5. Theme 4 - Predictive Modelling of Submerged Archaeological Deposits

5.1 Introduction

Sections 2, 3 and 4 (Themes 1, 2 and 3 respectively) have highlighted the fact that submerged continental shelves are potentially rich sources of archaeological material. In the interests of managing this resource, and accessing it for the research purposes, these deposits must be located. However, underwater survey is an expensive, time consuming and complicated business. Acoustic systems can be used to locate archaeological material such as shipwrecks or past landscapes (e.g. Garrison, 1991; Praeg, 2003), but their effectiveness in locating prehistoric sites or prehistoric material such as described in Section 3 has yet to be tested. Divers, meanwhile are restricted to the shallower parts of the continental shelf, and can only spend limited amounts of time underwater. In addition, poor visibility may also hinder survey attempts, and while burial of archaeological material may promote its preservation, it may also retard its discovery (Flemming, 1983; 2002). In general, existing underwater work has indicated that even intensive searching with acoustic systems in conjunction with diver survey stands only a marginal chance of locating artefacts (Flemming, 1998).

Consequently, attention has been turned to the development of predictive models in order to facilitate the process of discovery (Bates et al, 2003; SALT, 2003). If areas of high archaeological potential ('archaeological hot-spots') can be determined in advance, then survey can focus intensively on these regions, hence reducing the time and expense. Furthermore, knowledge of areas of archaeological sensitivity can also provide a guide for shelf industrial concerns of where their work may affect the archaeological resource.

This document will briefly discuss the nature of existing predictive models and discuss their applicability for use in submerged environments. This discussion will take into account any conclusions drawn out of Themes 1, 2 and 3 and will attempt to provide guidelines for future use of predictive models for submerged prehistoric archaeology. This is intended to avoid the development of models based on inapplicable data or incorrect assumptions, which, if put into practice, may hinder any future attempts to access and manage the underwater resource.

5.1.1 Background

The use of predictive models in submerged landscape research has been postulated for some time. Note Flemming's comment from 20 years ago:

"If submarine archaeological sites are to be found in the region of critical straits and land bridges we must be able to predict the approximate location of sites so as to minimise the search area, and the conditions must be known which will maximise the chance of survival of material" (Masters & Flemming, 1983:138).

However, despite the evident potential that models may have, this concept has been infrequently followed up in the intervening years. One exception to this was the predictive model created in the 1980s by Danish archaeologists to predict the location of submerged Mesolithic fishing sites (Fischer, 1995b). It arose out of the realisation that:

" [a] systematic diving survey of the entire seabed would be in practice impossible to carry out. In any case… it would take too long in relation to the tempo of destruction achieved by present day construction and raw material exploitation in the sea bed. [The] solution to this problem is model based prediction of site location" (Fischer, 1995:373).

The basis of the model was the correlation of archaeological sites with the most suitable present day localities for fishing with standing gear and fish traps. The importance of fishing in the Scandinavian Mesolithic could already be seen from existing archaeological evidence from isostatically uplifted shorelines while the information concerning the location of fishing sites was obtained by interviewing fishermen who practised traditional methods of fjord fishing with stationary fish traps. They indicated that the best places had certain topographical characteristics that facilitated the concentration of fish and minimized damage to the fish traps by wave action. Examples included the mouths of streams, places where fjords narrowed and the tips of peninsulas or headlands (Figure 131 - Fischer, 1995b; Fischer & Pedersen, 1997). The advantage of focussing on these topographical characteristics is that they can be read off depth contours on commercial undersea maps.

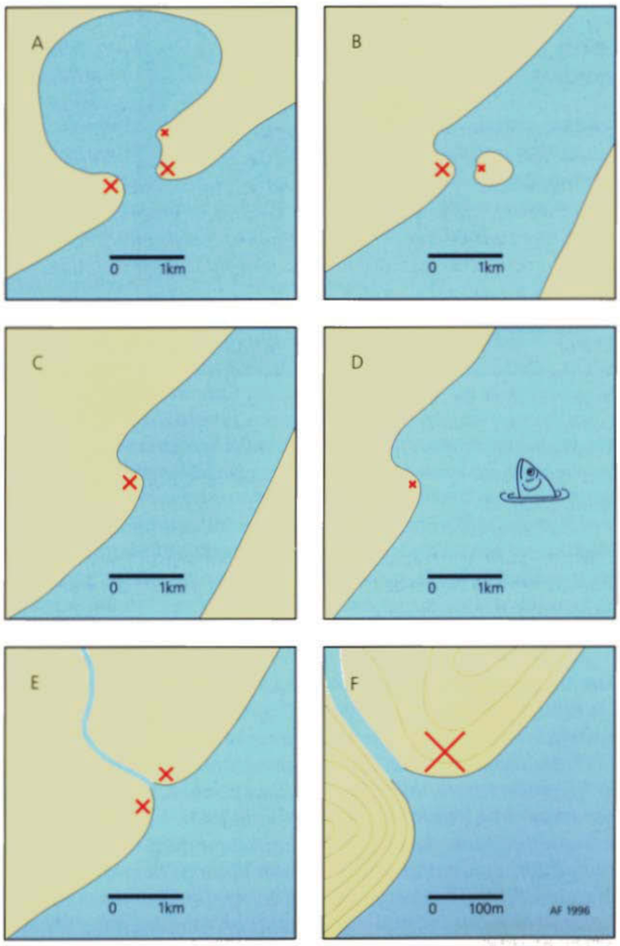

Figure 131. Sketch map of typical locations of Scandinavian Mesolithic coastal sites. A) Along narrow straits with a large hinterland on both sides of the channel. B) along narrow straits between the mainland and a small island. C) and D) on projecting headlands. In these areas the most suitable sites were in the lee of the headlands, where the impact of strong is minimized. E) and F) By major river mouths. Particularly favoured areas were located on evenly sloping terrain. In all sketches the larger X indicates a more suitable site (from Fischer & Pedersen, 1997).

Testing of the model by underwater diving surveys has highlighted its usefulness, with success rates of greater than 80% claimed in some instances (Fischer, 1995b).

The importance of the model with respect to both academic research and cultural resource management is illustrated by the fact that it greatly increased the number of known Mesolithic sites in both Swedish and Danish waters thus providing new evidence for archaeologists to work with, and also facilitated the underwater survey that preceded the construction of the A/S Storebaelt Fixed Link bridge (Pedersen et al, 1997).

Predictive surveys were also undertaken by American archaeologists in the waters off Northwest Florida (Dunbar et al, 1991). Their models were based on the correlation between terrestrial Palaeo-Indian sites, chert sources and karstic terrain features, notably rivers and sinkholes. A number of artefacts were collected by these investigations, though not in the same quantities as the Scandinavian surveys.

Unfortunately, although not within their original remits, neither approach has been tested in a variety of different submerged environments, and it is probable that they are both somewhat spatially and temporally delimited and may not provide immediate insight to environments submerged in central shelf localities. This limitation is due to the somewhat atypical interaction between sea-level change and sea-bed change in the sheltered environments investigated during the Danish study, and the karstic environment that characterises the Northwest Floridian coast. Furthermore, the only material recovered by either approach post-dates the early Holocene and thus it is questionable whether they may be applicable to earlier sites. Finally, though it is accepted than not all of the material is in primary context, there has been little discussion of the implications of this, beyond the statement that *"disturbed features and redeposited tools…[are] archaeologically less interesting sites"* (Pedersen & Fischer, 1997:119), and the mechanism behind it, beyond a general allusion to 'wave erosion' (e.g. Fischer & Pedersen, 1997).

5.1.2 Predictive Modelling in Terrestrial Contexts

It is beyond the scope of this project to provide an in-depth review of the construction and use of predictive models in terrestrial archaeology, so this section will provide only a general overview of their fundamental features and thus provide possible routes forward for the marine environment. For more detail the reader is advised to consult Judge & Sebastian (1999), or Wescott & Brandon (2000).

Predictive modelling of archaeological settlement patterns operates on the principle that human choices in positioning a site or settlement are constrained and influenced by the affordances and characteristics of the local environment (Brandt et al, 1992; Warren & Asch, 2000). Therefore, if patterns exist between site locations and one or more environmental variables or features, and if relationships between them can be ascertained, a model can be constructed that focuses on the effect of these variables in determining site location (Brandt et al, 1992).

"Prediction is …the elucidation of settlement 'rules' in a form that allows us to map locations which conform to the conditions predicted by the model for settlement" (Stančič & Veljanovskji, 2000:148).

The most commonly used variables relate to environmental factors, such as slope or distance to fresh water because they are easy to obtain from soil, geological and hydrological maps (Kamermans, 2000) or even satellite remote sensing data (e.g. Custer et al, 1986). In addition, it is known that groups of people ranging from nomadic hunter-gatherers to urbanised societies respond to environmental pressures (Brandt et al, 1992). More recently however, ideas of bringing socio-cultural variables into modelling have been advanced (Gaffney & van Leusen, 1995; Stančič & Kvamme, 1999). These variables will be discussed in more detail in section 5.1.3.

The construction of predictive models, hinges not just on the choice of variables, but also on two fundamental assumptions:

1. A knowledge of known archaeology allows the establishment of locational factors, that can be empirically tested (Stančič & Veljanovskji, 2000). Fundamental to this assumption is the idea that settlement patterns are strongly guided by environmental characteristics (Warren & Asch, 2000).

2. These environmental features can be obtained, at least indirectly, from modern maps or environmental characteristics (Duncan & Beckman, 2000; Warren & Asch, 2000).

Predictive models of archaeological site location are divided into two main categories; inductive and deductive.

- Inductive, or correlative, predictive models are the most commonly used type in archaeology (Church et al, 2000). These examine distributions of known archaeological sites and identify and quantify correlations between the site locations and particular environmental variables, or landscape features, which are selected on the basis of statistical significance (Judge & Sebastian, 1988; Church et al, 2000; Ebert, 2000). For example: sites are located on level to moderately level slopes composed of soil type A and that are within X distance from water (Church et al, 2000). The correlations are assumed to represent causality and thus, from them, predictions can be made as to the locations of sites in unsurveyed areas, if the environmental characteristics of these areas can be determined (Kamermans, 2000; Warren & Asch, 2000).

- Deductive, or exploratory predictive models are less common (Church et al, 2000; Kamermans, 2000). These attempt to predict how particular patterns of human land use will appear in the archaeological record on the basis of deductions derived from prior archaeological, historical or ethnographic information (Judge & Sebastian, 1988). For example: residential hunting sites dating to the Archaic period are located in the foothills between elevations of X to Y on moderately level slopes and within X distance of water because the resources of food (mule deer) and water are present and these resources form the most reliable subsistence base available at that time (Church et al, 2000). The distribution of known sites can then be used to evaluate the model (Kamermans, 2000).

The relative merits of each of these two approaches with respect to submerged landscapes will be discussed in Section 5.1.4. However, it should be noted that the two approaches need not be used in isolation. Indeed, many researchers actually use a combination of inductive and deductive methodology in the form of a continuous process over time whereby the model can be reformulated as new information is incorporated (Figure 132 - Kamermans & Wansleeben, 1999).

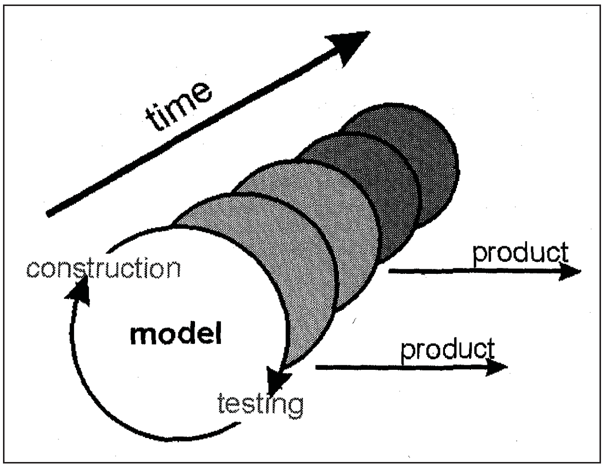

Figure 132. Constructing and testing of a model is a continuous process. While the stability and reliability of the model will probably increase over time, the intermediate results can still be useful products (from Kamermans & Wansleeden, 1999)

5.1.3 Variables Modelled

This section provides an overview of the environmental and social variables which tend to be incorporated into predictive models. Each class of variables will be discussed in isolation for the sake of clarity. However, it should be noted that the application of single classes of variables in a model may result a different prediction depending on which class is used. Consequently, most models tend to use combinations of variables (Kamermans, 2000).

5.1.3.1 Topographic variables

Measures of terrain such as slope, aspect or relief are often implicitly (in inductive models) or explicitly (deductive models) assumed to equate to measures of shelter (Church et al, 2000). Sites located in valleys may be more sheltered from wind and weather than those on the interfluves, while certain slope faces may receive more sunlight. For example: the location of sites on south and west facing slopes of river valleys in Limburg (Netherlands) has been related to Middle Palaeolithic groups sheltering from cold northerly and easterly winds (Kolen et al, 1999) while similar patterns (i.e. warmer temperatures and reduced wind chill in valleys) have been noted in the Middle Palaeolithic of southwest France (see Theme 2) (Davies et al, 2003; Mellars, 1996).

Topographic or terrain variables may also relate to the placement of sites in response to subsistence practices. Note the positioning of submerged Mesolithic sites in Scandinavia to take advantage of topographical features that were optimal places for fishing with standing gear (Fischer, 1995). Hunting strategies, and thus the archaeological sites that result from them are in some instances topographically based. A number of sites are positioned at cliff bases (e.g. La Cotte de St. Brelade: Scott, 1980) or in tunnel valleys (e.g. Peterfels - Albrecht, 1983: see Section 3.3.4.3). Many hunter gatherer sites are believed to be situated at locations which, due to their topography, provide good views of the surrounding area and thus the location of prey species. An example are the Mesolithic sites of Northern England which tend to be located on ridges, hills and valley heads (Kvamme and Jochim, 1985).

5.1.3.2 Hydrologic variables

Water is crucial to the survival of humans, plants and animals, and consequently distance to water is often one of the key resources modelled (Church et al, 2000). Examples of archaeological sites being located in close proximity to water are numerous, with concentrations of sites occurring along lakeshores, rivers and by springs. Studies of the Magdelenian occupation of the Paris Basin have indicated that the vast majority of sites are located along river valleys rather than on the plateaus between them (Audouze, 1987). An important Lower Palaeolithic site has been found in the travertine springs at Bilzingsleben in Germany (Gamble, 1999) while lakeside occupations are found in all periods and in diverse contexts ranging from the Mesolithic settlement at Star Carr (Mellars & Dark, 1998) to the Lower Palaeolithic site of Hoxne (Singer et al, 1993 - see Section 3).

5.1.3.3 Geomorphological variables

Geomorphological variables consist of various landforms which may have influenced human settlement, such as beach ridges, lagoons, estuaries, caves or rockshelters (Kamermans, 2000). Each of these may have influenced settlement patterns by providing particular advantages in different areas, for instance, caves and rockshelters provide shelter from the elements while lagoons and estuaries are often rich in resources. For example, ethnographic studies indicate that open prograding coasts in Alaska were frequently occupied in contrast to the situation in Florida, where lagoons rather than beaches tended to be settled due to their high productivity and shelter from the elements (Dunbar et al, 1991; Mason, 1991).

Soil type is also a feature that is often incorporated into models as this may influence the distribution and nature of the local vegetation. This may be more important with respect to settled farming societies rather than nomadic hunter-gatherers, as the location of fertile soil is likely to be a major influence on where crops can be grown and hence settlements located.

5.1.3.4 Resource variables

A number of resource types can be seen as influencing human settlement patterns, these can broadly be divided into food water and raw materials. Water has already been dealt with in Section 5.1.3.2, so this section will deal with the other two.

In the prehistoric period the dominant raw material that is seen to influence settlement patterns is stone. In the Aquitaine Basin of France there are open air Middle Palaeolithic sites situated near flint sources regardless of topography (Turq, 1999) while underwater investigations in Florida have been based partly on correlations between site locations and chert sources (Dunbar et al, 1991).

Similarly, with respect to food, the location of edible or even medicinal plants (Dalla Bona, 2000) may also have been important. However, as these do not preserve well in the archaeological record, their influence is uncertain. Furthermore, stone sources offer some distinct advantages for predictive modelling. Their stability means that their location is unchanged over long periods of time and hence are more easily modelled under the assumption that modern conditions are equivalent to those in the past (Section 5.1.2). Their varying spatial distributions though, do mean that models constructed for one area (e.g. a lithic rich area) may not be applicable to other (e.g., lithic-poor) areas (Church et al, 2000).

Animal bones are more commonly preserved and this has lead to suggestions that the location of certain sites was determined by their proximity to certain prey species. Note for example the contrast between the French Upper Palaeolithic sites of Etiolles and Pincevent (Audouze & Enloe, 1991) described in Section 3.3.4.3.

5.1.3.5 Social variables

The incorporation of social variables is a relatively new feature of predictive modelling and stems from the realization that settlement patterns may be more than just environmentally determined. Therefore models have to consider the creation of a symbolic, political or economic landscape by past societies and its influence on site location.

There are a number of ways of accomplishing this. One proxy has been assumed to be the distance between sites. For example, the distance between hillforts on the island of Brac (Croatia), has been assumed to be a reflection of the size of the economic territory required to support each hillfort, while the positioning of, and degree of intervisibility between, each hillfort has been related to the need to exert visual control over large territories (Stančič & Kvamme, 1999).

Alternatively, the location of sites may be also due to particular places in the landscape having ritual or social significance to past people. Neolithic monuments in the Black Mountains of Wales appear to have been situated so as to direct and focus attention on significant features of the landscape - the Black Mountains themselves and the valleys running through them (Tilley, 1994). Incorporating such variables is somewhat more difficult in the case of more archaeologically ephemeral societies, such as nomadic hunter-gatherers, which do not construct monuments, though some attempts have been made to understand how they may have bestowed symbolic attributes on the natural landscape. Boaz and Uleberg (2000) for instance have related changes in the topographic characteristics of site locations to changing perceptions of landscape caused by relative sea level change during the Mesolithic of southern Norway.

5.1.4 General Criticisms of Predictive Modelling

The above overview may have given the impression that predictive models represent an elegant and effective solution to the problems of site prospection and cultural resource management. However, a thorough assessment of the effectiveness of these models requires that any criticisms of them are taken into account.

These critiques largely concern the assumptions that are made in the modelling process (Section 5.1.2), the variables modelled (Section 5.1.3) and the misconceptions that come about through use of these models. Some of the criticisms apply to inductive models, and others to deductive models. There are also several which apply to both categories.

5.1.4.1 Critique of inductive models

Inductive predictive models rarely take into account factors which may modify or distort the archaeological record, such as post-depositional taphonomic forces. Consequently, patterns inferred from the known distribution of archaeological sites may be substantially different to the actual past patterns, thus the statistically generated correlations may result in the creation of a misleading model (Kamermans & Wansleeben, 1999; Kuna, 2000). The skewing of the model by post-depositional transformations can be mitigated if a deductive approach is taken, in that the rules governing settlement behaviour can be inferred from theoretical models of past societies rather than their observed archaeological remains.

Inductive modelling has also come under fire because it rarely provides explanations of the correlations it finds between sites and environmental variables that go further than relatively anecdotal statements (Ebert, 2000), or in some cases which are not explicitly explained at all (Church et al, 2000). This makes it difficult to determine if the inferred patterns are indeed the result of human locational tendencies, or are just an artefact of the nature of the background environment.

Essentially the main criticisms concern the data that is inputted into the model. If the correlations discovered between sites and socio-environmental variables are a valid representation of past rules of site location, then the model can be considered applicable. However, if the correlations are merely statistical artefacts created by post-depositional processes or the background environmental noise, then the usefulness of the model must be questioned.

5.1.4.2 Deductive models

In contrast to inductive models, the deductive technique derives its rules of settlement location from models of behaviour rather than statistical correlations between sites and a set of variables. This provides it with an instant advantage over inductive modelling in that it is immediately a more explanatory approach.

However, deductive models have been, criticised on the basis that they assume that the particular form of human behaviour in a given environment will create a specific pattern in the archaeological record when in reality it could create multiple different archaeological signatures (Kamermans, 2000). In addition, with respect to social variables, ascertaining the relationship between site locations and the perceived cultural, religious or symbolic properties of the landscape, which may have played a part determining the location, are not easy to deduce, and can often be a somewhat subjective exercise (Kuna, 2000).

Finally, questions have been raised over the nature of the principles of least effort, or 'cost-distance theories' that are often used to explain the relationship between sites and their distance to particular environmental features. According to these, more important factors in site placement will be situated closer to the site as less energy will be expended in achieving the benefit these features provide. However, as Ebert (2000) has pointed out, it is not certain that people rigidly behave in this rather mechanistic manner. Other important structuring factors may include the time taken - which may be dependent on local topography or vegetation and may not have a linear relationship with distance - rather than energy expended, to reach a feature, or the sequencing of multiple activities within a given area (Ebert, 2000).

5.1.4.3 Inductive and deductive models

One major criticism of the both categories of model concerns the use of modern data. In inductive models, relationships between site locations and easily obtainable modern environmental characteristic are commonplace, while in deductive models, deduced settlement rules are then applied to the modern landscape in an effort to predict site locations or test hypotheses concerning about site location. However, the dynamics of the environment and climate over time make this a rather tenuous assumption especially with respect to early periods of prehistory (Church et al, 2000) and as Hosfield has pointed out, this makes attempts to predict the location of early prehistoric sites (e.g. Lower and Middle Palaeolithic) on the basis of modern environmental data an "uninformative and fruitless exercise" (Hosfield, 1999:245). It is not just the dynamics of the environment that models tend to gloss over. Rules governing human-landscape interactions are often assumed to be rather inert, thus sites are continually assumed to be placed in the same position even across major time spans, regardless of changing past human ideas of settlement location. (Kamermans, 2000). On the whole predictive models tend to suffer from a rather static view of environment, society and their interaction.

This may have partly arisen due to the extensive use of predictive models in cultural resource management. Environmental planners tend only to be concerned with designating areas as archaeologically rich or archaeologically poor, with little regard to the type, period or nature of the site (Kamermans & Wansleeben, 1999). Many models therefore reflect this need.

As a result, it has been suggested that future predictive models should take into account different time periods (Kamermans & Wansleeben, 1999). The rationale behind this is that the locational preferences of societies may change over time, thus necessitating the constructing of separate models.

The choice of variables used by both types of model has also been roundly criticised. A focus on environmental variables has led to suggestions that predictive models are environmentally determinist. In reality, cultural, political, symbolic or social factors may have played as great a role in determining settlement patterns (Dalla Bona, 2000; Kuna, 2000). To some extent, attempts are being made to redress this balance. Note for example, the recent studies which explicitly incorporate social factors into their models (e.g. Stančič & Kvamme, 1999). However, as stated in Section 5.1.3.5, accomplishing this is still a relatively difficult, and often highly subjective task.

Another problem involves a failure to see some of the complexities associated with many of the variables. For example, distance to water is simply a measure of the distance of a site to the nearest water source. It takes no account of the seasonal availability and duration of the water source, its quality or whether it provides any other resources (e.g. fish), all factors which might also influence the decision of past humans to locate their sites in relation to it (Church et al, 2000; Ebert, 2000).

Related to this is the way in which past humans may have viewed each of these variables. It is unlikely that the affordances or potential offered by each variable were equally distributed, and indeed the perceived benefits of each may have changed over space and time (Dalla Bona, 2000). For example, Dalla Bona (2000) has pointed out that while water may be an important locational factor, it is unlikely that sites will be distributed evenly around a lakeshore. Certain areas within this already favourable zone may have been perceived as more, or less preferable. In effect, it is the particular combination of variables in a certain context that is important. This makes it difficult to judge which were considered important in locating sites.

Overall, it seems that the effectiveness of predictive modelling is somewhat compromised by these criticisms. Consequently, archaeological prediction in terrestrial contexts is not perfect. Predicted archaeologically rich areas may contain barren zones, while area of low potential could contain isolated, but important sites (Kuna, 2000). Nevertheless, if these shortcomings are understood and models are recognised as providing levels of confidence rather than absolute correlations between site locations and the environmental variables, they can still be flexible and powerful tools (Duncan & Beckman, 2000).

5.1.5 Model Applicability in Submerged Prehistoric Contexts

Having discussed the usefulness of conventional (i.e. terrestrial) predictive modelling approaches, attention must be turned to their applicability in submerged contexts. The main issue is whether the unique situations produced by underwater archaeological deposits, as detailed in Sections 2 – 4 (Themes 1, 2 and 3) renders these approaches more or less applicable. On these basis of these three themes and the above analysis, some ideas can be advanced:

- At present, a straightforward inductive approach based on the statistical correlation of known submerged sites with environmental variables will not be possible since such a concentration of sites is not known, with the exception of the submerged Mesolithic sites of south Scandinavia (see Section 3.6: Fischer, 1995b; Pedersen et al, 1997). However, the settlement pattern in this area may not be applicable to more exposed and open coasts such as those of the English Channel and North Sea.

- Alternatives to this therefore include an inductive approach based on the statistical correlation of known terrestrial sites with environmental variables, or a deductive approach which identifies settlement pattern rules based on the known terrestrial record. To some extent this is the approach that has been advanced in Section 3: Theme 2. Following Kamermans & Wansleeben's (1999) observation that the two types of approach are often used in tandem, there is no reason why this combined approach could not be attempted. The relationships inferred from these approaches can then be applied to the submerged environment.

Regardless of whether the two approaches are used together or in isolation, the model must overcome several major pitfalls:

- Section 4.1 made the point that large areas of the seabed are unlikely to bear a great deal of resemblance to their pre-submergence topography and geomorphology. Though there have been recent calls for modellers to take into account post-depositional processes to a greater extent (e.g. Church et al, 2000; Kamermans & Wandsleeben, 2000), predictive models still tend to rely on the assumption the environmental characteristics obtained from the present landscape will equate to those in the past (Section 5.1.2). In the light of the major landscape changes resulting from syn-and post-transgressive processes, taking post-depositional landscape modification into account will be absolutely essential. To some extent, landscape geomorphology can be reconstructed if detailed geological and geophysical surveys are undertaken and especially if sequences are dateable. On the regional scale, a wealth of evidence exists in documents such as the British Geological Survey reports for the North Sea and English Channel. Similar information is also available for the other countries surrounding these regions. On a finer scale, more detailed information is available from areas in which comprehensive surveys have been performed, such as the palaeo-Arun (Gupta et al, 2004a,b). Essentially, the techniques for reconstructing the past landscape do exist, however, they have only been applied in detail to certain areas. In these areas there may be scope for modelling. But for the shelf as a whole, much more accurate and detailed reconstructions will be necessary to enable fine scale modelling.

- Section 3 (Theme 2) has indicated that a wealth of terrestrial data exists with respect to inland occupation. However, barring the Mesolithic and later periods, the prehistoric record is characterised by an overall lack of evidence for coastal occupation. Theoretically, much of the submerged evidence should relate to coastal use or settlement, given that transgression would have meant that all parts of the presently submerged landscape would have been coastal at some point in time. This paucity of evidence would make the construction of a predictive model (either inductively or deductively) somewhat difficult, and until more evidence is located, it would have to be largely based on conjecture and assumptions about the nature of early coastal occupation (see Erlandson (2001) for an overview of this subject). Construction of a predictive model for material that would have related to inland use is somewhat more secure.

- Predictive models tend to focus on the idea of a 'site'. These are usually conceived as concentrations of archaeological material and range from extensive settlements to scatters of stone tools. The size of these features is also variable and can range from several square metres up to several hectares (Schiffer, 1987; Flemming, 1998). In any case, the usual assumption is that they will be in primary context. As Sections 3 and 4 have pointed out, a large proportion of the submerged evidence will likely take the form of reworked secondary and tertiary contexts. As these have been removed from their point of deposition, this negates traditional predictive modelling approaches that infer or deduce rules governing human choices in site location. The issue may be further complicated by the fact that these deposits may take the form of extensive collections of material situated within a substrate rather than discrete sites.

- This may result in a preservational or context guided approach whereby modelling focuses not just on where past humans would theoretically have located their sites, but on where conditions have meant that this evidence is likely to be preserved, in other words, a 'deposit' rather than 'site' based approach. For example: areas with a thick sediment cover could be assumed to have a high potential of primary and terrestrially formed secondary contexts and targeted for further investigation, while areas characterised by long term erosion could be classified as lower potential. This approach would however class secondary and tertiary contexts as a lower priority, a judgement that cannot be made on the basis of present information. Alternatively, this could be reversed in that areas of thick sediment cover could be assumed to be protected from natural reworking, and investigations focus on areas of erosion, where artefacts may be naturally exposed and may be under threat. This approach may have an advantage in that it may be able to target areas in which primary, secondary or tertiary contexts are preserved on the basis of known past and present sedimentary regimes rather than assumed human choices about a landscape which may not be possible to reconstruct.

- At this point in time it is probably worth noting an issue that has not yet been raised to any significant extent, with the exception of Flemming (1996). This is the human response to sea level change in the past. Section 4 has illustrated the complex geomorphological responses that coasts exhibit in response to sea level fluctuations, but as yet these have rarely been considered in relation past human settlement. Rather than simply reviewing the suite of environmental changes resulting from sea level change, it would be worth considering which of these operate within a temporal and spatial scale appropriate to human perception and response. An examination of human responses to sea level change has implications in terms of site formation processes, in that it represents the ‘cultural’ element of the taphonomic process (Schiffer, 1987), but also has wider resonance in terms of assessing how past societies coped and responded to changing environmental conditions. In any case, the past human response may well have resulted in the creation of distinct archaeological signatures, and therefore may be a element that is worth considering in future predictive modelling exercise.

- If a model is to be constructed, other considerations will have to include its scale and complexity. From the perspective of environmental assessment, a model that is capable of designating large areas (i.e. several kilometres to tens of kilometres) of seabed as archaeology sensitive, or archaeologically barren has attractions. However, from a purely academic or research oriented point of view, a more detailed model that focuses on different time periods or sites types (e.g. coastal sites) may be considered to be more useful. Decisions will therefore have to be made as to which line a predictive model takes.

In summary, based on the information explored in Sections 2 – 4 (Themes 1, 2 and 3), sufficient evidence currently exists to construct very large-scale (i.e. shelf scale) models or reconstructions with limits imposed by the position of palaeo-shorelines, glaciers and the patterns that exist in terrestrial contexts, similar to those done by Coles (1998). These overviews will only be accurate to within kilometres to tens of kilometres. At the other end of the scale, limited predictive models could be constructed for certain localized (i.e. kilometres or less) areas, but only if sufficient geological and sedimentological evidence is available to enable both a secure reconstruction of the palaeo-landscape to be undertaken and allow some assessment of the impact of marine processes on the distribution of archaeological material. Modelling the scale in between may be somewhat more difficult until more information becomes available. Nevertheless, some predictive models should be constructed and tested in the near future provided the ideas advanced above are taken into account, as these may provide new data that enable the construction of a next generation of more accurate models.