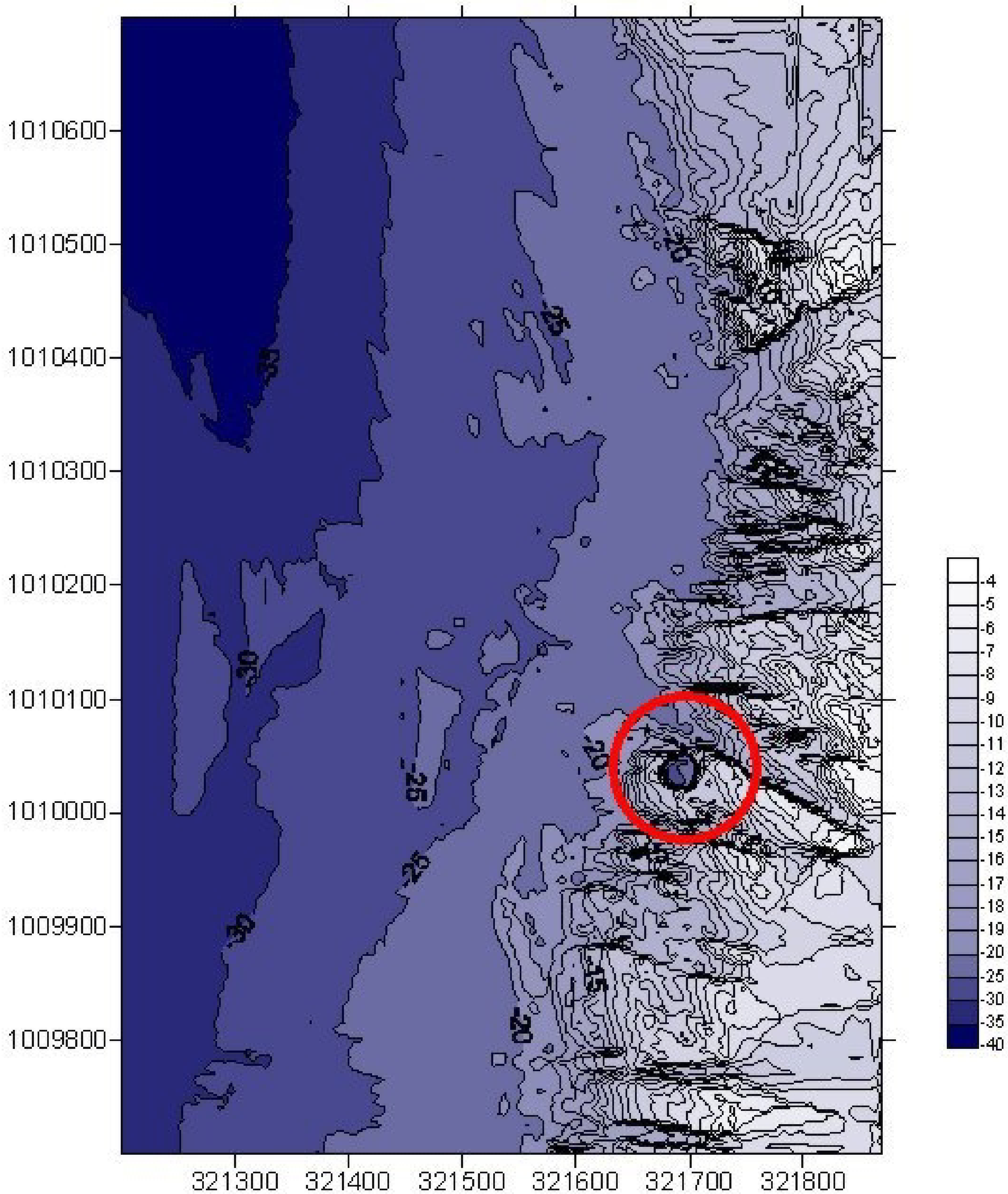


Figure 12 *This bathymetric map compiled from swath sonar shows a collapsed circular depression, marked with the red circle, which is probably a collapsed cave at the foot of a cliff. Location is on the west coast of Orkney. (Credit, R. Forbes).*

Dr Forbes continues: "Another item of note has been the report of a stone structure at 8-10 metres in the Bay of Firth by a local clam diver. When asked to draw this, he produced a sketch described by the County Archaeologist as a "stalled cairn". Looking at the chart of the area one can well imaging this as an inundation site. We are hoping to get a better location for the site so we can have a look as this would truly be a find of significance."

While neither of these sites is as yet conclusive, they constitute potential examples of exactly the kinds of sites predicted in Section 2 above.

Another area of research in progress is a recently funded project led by Dr Penny Spikins of the University of Newcastle upon Tyne. This project is entitled "A search for submerged early postglacial sites: prospection based on GIS based predictive models". The project includes stages of model design based on the analysis of known sites on existing coastlines; extension of the models offshore; analysis of the limits of preservation and search feasibility; and finally investigation by divers. One of the study areas for this project is Orkney.

4.5 Palaeontological data

Terrestrial animal bones from beneath the sea, whether completely silicified or not, can potentially tell us about the fauna and flora of the submerged terrestrial landscape. If bones of certain animals are found, and if we can show that they are in situ, then that gives information on the landscape and the vegetation, or other animals, upon which they depended for food. This in turn provides a basis for estimating the animal food base available to human hunting, trapping, or scavenging. Many Pleistocene and early Holocene terrestrial animal bones are trawled up every year from the North Sea and around Scotland. It is difficult to determine the exact location and provenance of the bones, both because the trawlers can only report that the finds were made during a trawl of 10km length or more, and because the bones may have been transported by sediment movements, seabed currents, ancient rivers, or ice transport during the previous thousands of years, before final deposition in the sediment. The situation of the bones within the sediments, and the nature and origin of the sediments, must therefore be determined in order to explain their origin and degree of transport.

The radial spreading of the ice sheets centred on Scotland has resulted in many earlier fossil bones being transported south east into the central North Sea, and east, north, and west from the Scottish coast, where they are superimposed on, or may occur under, remains which may have been deposited in situ, from animals living on the exposed continental shelf. For example, fossils of widely differing ages are found in the area of the Brown Ridge in the central southern North Sea. However, the precise stratigraphy of the Ridge, the surrounding depressions, and the extent to which bones are dragged out of the sediment by trawls, or are first eroded, possibly transported by waves or currents, and then collected in the trawl, are unknown. Many bones have been retrieved and dated to the period 10,000 to 7,000 years BP, which is long after the ice caps had melted from the land, and therefore these bones cannot have been transported by ice. To this date worked bones and antlers have only been recovered from the Brown Ridge area (Loewe Kooijmans, 1970/71), and Post, 2002, personal communication).

Some of the palaeontological materials from the North Sea have been studied and documented by academics, but the great majority are processed by fishermen, collectors, and commercial fossil shops. The volume of recoveries is such that it is impossible to process all the bones as if they have uniform research value, and there is in most cases a working relationship between the collector community and the professional museum and university community. This relationship needs to be developed and strengthened. The North Sea fossils sold in Britain, other than those from the Brown Ridge, come from two main areas. Most Scottish specimens come from a large area to the west of northern Scotland and also a smaller area southeast of Shetland. The Scottish specimens come from Aberdeen trawlers, which fish mostly in an area to the west of Scotland. The fossils which are in the north east North Sea off the coast of Aberdeenshire are spread more thinly and are more fragmentary than those in the Brown Ridge area, because of glacial action.

The species of mammal recorded from the Scottish North Sea are (in order of abundance of fossils) reindeer, *Rangifer tarandus*, bison, *Bison* sp., musk-ox, *Ovibos moschatus*, woolly mammoth, *Mammuthus primigenius*, red deer, *Cervus elaphus*, and some woolly rhino, *Coelodonta antiquitatis*. I am indebted to Drew Baine and Andrew Kitchener of the National Museums of Scotland for this information.

4.6 Summary

The SEA4 is an extremely complex and difficult area in which to work. Although sports divers do frequently visit Scapa Flow to dive on the wrecks of the German warships, there is not a high density of divers throughout the area, even within the archipelagos, which might result in chance discoveries of prehistoric sites in shallow water. Research diving by members of Heriot Watt University, and planned work by the University of Newcastle upon Tyne will provide new data, but progress is inevitably slow. The potential value of research data and new submerged sites in SEA4 is very high, and all sources of information should be combined to try and accelerate the acquisition of knowledge.

5. Consideration of the potential impacts of oil field operations on submarine prehistoric archaeological remains

5.1 SEA4 is a very difficult area for submarine prehistoric archaeology apart from the sea areas within the archipelagos of Orkney and Shetland, and the immediately adjacent waters shallower than about 30m. Within this area the prospects are very good. In view of the sophisticated structural techniques and the range of symbolic features such as standing stones and cairns, there could be many interesting and valuable discoveries beneath the sea. In deeper water, as discussed above, it would be very difficult for sports divers or research divers to find archaeological remains, and it would be very expensive to conduct academic research projects.

Offshore hydrocarbon prospecting and exploitation have several phases of activity which could impact on submarine prehistoric archaeology.

i) Coring of seabed to investigate pipe routes and foundation engineering for platforms.
ii) Emplacement of platforms, concrete gravity, jacket or jack-up. Consider the total footprint of the platform, and associated support systems.
iii) Permanent anchors for semi-submersible platforms.
iv) Pile driving.
v) Drilling and running casing.
vi) Pipe entrenching.
vii) Coastal entrenching, terminals, docks, shoreside structures, jetties.

5.2 The total area of sea floor disturbed, excavated, or drilled in the course of these activities is small compared with bottom trawling, aggregate dredging or beach replenishment, but there is always a chance that a single core may penetrate a prehistoric site, as in the case of the Viking Bank core, or that a trench for a pipeline will intersect one or more prehistoric sites over the tens or hundreds of km of burial. All shallow sediment cores sampling the top 1-10m of sediment in sensitive areas should be checked routinely for prehistoric materials.

5.3 The excavated sediment from pipe entrenching machines is not brought to the surface, but is ploughed or jetted to the side of the trench, there is thus no chance at present to investigate the occurrence of prehistoric artefacts in the sediments. Consideration should be given to some way of monitoring this process, either by recovering sediment, or close video inspection by ROV. Prehistoric artefacts have been retrieved from 50m depth by ROV and clamshell grab (Josenhans *et al*., 1997) off British Columbia.

5.4 Trawling and dredging both disturb the upper 0.5-1.0 metre of sediments over large areas, but are outwith this report. The offshore aggregate industry already has a very healthy collaborative relationship with the academic archaeological community, and indeed funds from the industry provide support for some very important excavations. Many land excavations have been started by good observations from industry workers. Louwe Kooijmans has shown that fishermen also can become prolific sources of information and assistance in retrieving subsea archaeological materials. The Solent fishery demonstrates the same point, with some of the local fishermen having collections of flint tools which are catalogued by the County archaeologist, but left in the possession of the finders.

6. Consideration of the opportunities presented by oil and gas operations in an area for site/artefact identification, e.g. seismic survey, sub-bottom profiling, coring, ROV

6.1 The previous discussion shows that, given sensible preparation, briefing, and mutual understanding offshore industries can actually serve the archaeological community. It is not within the terms of this report to make specific proposals of this nature, especially since the cost implications and time lost (if any) are not immediately apparent. However, on the assumption that some staff time, funds, and assistance might be available, the following paragraphs show that activities of the offshore oil and gas industry could be positively helpful, with appropriate monitoring.

6.2 *Acoustics*
Acoustic surveys of various kinds can contribute to the discovery of submarine prehistoric sites, but, to date, only through circumstantial identification of likely topographic and stratigraphic conditions. No acoustic system has yet been used successfully to demonstrate that a particular structure or surface feature contains worked flints, shell midden deposits, charcoal, carved wood, or bones. Swath bathymetry, side-scan sonar, and conventional shallow sub-bottom profiling can identify a drowned beach ridge or river valley, or similar features of archaeological relevance beneath a few metres of modern sediments. The ability to resolve the sub-millimetre characteristics of stones a few cms across that would tell the human eye that they are man-made cannot be achieved at present by acoustics. Similarly it is difficult, perhaps impossible, with acoustics to detect tree-trunks or other organics in peat, or to distinguish a humanly-biased selection of shells, that is a midden, from natural shell gravel. More research is needed on this problem.

6.3 Chirp technology can show fine-scale stratification which gives strong clues, but physical sampling by core, grab, diving, or ROV has always proved essential to establishing the existence of a submerged prehistoric site. No cross-correlation check has been carried out using high frequency, high resolution acoustics over known submarine prehistoric sites to test signatures of anthropogenic materials. The Danish experience, where acoustics are used routinely to select optimal diving sites on the basis of topography suggests that no such direct signature yet exists. Ongoing work in Norway and Denmark indicates that some data on this problem will soon be available, at least regarding large features such as wooden posts. Consideration of the wavelength of high frequency sound, which is of the order of 4 -15 mm in the frequency range 400-100 kHz, suggests that the resolution could not distinguish shapes at the level required to identify worked flints. Medical type acoustics at 4 MHz has a penetration of only 20-30cm. Given the present state of knowledge and acoustic signal interpretation, commercially obtained records could be used to improve site identification on the basis of topographic and sedimentary criteria.

6.4 *Coring, grab samples, and site investigation*
Coring and sampling of seabed sediments can identify sedimentary facies, and detect material such as peat, beach gravels, clay, deltaic muds, and organic materials indicating age, and pollen indicating vegetation, temperature, and shells indicating salinity. BGS cores and commercial cores which have been archived provide a massive body of data which has not been exploited archaeologically. In future, any planned core or grab sample investigation by offshore operators should be checked against the list of archaeologically sensitive areas and, in the high-probability archaeological zones, the cores must be examined for archaeological signals.

6.5 *Dredging and pipe entrenching*
Bulk movement of seabed sediments has the potential to damage prehistoric sites in the SEA4 area very seriously. Paradoxically, in the SEA4 area, this may be the only way that archaeologists could ever discover sites in water more than a few tens of metres deep. As mentioned in para. 5.3 such operations should be monitored or sampled at intervals to check for artefacts or designated indicators.

6.6 *Avoidance*
Acoustic systems and seabed sampling create the potential to gain advance warning of the probable presence of prehistoric sites, and hence to plan avoidance of intervention. Avoidance would usually increase costs for the operator. Repeated instructions to avoid newly indicated potential sites would complicate logistics and add more to costs. Over-sensitive thresholds for site avoidance would ensure that no artefacts were recovered, and no sites discovered for archaeological research. It follows that avoidance criteria should be set at a coarse, non-sensitive level. Mandatory instructions to divert or

delay operations should only be considered after human artefacts or mammal bones have been recovered. Even then it is possible that the decision would be to monitor operations and the sediments disturbed on a 100% basis, rather than avoid the site.

6.7 *Preservation in situ*

The legally preferred method of preserving submarine archaeological sites is *in situ* (See Section 1.11). Strictly speaking this means no disturbance at all, but discovery and research does involve disturbance, unless the artefact is on the surface. The objective is to balance over time the sum total of acquired and published knowledge and the sum total of preserved artefacts left *in situ* for future generations. Research excavation underwater increases knowledge but destroys sites. Undiscovered sites represent future knowledge, but present ignorance. The marine environment in SEA4 falls into two radically different types. Within the sheltered voes of Shetland and Orkney preservation *in situ* is probably practical. When a prehistoric submerged site is known it could be protected from possible damage or interference from divers or inshore industrial activities. Outside the shelter of the archipelago waters SEA4 is an exceptionally hostile environment. Waves and currents erode sites constantly, so that there is a powerful argument to discover and excavate sites, monitored under academic supervision. This approach differs from the management protocols of the Danish archipelago, where hundreds of submerged sites are known, and the great majority are preserved *in situ*. Preservation *in situ* in the open sea area of SEA4 is indistinguishable from deliberate neglect unless it can be proved that sediments are stable or accumulating over the site.

6.8 Conclusion to section 6

Offshore oil and gas operations, and the sub-contracted services, present a good opportunity to discover and record submarine prehistoric sites in SEA4, outside Territorial Limits. Regulations and Avoidance criteria should be set a level such that acoustic surveys and sampling systems have the maximum chance of physically proving the existence of archaeological sites.

7. Summary of existing practices regarding the reporting, investigations and protection of prehistoric and archaeological remains

7.1 The Outer Continental Shelf legislation in the USA requires offshore operators to conduct extensive pre-disturbance and avoidance surveys before starting operations, so as to protect prehistoric archaeological sites, as well as shipwrecks. By the early 1980s the situation was attracting severe criticism because hundreds of millions of dollars had been spent, and no prehistoric artefacts had ever been found on the outer shelf, and no academic search was being conducted for remains. During the same period American marine archaeologists working on minuscule budgets, and usually assisted by large teams of volunteers, were studying palaeo-indian prehistoric sites in water depths up to 10-20m at many locations on all sides of the USA (e.g., Stright, 1990; Cockrell and Murphy, 1978; Ruppé, 1981). Flemming (1981) wrote to comment on the absurdity of this position. UK regulations should avoid repeating this mistake.

7.2 The assumption behind a strict code of *in situ* preservation is that academic institutions or statutory regulatory bodies will both discover, classify, and excavate sites, and have sufficient funds to prove or disprove the existence of artefacts in high-potential areas. For the SEA4 area outside the internal seas of the archipelagos and outside Territorial waters this is incorrect. Only commercial companies can justify the cost of seabed work in these conditions. It is therefore preferable to allow commercial companies to proceed in the manner which is technically and economically the most efficient, and to monitor the archaeological impact. When the existence of a site is certain, then academic resources should be deployed to monitor, and, if suitable, excavate.

7.3 The BMAPA is working with English Heritage to develop a detailed protocol for the management of archaeological sites impacted by aggregate dredging, and the principles developed in that document could be adapted to the offshore sector. Notwithstanding the fact that aggregate dredging is not a major industry in Scottish Waters, this document still provides a valid basis for assessing obligations offshore. Expert groups such as the Archaeological Diving Unit (ADU), the Hants and Wight Trust for Maritime Archaeology, and the Nautical Archaeology Society in Scotland, should be consulted. Sites need to be reported and studied whenever possible. Procedures could be recommended consistent with BMAPA and RCHME schemes in England to encourage and promote the reporting of sites with a minimum interference with work schedules. Notice of intention to carry out operations or to disturb the surface sediments in key areas is the major step. Within Scottish Waters the recording of sites would presumably become part of the NMRS managed by RCHAMS.

7.4 It is obvious that the work of Louwe Kooijmans and van der Sluis produced hundreds of palaeontological finds, and some prehistoric artefacts, in less than 10 years by collecting materials reported by Dutch fishermen who were fishing on the UK side of the median line (See the SEA3 Report, Flemming, 2002). Post (personal communication) has confirmed that many tons of Pleistocene terrestrial mammal bones are landed by Dutch fishermen each year. A few finds (Dogger, 1832, Leman/Ower 1932) were also reported by UK fishermen. But the discrepancy is not really explicable. There must be material in many other areas, even allowing for the different geology and sedimentary regime in the northern North Sea and north-western approaches, where active modern marine sediments are sparse. Preliminary enquiries suggest that Scottish fishermen are retrieving small quantities of palaeontological items, and this line of analysis should be followed up so as to identify the areas which may have supported *in situ* mammal populations, and where bones have been transported into areas by glacial transport or post-glacial run-off. If an in *situ* fauna can be identified, this would be an indicator towards the possibility of human occupation. In this sense, all industries offshore which have the potential to impact or disturb prehistoric archaeological materials may provide data which impact on the management of offshore prehistoric archaeology as a whole.

8. Recommended mitigation measures to prevent damage to prehistoric and archaeological remains from oil and gas activities. These should draw on, and where appropriate be concordant with, draft guidance produced by BMAPA and RCHME

8.1 The objective is to achieve a constructive and positively beneficial relationship between the offshore oil and gas activities in sector SEA4, and the archaeological research community, and associated legislation, both national and international. As already pointed out, the marine aggregates industry is minimal in Scottish Waters, and the equivalent body to RCHME in Scotland is RCHAMS. Nevertheless, the obligations and procedures worked out by BMAPA and RCHME do exist, and DTI has instructed in the terms of reference of this report that the recommended procedures for the offshore oil and gas industry should be consistent, both in terms of contiguous geography and as between different industries.

8.2 The following comments are intended to suggest the areas of discussion which might promote and maintain such a relationship. None of these comments should be regarded as assuming any particular outcome of that discussion process.

8.3 The first question to consider is whether any known areas within SEA4 should, on the present evidence, be restricted in such a way that offshore hydrocarbon activity of any kind should be curtailed or banned. Since Historic Scotland already has the responsibility to manage and protect sites out to the 12 mile limit, this discussion will only apply to the sea bed beyond that limit. Notwithstanding possible legal arguments which could suggest that such pre-emptive restrictions might be desirable, we need to consider the practical effects for archaeology, in addition to the economic and industrial impacts. The experience with the OCS legislation on archaeology in the USA shows that when such regulations are rigidly enforced, large sums of company money are spent in pre-disturbance and avoidance surveys, and no archaeological artefacts are ever discovered. Meanwhile cash-strapped archaeological teams struggle to recover deposits of prehistoric artefacts found in the coastal zone, usually assisted by sports divers. Since so many known artefacts have been retrieved in European waters by commercial activities from at least three major industries (Fishing, aggregate dredging, and port engineering), an overly restrictive policy would be self-defeating for archaeology, as well as expensive for industry.

8.4 The legal point of view might be that commercial exploitation of resources will disturb unknown archaeological sites, and may do damage before work is halted or diverted. Therefore exploitation should be restricted, or subject to exhaustive pre-disturbance surveys. While this may prevent commercial damage to sites, it also ensures that no sites will be discovered by archaeologists, while natural wave and current erosion will progressively destroy deposits anyway. In the high energy hydraulic regime of SEA4 the archaeological resource is continuously declining.

8.5 It is therefore in the interests of long term preservation of the archaeological sites, and in the interests of acquisition of archaeological knowledge, that we use industrial and commercial activities as a means of identifying archaeological prehistoric sites in the offshore area. Since so many prehistoric sites exist on the mainland coast, and on the coasts of Orkney, Shetland, and the smaller islands, and since the internal lochs and enclosed waters of the archipelagos so obviously are likely to have prehistoric remains within them, these areas must be strictly controlled, and Historic Scotland has the authority to do so. On the coast and in shallow water sites will usually be known to the local authorities, and are in most cases documented by RCHAMS and HS. The approach suggested here of encouraging and then monitoring industrial activity would only apply further offshore, perhaps outside Territorial Waters. There should be a logical continuity of the protocols at the Territorial Limit.

8.6 The ideal structure would require or encourage the industry and its sub-contractors to check whether their activities are in archaeological prospective zones, and to identify, and report, when their activities positively detect prehistoric artefacts, or, in the case of acoustic surveys, provide very strong evidence. If this can be achieved at minimal or acceptable cost/delay to industry, then there is a positive advantage in allowing operators to start activities in zones of archaeological potential, while avoiding positively identified sites, if any.

8.7 This may sound heretical, but the conditions and circumstance in the North West Approaches, and adjacent Atlantic need to be treated realistically. There is no comparison with the Danish situation where complex and relatively undisturbed sites, each with thousands of artefacts, are known to occur with a spacing of the order of 1 - 5km. Even if there were originally quite a dense scatter of artefacts in the SEA4 seabed there are no means now for finding sites in the complex topographic conditions of low hills, moraines, rocky outcrops, gullies and depressions by surface observation. High resolution acoustics, both swath bathymetry and sub-bottom profiling would be very useful, but some form of disturbance, dragging, dredging, coring or excavation is essential if we are to find anything at this stage. In coming years, if and when we know much more, this situation may alter, and limited areas could be strictly protected for future controlled research.

8.8 The guidance for BMAPA (BMAPA and RCHME, 2001) is reasonable, as a consultation draft Guidance Note. The Guidance Note provides for Site Assessment, (desk-based studies of existing knowledge); Archaeological Field Evaluation (a limited programme of non-intrusive or intrusive fieldwork); Avoidance, Reduction, and Remedying or Offsetting. There are recommended protocols for monitoring commercial dredging. An equivalent document for the offshore oil and gas industry should address the equivalent issues.

8.9 In the North West Approaches open waters it would be extremely difficult to mount a major excavation with strict site stratigraphy, and it is probable that, in the near future, academic activity would be limited to analysis of finds by commercial operators, and occasional dives to check for surface finds, possibly by the ADU, or the Heriot Watt diving group on Orkney. When more sites are located and understood, excavation might become advisable, especially if a site revealed a major item such as a bog body in peat.

8.10 The success of this approach depends upon many more people in the commercial sector being aware that prehistoric artefacts could be present in almost any sediment recovered form the seabed in SEA4, and learning to recognise artefacts of flint, bone, and antler. It has been suggested that stone tools are so obscure that non-experts would never learn to recognise them. I doubt if this is true, and recognition kits or guidance notes could be distributed or posted as notices at very little cost. Since the older tools tend to be larger, there is a greater chance of recognising those artefacts which are the least likely to be found.

8.11 Excavation procedure: The responsibility for excavation of offshore sites rests with the archaeological authorities and the university research community. Any plans for excavation or submarine survey for archaeological purposes would be conducted in accordance with the standards of safety normal for offshore operations, and diving would be conducted in accordance with HSE regulations. This paper cannot comment on funding in regard to offshore archaeological projects.

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Annexe 1 - Articles 149 and 303 of UNCLOS

Article 149. Archaeological and historical objects

All objects of an archaeological and historical nature found in the Area shall be preserved or disposed of for the benefit of mankind as a whole, particular regard being paid to the preferential rights of the State or country of origin, or the State of cultural origin, or the State of historical and archaeological origin.

Article 303. Archaeological and historical objects found at sea

1. States have the duty to protect objects of an archaeological and historical nature found at sea and shall co-operate for this purpose.

2. In order to control traffic in such objects, the coastal State may, in applying article 33, presume that their removal from the sea-bed in the zone referred to in that article without its approval would result in an infringement within its territory or territorial sea of the laws and regulations referred to in that article.

3. Nothing in this article affects the rights of identifiable owners, the law of salvage or other rules of admiralty, or laws and practices with respect to cultural exchanges.

4. This article is without prejudice to other international agreements and rules of international law regarding the protection of objects of an archaeological and historical nature.

Annexe 2 - Acronyms

ADU	Archaeological Diving Unit
AMS	Accelerator Mass Spectroscopy
AHOB	"Ancient Human Occupation of Britain" project
AHRB	Arts & Humanities Research Board
BMAPA	British Marine Aggregates Producers Association
BGS	British Geological Survey
CBA	Council for British Archaeology
DCMS	Department of Culture, Media, and Sport
DTLR	Department of Transport, Local Government, and the Regions
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EU	European Union
HS	Historic Scotland
MoD	Ministry of Defence
NAS	Nautical Archaeology Society
NHA	National Heritage Act 2002
NMR	National Monuments Record
NMRS	National Monuments Record of Scotland
OCS	Outer Continental Shelf, (legislation, USA)
RCHME	Royal Commission on the Historical Monuments of England
RCHAMS	Royal Commission on Historic and Ancient Monuments for Scotland.
ROV	Remote Operated Vehicle
TttW	"Taking to the Water". Policy statement of English Heritage, 2002
UCPUCH	UNESCO Convention on Preservation of the Underwater Cultural Heritage
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea 1982
UNESCO	United Nations Educational, Scientific and Cultural Organisation.
VC	Valetta Convention, European Convention on the Protection of the Archaeological Heritage (Revised) 1992