Journal of Island & Coastal Archaeology, 5:253–270, 2010

ISSN: 1556-4894 print / 1556-1828 online
DOI: 10.1080/15564894.2010.506623

FORUM

Submerged Prehistoric Landscapes and Underwater Site Discovery: Reevaluating the 'Danish Model' for International Practice

Jonathan Benjamin
School of History, Classics and Archaeology, University of Edinburgh, Edinburgh, Scotland, UK

ABSTRACT

Paleoenvironmental studies of late Pleistocene climate change and postglacial sea-level rise have coincided with and inspired archaeological fieldwork in submarine environments. Underwater archaeological contributions have significantly enhanced the Mesolithic-Neolithic record in and around Europe; however, despite recent advancements, a clear approach to broadly investigate submerged prehistoric landscapes remains undefined. While a specific survey strategy has been tested in southern Scandinavia, these practices lack some considerations if they are to be productively applied on an international scale. Through a systematic identification of physical and cultural variables and a practical, common-sense approach, this paper re-evaluates the 'Danish model' for submerged prehistoric landscape archaeology and presents a framework for the identification of locations for underwater archaeological survey and site discovery. In addition to the methodological evaluation, specific research priorities are introduced.

Keywords underwater archaeology, Mesolithic, Neolithic, submerged prehistoric landscapes, archaeological prospection, sea-level rise

Received 13 May 2009; accepted 28 May 2010.
Address correspondence to Jonathan Benjamin, School of History, Classics and Archaeology, University of Edinburgh, Doorway 4, Teviot Place, Edinburgh EH8 9AG, Scotland, UK. E-mail: jonathan.benjamin@ed.ac.uk

INTRODUCTION

While it may be tempting to treat 'underwater archaeology' as a single sub-discipline within archaeology, fieldwork conducted in submarine environments should not be considered homogeneous. Variations in scope and practice abound within archaeology underwater and the terminology used to define the subfields can be confusing since 'Underwater Archaeology' is often used synonymously with 'Maritime Archaeology' or 'Nautical Archaeology'. In his seminal work, Muckelroy (1978) diagramed the sub-disciplines of archaeology underwater and proposed the term for non-ship, non-maritime related archaeology conducted underwater to be simply "archaeology under water" (Figure 1). Despite this identified distinction, there exists a preconceived notion about underwater archaeology both within popular culture as well as the archaeological community: "To most people maritime archaeology means wrecks, spectacular time capsules like the Mary Rose. Less appreciated are the extensive prehistoric landscapes..." (Miles 2004: xiii). Numerous summaries or methodological publications are devoted to the broader topic of archaeology underwater (e.g., Bass 1966; Blot 1996; Bowens 2009; Dean 1992; Delgado 1997; Gianfrotta and Pomey 1981; Goggin 1960; Green 1990; Ruppé and Barstad 2002; St. John Wilkes 1971; Volpe 1999), and focus mainly on maritime or nautical archaeology.[1]

Recent paleoenvironmental studies of late Pleistocene climate change and postglacial sea-level rise (e.g., Christensen 1995; Dawson 1984; Fairbanks et al. 1989; Flemming 1968; Lambeck et al. 1998, 2001; Pirazolli 1985, 1996; Shackelton et al. 1984; Shennan and Horton 2002; van Andel 1989, 1990) have coincided with innovative work on submerged prehistoric coastal landscapes (e.g., Andersen 1980, 1985; Dunbar et al. 1992; Faught 1988, 2004; Fischer 1987, 1993, 1995; Flemming 1983; Galili et al. 1993, 1997; Grøn and Skarrup 1991; Hartz and Lübke 1995; Hudson 1979; Josenhans et al. 1997; Larsson 1983; Lübke 2001, 2003; Masters 1983; Momber 2000, 2005; Raban 1965, 1983; Ruppe 1980, 1988; Skaarup 1983, 1995). The pioneering work of these archaeologists and 'submerged prehistorians' can be considered amongst the most technically remarkable fieldwork and have lead to highly informative archaeological discoveries in Northern Europe, the Mediterranean Basin, and North America.[2]

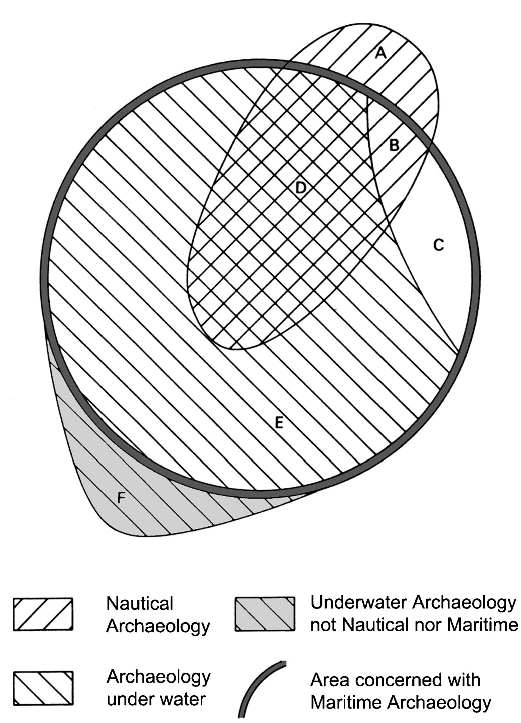

Figure 1. *Fields of archaeology concerned with underwater methodology (redrawn after Muckelroy 1978). Nautical Archaeology and Maritime Archaeology are not always underwater as illustrated by areas A, B, and C. Submerged sites, which can be historic or prehistoric, and are not found within the scope of Nautical or Maritime Archaeology are indicated by area F.*

Despite the advancements in underwater research, a systematic search strategy to broadly investigate submerged prehistoric landscapes is lacking. This is mainly due to the scale of the problem (the sheer number and combined area of archaeological landscapes now underwater), the expense of systematic investigation underwater, and the fact that submarine environments vary dramatically by location. The numerous considerations determining archaeological potential make a universal methodology virtually impossible. Still, there are fundamental aspects of any region that can be evaluated in order to consider its appropriateness for an in-depth assessment for potential cultural resources on its continental shelf. These methods, discussed in detail below, can be applied on a pan-European, or indeed international scale, through a combination of sophisticated analysis, common sense, and simple familiarity with individual landscapes and local resources. Based on the necessary practicality and flexibility, this paper presents a framework for identifying appropriate variables in order to evaluate coastal regions for potential prehistoric underwater archaeological site discovery.

'STONE AGE' ARCHAEOLOGY AND THE SUBMERGED COAST

The importance of the coast to prehistoric hunter-gatherer populations has been a topic of significant research in recent decades (e.g. Bailey 2004; Bailey and Parkington 1988; Bonsall 1996; Erlandson 2001; Erlandson and Fitzpatrick 2006; Larsson 1995; Milner 2005; Pluciennik 2008; Rowley-Conwy 1983; van Andel 1989; Zvelebil 1998). Advantages of coastal living have been defined by Bailey (2004) and can be simplified as follows:

1. Transportation and communication; this encompasses trade and social activities, and includes seaborne migrations and exchange;
2. Access to food resources, specifically the abundance and variety of marine and terrestrial plants and animals; and
3. Access to other (non-food) resources.

This includes fresh water in high water-table environments and at coastal river-mouths, as well as available material for tool production. Examples of these materials include pebbles and river rocks, driftwood, and other organic materials used for structures; tools; and fuel. Furthermore, recent work in the archaeology of submerged cultural landscapes has lead researchers to suggest that geomorphological conditions for the preservation of archaeological and palaeoenvironmental material exist throughout the world and that new techniques are "providing the momentum for a rapidly expanding field of investigation" (Bailey and Flemming 2008: 2153). Indeed in their recent publication *Archaeology of the Continental Shelf: Marine Resources, Submerged Landscapes and Underwater Archaeology*, Bailey and Flemming neatly summarize previous work on this topic and, more importantly, broadly address geological/geomorphological considerations and issues surrounding submerged site preservation and discovery.

Since research in submerged cultural landscapes is relatively recent within the wider field of archaeology, methodology for investigating underwater prehistory is still in development. Furthermore it is often the case that the initial discovery of material takes place accidentally through commercial and/or amateur maritime activity (see Flemming 2004; Masters and Flemming 1983). Building on methods and techniques from the research of the past four decades, current and future generations of prehistorians working on land and underwater will continue to develop the field. Erlandson and Fitzpatrick (2006: 14) rightly remind the scientific community that careful consideration and planning for research in submerged terrestrial landscapes is essential because "repeated failures may threaten the availability of future funding." Additionally, it is the responsibility of a professional archaeologist to employ the appropriate staff and equipment needed to carry out proper archaeological fieldwork in submarine environment. The question remains: how can submerged prehistoric coastal landscapes be addressed by archaeologists?

SOUTHERN SCANDINAVIA AND THE 'PRESUPPOSITION MODEL' FOR SUBMERGED PREHISTORIC SITE DISCOVERY

Prehistoric coastal settlements differ in size, artifact quantity and quality, seasonal indicators, and overall preservation compared with inland sites (Fischer 1995). There is therefore little doubt that valuable and original information has come from underwater archaeology in southern Scandinavia. Fischer (1995: 371) cites three primary reasons to study submerged Stone Age sites: 1) preserved organic material; 2) new environmental data; 3) alternative information contributing to theories of adaptive strategy, demography, and social organization. Some of the initial and important discoveries, such as submerged forests and the skeleton of Korsør Nor, were discovered in the middle twentieth century by the military, sport divers, and other non-archaeologists (Fischer 1995). However, a number of the sites were not discovered accidentally; they are the result of a specific type of underwater survey, found using a model for the presupposition of submerged Stone Age sites.

Mesolithic and Neolithic contributions from southern Scandinavia can be considered highly informative within European prehistory. This is due in part to the fact that historically there have been more archaeologists and more archaeological material available in Scandinavia than anywhere else in the world (Price 1991; Rowley-Conwy 1995). Since southern Scandinavia has an importance to the European Mesolithic "disproportionate to its geographical extent" (Larsson 1990: 257), it follows that the underwater sites from this period are significant to the Scandinavian archaeological record and thus to prehistoric European archaeology. "We must remember that as much as two thirds of the former land area was submerged in the Early Mesolithic—a process which must have influenced the structure of coastal settlement" (Larsson 1990: 278). Indeed archaeologists have been investigating submerged environments for four decades in southern Scandinavia (e.g., Andersen 1980, 1985, 1987; Fischer 1987, 1993, 1995, 1997; Grøn 1995; Grøn and Skarrup 1991; Larsson 1983, 1995; Malm 1995; Skaarup 1983; Sørensen 1996) and the Baltic coast of northern Germany (Hartz and Lübke 1995; Lübke 2001, 2003).

Systematic underwater excavations of prehistoric sites in the southwest Baltic were initiated in the 1970s by the Langeland Museum in the South Funen Archipelago (Grøn 1995; Skarrup 1995). By the early 1990s about sixty sites were recorded in this area (Skaarup 1995: fig. 1). In 1975, recreational divers discovered what would become the famous site of Tybrind Vig (Andersen 1980; Malm 1995), although material had been found and collected in the locality in the late 1950s. This would become the first full-scale excavation of a submerged Mesolithic site in Denmark (Malm 1995). In 1984 Mesolithic layers at Argus Bank were obtained at depths of 4–6 meters in the Småland Bight: the marine area which forms a bay and separates the islands of Falster, Zealand, and Lolland in southeastern Denmark (Fischer 1987, 1995). This site was determined to be from the middle-Mesolithic Kongemose culture, and included a well-preserved hearth.

By 1985 there were ten recorded sites in the Småland Bight. Interviews with a number of elderly locals who had fished in the early twentieth century established which species were caught, which were desired, and what methods were used: line, trap, nets, etc. Additionally, specific fishing spots, seasonality, and details of the catch have since been discussed (Bennike et al. 2007; Fischer 1987, 1993). It became evident that there were similarities in these sites and thus the 'fishing site location model' was established by studying the nature of the topographic location of fishing sites (Fischer 1993, 1995, 1997, 2007). These were common locations where fish and eel swam—excellent places to trap or net a fisherman's catch. "Settlements were placed on the shore immediately beside good sites for trap fishery. Such places were at the mouths of streams, at narrows in the fjords, and on small islands and promontories close to sloping bottoms in the fjords" (Fischer 1993: 66, Figure 2 in this paper). While the term 'model' could be objectionable for the prediction of sites, as compared with the

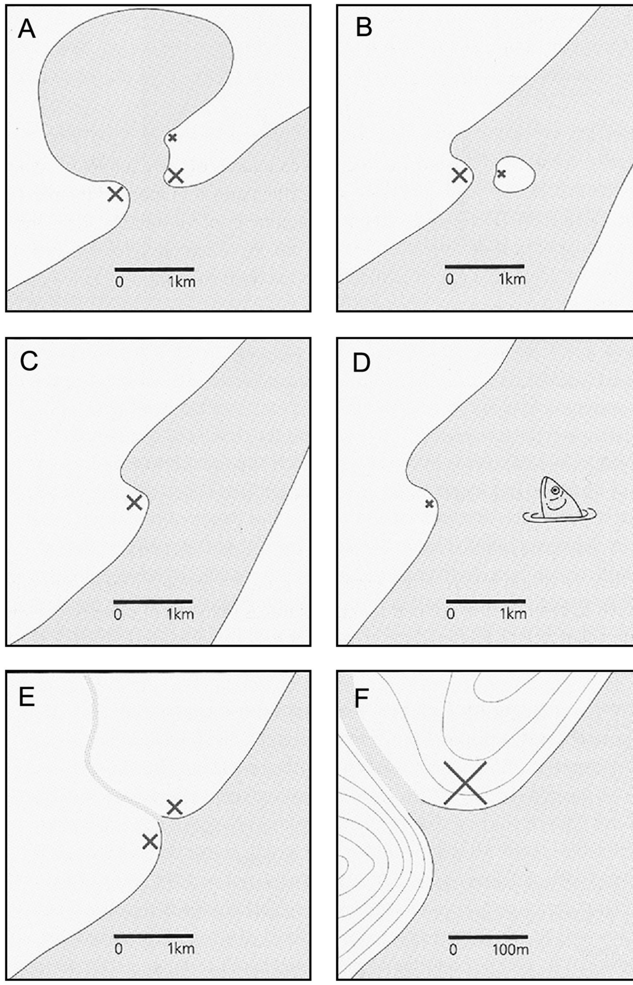

Figure 2. *Topographic locations of Mesolithic coastal settlements based on the southern Scandinavian model (after Fischer 1995). A) Narrow inlets connecting large bodies of water. B) Between a small island and mainland. C and D) At the tip of a headland. E and F) At the mouth of a stream.*

parameters set by Jochim (1976), this series of assertions was employed successfully and the resulting discoveries speak for themselves. Furthermore, as a method of control, areas that were not considered promising for marine resource exploitation were surveyed with negative results and it was concluded that Stone Age settlement sites and their locations were not random (Fischer 1993, 1995).

In 1985, a two-day initial survey was conducted to test the hypothesis based on the topographic assumptions of the existing underwater sites in Denmark. Using Royal Danish administration of Navigation and Hydrographic charts, at a scale of 1:70,000 (see Fischer 1995: fig. 7), locations were determined and plotted, and divers were sent to investigate these areas of potential interest. Results were overwhelmingly positive. In total the site location model proved >80% effective according to Fischer (1995). The number of Kongemose and Ertebølle sites in southern Scandinavia, in particular, has increased substantially since the adoption of this survey strategy. A result of the successful survey in 1985, a further two weeks of fieldwork were carried out and by the following year upwards of thirty new sites had been discovered in the Småland Bight including Vigsø Skal and Malmgrunden (Fischer 1993). In addition to visual survey, in some cases small test pits were dug by hand to investigate for the presence of archaeological material below the seabed. During the survey, in best conditions, it was possible to conduct three short dives per day while air tanks were refilled aboard the boat en route to the next location (Fischer 1993).

As defined by Fischer, the survey model can be broken up into three phases:

Phase I—Map plotting;
Phase II—Localization and delimitation for sites by echo-sounder; and
Phase III—Marking of the theoretical site with a marker buoy, and diving to investigate.

Fischer (Fischer 1993: 57) continues: "The model and working method described can be applied to the recording and protection of undersea Stone Age settlements in many other countries of the world." This assertion shall be addressed. Drawing on experience from North America, Ruppe (1988: 57) has listed "three major factors to be considered in a study of inundated terrestrial sites: sea-level change, coastal geomorphology, and coastal settlement patterns." This contribution, when reviewed alongside the Danish example, provides significant insights into the preparation required to investigate submerged prehistoric landscapes for their archaeological potential.

REEVALUATING THE SURVEY STRATEGY FOR INTERNATIONAL PRACTICE

While some practical survey methods have been established and proven functional in the southwest Baltic, there are important elements of this method which are missing, have been taken for granted, or have been deliberately excluded. If the described survey strategy is to be applied internationally, as proposed, the 'presupposition model' must be re-examined. Based on theoretical project planning and practical field experience a revised model for the international application of the 'Danish Model' for submerged prehistoric site discovery is suggested as follows:

Phase I—Regional familiarization: archaeology, geography, geology, geomorphology, oceanography, and hydrology.
Phase II—Ethnographic component: cultural parallels, historical research, and modern interviews.
Phase III—Map, chart and aerial imagery analysis, and location plotting.
Phase IV—Observation of potential survey locations, physically and with sonar.
Phase V—Marking of theoretical site with GPS and diving to investigate.
Phase VI—Post-fieldwork analysis, interpretation and dissemination.

I) Regional Familiarization: Archaeology, Geography, Geology, Geomorphology, Oceanography and Hydrology

Any fieldwork, above or below sea level, requires an understanding and knowledge of archaeological practices and material. However, for the purposes of this model, it must be stated: archaeologists should be, or must become, familiar with the specific regional material culture and prehistoric settlement patterns prior to conducting fieldwork. The familiarization process is especially important when a local underwater archaeological community does not exist or when an international team attempts to survey foreign territories. Furthermore, the logistics of underwater archaeology confirms the need for surveyors to be able to effectively and independently identify archaeological material underwater (Muckelroy 1978) due to limited communication, time constraints, a finite air supply, and the physiological limitations of breathing compressed gasses.

Regional variables must be clearly defined if these survey methods are to be successful at an international level. Familiarity with settlement distributions and the economic practices of prehistoric groups, such as exploitation of biologically productive areas (e.g., Perlman 1980) or specific raw materials (e.g., Dunbar et al. 1992), should assist in the successful prediction of prehistoric site locations (Ruppe 1988). Furthermore, cultural practices, independent of or complimentary to resource exploitation patterns, should not be ignored. This can be achieved by studying areas that have not been submerged, or locations which have since undergone isostatic uplift (Bailey and Flemming 2008; Benjamin 2007; Bonsall 1996; Fischer 1993). Fischer himself suggests that there were foregone considerations for choosing specific locations within the Småland Bight because "it is an area with abundant raw materials and in all probability also abundant remains of an extensive Stone Age occupation" (Fischer 1993: 61). More sophisticated demographic and resource modeling (e.g., Jochim 1976) may also be helpful if the data and means are available.

Researchers must also examine the geological, geomorphological, oceanographic, and hydrological components of a region both for their potential impact on the prehistoric habitat and its inhabitants, as well as the possibility for site survival (see Bailey and Flemming 2008; Benjamin 2007; Westley and Dix 2006; Dunbar et al. 1992; Masters and Flemming 1983; Ruppe 1988). In order for modern archaeological investigation to provide positive results, sites must have originally existed in a given location and, critically, they need to have survived. This is perhaps the most important element omitted from Fischer's initial model: as a result of years of practical experience with coastal morphology and archaeology, the problematic areas were automatically and deliberately omitted in Denmark (Fischer, personal communication, 2004). Consideration of the physical environmental elements is extremely important, and local variables such as coastal topography, tidal activity, sea currents, surge, as well as geological composition and rates and type of sedimentation must not be overlooked.

The identification of accessible cultural landscapes includes evaluating issues of erosion, sedimentation, and changes in topography (Grøn 1995). In cases of extreme physical change, topographic models would naturally become less reliable. Furthermore, material from inflowing agricultural systems and industrial activities can have a devastating impact on submerged landscapes and underwater sites. Grøn has advocated familiarization with regional geological surveys where, in the best cases, hundreds of borehole data are available to archaeologists, as was the case at the Strynø Basin project.[3] It is thus suggested that the regional marine geological and geomorphological data be studied with a focus on Holocene sedimentation and coastal erosion for their impact on archaeological surveys. Consideration of geological and geographical variables should be carefully evaluated and can be done concurrently with location plotting.

It is important to note, though it may seem counterintuitive, Holocene sedimentation and 'undesirable' seabed composition do not necessarily imply that archaeological discovery is impossible. "Approximately 80% of the Danish sea bed is classified as mud and sand, which to the inexperienced underwater researcher may sound like a non-rewarding place to start surveying. Nearly all the rest of the Danish sea floor may appear equally unpromising" (Fischer 2007: 3). Furthermore, it is established that submerged prehistoric material has been discovered in a variety of seabed compositions and coastal environments (Flemming 1983) and that eroding land surfaces can lead to the exposure of prehistoric material (e.g., Andersen 1980; Momber 2000; Raban 1983). While a thorough geological assessment will be useful, it should not be the sole consideration when planning underwater survey; localized areas may exist as exceptions to an otherwise unlikely region of study.

Sea-level models and curves should be consulted if available and should be treated as a general guideline for presenting depth to age ratios and coastal environmental change. However, one must remember that such models are only as precise as their underlying data set. Sea-level models must themselves be evaluated; in a case where data are limited, the resulting sea-level curve should be treated as an approximation. A conservative window of +/− several meters may be required in order to evaluate a specific region based on the available sea-level curve. This is especially true since coastal landscape morphology can vary greatly by individual location.

II) Ethnographic Component: Historical Research and Interviews

The ethnographic and historical research component was, to an extent, practiced in Denmark. However this element was not included in the early guidelines suggested for international practice. Fischer describes interviewing local fishermen in Denmark (Fischer 1993, 1995), and this step is important. Identification of local marine resources, exploited by prehistoric and modern peoples alike, can help establish the types of fishing practiced in a region (i.e., active, passive, or both) (Fischer 2007; Pedersen 1997). By reviewing the marine resource exploitation patterns of prehistoric populations and comparing them with traditional fishing practices employed in that region, researchers can determine if prehistoric peoples exploited similar species as modern fishermen practicing traditional (non-industrial, non-commercial) methods of fishing. Ethnographic parallels should also be sought. Archives containing ethnohistoric accounts of regional maritime practices should be thoroughly investigated and will help identify what kinds of marine resources were used, as well as how and where these practices took place. If stationary traps, nets, fences or other structures are used, then there is a strong likelihood that prehistoric populations will have lived nearby, in order to protect their investment and fishing rights (Fischer 2007; Pedersen 1997).

The sport (non-archaeological) diving community is a valuable resource and any underwater field archaeologist has probably experienced this firsthand. Interviews with experienced local divers can tell the archaeologist about dive sites, conditions, submarine geology, and even lead to the sharing of unpublished finds (e.g., Benjamin 2007). When investigating a region or specific location for submerged archaeological potential, the sport diving, fishing, and other maritime communities should be consulted and exhausted for their knowledge of geographical and archaeological features and material. A trained specialist can then investigate any promising locations suggested to be of interest by non-archaeological divers.

III) Map, Chart and Aerial Analysis and Location Plotting

Analyzing the physical environment of the modern coast and near-shore waters using nautical charts and satellite imagery will greatly contribute to the evaluation of paleoenvironments and their suitability for submerged site discovery. This review of regional topography, bathymetry, and aerial imagery will establish factors likely to have promoted preservation or destruction of submerged sites and, in turn, act as a filter to establish the foundations for future investigations of the submerged environment. Factors to consider include exposure to coastal surge and waves, sediment type and quantity, the presence of caves, and sheltered areas in submerged environments (Bailey and Flemming 2008; Benjamin 2007, 2008).

Maps and charts can vary greatly in accuracy, and thus reliability. Since topographical positioning of sites relies on a well-founded knowledge of the paleoenvironment, maps and charts should be up to date and rich in bathymetric detail. A finer scale may be required if the data are insufficient. In the past two decades, nautical charts have become available for general use in electronic format. This technological advance is useful to the underwater archaeologist who can now zoom in and out of entire oceans on a computer screen, a convenience that eliminates the need for a room full of bulky nautical charts. While initial projects in Denmark relied on charts of 1:70,000 in scale (Fischer 1993), the author would suggest a ratio of 1:25,000 as a desirable minimum resolution, when available. If charts depicting appropriate resolution / bathymetric data are not available, more extensive seabed profiling may be necessary.

Aerial and satellite imagery have been used to describe and interpret archaeological landscapes in coastal zones (e.g., Cox 1992; Moseley et al. 1992), thus the notion and use of the technology are not new. However, the wide *availability* of this technology is a new phenomenon. The accessibility of reasonably high-resolution satellite imagery, with the introduction of internet-based maps, has already begun to impact studies of submerged cultural landscapes, assisting to define palaeocoastlines, and identify survey locations with potentially significant results (Benjamin 2007). Additionally, modern constructions, such as harbors, levees, and other features, both close to and in the water, can be identified from thousands of miles away. This is particularly useful in cases where such human impact may not be indicated in detail on nautical charts or regional maps. Furthermore, the quality and the geological composition of a landscape can, at times, be seen from above based on modern agriculture, forests, and barren terrain. When compared to bathymetric data from available nautical charts and topographic maps, satellite images are a valuable tool for project planning.

IV) Observation of Potential Survey Locations, Physically and With Sonar

There appears to have evolved a two-pronged approach, if not a methodological debate, on how to prioritize the study of submerged landscapes through archaeological diving and remote sensing operations (Johnson and Stright 1992; Masters and Flemming 1983). Gaffney et al. (2007) have mapped 23,000 km^2 of the North Sea Basin using seismic data collected for mineral exploration and it is likely that studies similar to this important research will eventually produce much greater bathymetric detail of the submerged environments around Europe. This will certainly serve to improve the precision in locating submarine sites and when the use of advanced sonar (i.e., multibeam) is possible for high-resolution mapping of the seafloor, this should be considered. However, sonar and mapping techniques should not *replace* underwater fieldwork by archaeological divers, and may not always be required. In some instances, as was the case in Denmark in the 1980s, nautical charts may provide a sufficient amount of information needed to evaluate the submerged landscapes. By reviewing aerial imagery in tandem with bathymetry it may be possible to evaluate a particular region without the need for costly sonar and mapping projects.

Once a theoretical framework has been established, archaeologists must investigate the region physically. From the surface, if the submerged area in question is adjacent to modern land the researcher should conduct a geological and archaeological survey of the onshore coastal environment. Confirming bathymetry in nearshore waters should also be conducted by comparing real-time data to the bathymetric charts used in the planning phases. Using a consumer-grade sonar (or fish-finder) can be an inexpensive method to confirm and record depth and contours (e.g., Benjamin 2007; Fischer 1993).

V) Marking of Theoretical Site With GPS and Diving to Investigate

Although GPS was used in Danish fieldwork (Fischer, personal communication, 2004) this remained ill-defined in the guidelines for international application of the survey model. From the dive boat, a sonar with integrated GPS can be used to both mark bathymetry and plot survey locations. This will help to locate dive spots in the future as well as to document and map areas surveyed.

Amateur divers have been successfully used for underwater archaeological projects (i.e., Andersen 1980; Skarrup 1983). It is important to note, however, that such individuals should be directed by trained underwater archaeology specialists whenever possible. Malm (1995: 388) asks: "Should one rely on volunteer divers and amateur archaeologists, who might not have so much archaeological routine, or on expensive marine archaeologists with the necessary competence and experience?" It should be pointed out that the use of strictly amateur divers on an underwater site or survey, even when directed by an archaeologist from shore or a boat, may be disadvantageous and could compromise the research. This could, in turn, impact future funding of similar or follow-up projects. Malm continues, implying the observed need in previous decades: "Experienced marine archaeologists do not—so far—hang from trees."

While trained underwater archaeologists still do not grow on trees, the discipline of underwater archaeology has grown significantly since the first excavations at Tybrind Vig in 1978. Archaeology departments and postgraduate programs at academic institutions worldwide now include training and education in underwater archaeology. Furthermore, work from the past four decades has inspired a new generation of motivated and qualified archeologists, trained and capable of carrying out professional archaeology underwater. A properly managed project must include the necessary planning and budget to incorporate a trained underwater specialist to direct the work carried out underwater, supervise amateur divers and prepare the report. As defined by the Institute for Archaeologists: "A Nautical Archaeological specialist is a recognized named person who has quantifiable (peer reviewed publications, academic qualifications, MIfA) and qualifiable experience (named projects at MIfA level of responsibility) in researching, excavating, recording, interpreting, reconstructing and publishing Nautical finds" (IFA 2008: 2).[4]

VI) Post-Fieldwork Analysis, Interpretation and Dissemination

This is standard practice in archaeology and is no exception here.

A NOTE ON PREDICTIVE MODELS

The use of predictive models has been suggested to be limiting; Price (1995: 424) states that "we do not learn from them. . ." implying that the material from sites discovered through site-location models will supply redundant information. However, this suggests that there is no more to gain from new material at coastal Mesolithic sites; that everything has already been discovered, recorded, and interpreted. This assertion has been proven to be faulty since subsequent material discovered from the southwest Baltic, including those sites discovered through the use of predictive models, have been both informative and important within European archaeology. The well-preserved Mesolithic blade from Timmendorf-Nordmole, northern Germany, found complete with organic hafting (Lübke 2001), reminds the archaeological community of the potential for unique preservation and high-quality material from submerged locations. Furthermore, predictive models applied to areas where the archaeological record is particularly lacking can be seen as a strategy for beginning the challenging task of locating prehistoric sites underwater.

RESEARCH PRIORITIES AND FUTURE STUDIES

Underwater archaeology has the potential to significantly add to our knowledge of prehistoric people and material culture ranging from c. 6,000 years ago and as far back as the middle Paleolithic (see Flemming 2004: fig. 2.5), and possibly older. However acknowledging the archaeological necessity and specific research priorities are important in order to justify the expense and energy required to properly investigate submerged prehistoric landscapes.[5] Although the Mesolithic and early Neolithic are not the only periods that merit further study, this short section is meant to introduce a significant archaeological research priority that can be greatly enhanced through underwater archaeological practice.

The transition from hunter-gatherer to an agricultural subsistence economy is considered a major event in human prehistory and took place across a variety of landscapes including coastal areas that are now submerged. As a result, underwater archaeology has the potential to transform the archaeological record and our ideas about Mesolithic and Neolithic life-ways. Current research is taking place throughout Europe and surrounding environs and employs a variety of methods including diving and remote sensing (see Bailey and Flemming 2008; Benjamin et al. 2011; Flemming 2004). Using the reevaluated Danish model for submerged prehistoric site discovery through archaeological survey, research priorities are introduced in the form of two examples: one in continental Europe and another in the United Kingdom. The following descriptions should be interpreted as preliminary considerations that reflect both geographical appropriateness for the described methodology, and the potential for significant archaeological contributions to be made through underwater methods. Furthermore, they can be seen to represent examples of geographically central and marginal areas in Europe.

The Eastern Adriatic

The Adriatic coast was a major route for the spread of agriculture into both southwestern and central Europe (Forenbaher and Miracle 2005). In 2004–2005, initial investigations in the submarine environments of the northern Adriatic were conducted (Benjamin 2007; Benjamin and Bonsall 2009); however, despite the discovery of archaeological material, no definitive evidence of submerged prehistoric sites were recorded in situ. Nevertheless, important geological and geographical considerations were evaluated and have lead to the renewed interest in the region; this time in central Dalmatia, Croatia.

The eastern Adriatic is important for understanding the mechanisms of the spread of agriculture, specifically because it provides waterborn access to central Europe from the southern Balkans and eastern Mediteranean. However early Holocene coastal settlements are relatively uncommon and the region is often overlooked for its greater significance to the Neolithization of Europe (Forenbaher and Miracle 2005). The lack of evidence for coastal occupation is likely a consequence of the innundation in the early and middle Holocene. Between 7000 BC and 5400 BC (the period of the Mesolithic-Neolithic transition) the Adriatic Sea rose 15 meters from approximately 20 m to 5 m below modern sea levels (Lambeck et al. 2004);[6] coastal sites older than 5400 cal BC are likely to have been submerged.

The central Dalmatian coastal region of Croatia (see Figure 3) has thus been

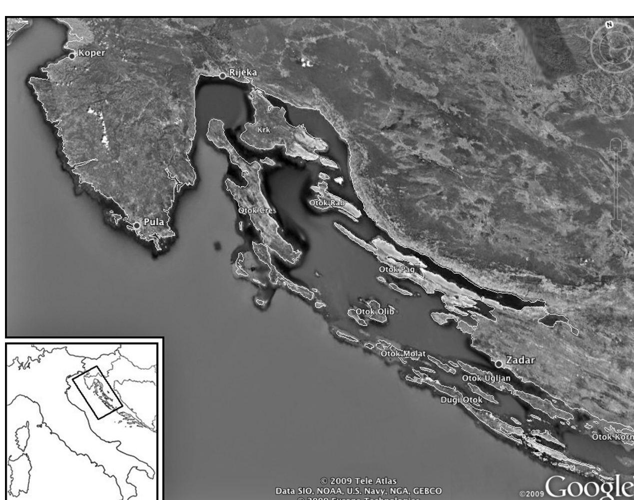

Figure 3. *The northeast Adriatic region, from the Gulf of Trieste to the Zadar Archipelago. The Zadar Archipelago, in particular, contains a variety of sheltered locations, as well as numerous sea caves (Benjamin 2007). Oblique satellite image © Google Earth.*

selected as a focus for investigation because of its potential for site preservation and for significant archaeological discovery. Minimal tidal activity, limited exposure to open sea storm surge, favorable sedimentation rates, and the abundance of protected geographic features such as bays, coves, straits, and submerged limestone caves, increase the likelihood for site survival and significant archaeological discovery (Benjamin 2007). In addition to the Danish model, due to its karstic limestone geology, methods and techniques from previous work conducted in Florida (e.g., Dunbar et al. 1992; Faught 2004; Ruppe 1980) may also be applicable in the eastern Adriatic (Benjamin et al. 2011).

Northwest Scotland

The Mesolithic of Scotland has recently been summarized by Saville (2004) and western Scottish material, in particular, has been presented for its contribution the Mesolithic-Neolithic transition in northwest Europe (e.g., Armit and Finlayson 1992; Bonsall et al. 2002). Still, the Mesolithic record is dominated by lithic assemblages, bone and antler tools, and shellfish remains and the current lack of high-quality mortuary or settlement information (i.e., dwellings and burials) has led Lars Larsson to suggest that in Scotland "the most favourable landscapes to investigate would be a lagoon or deep bay... preferably with a mixture of fresh, brackish and salt water and an irregular shoreline which provides the potential for headlands and islands to form as a consequence of changing sea-level" (Larsson 2004: 389). It is such geographical and environmental considerations that future research should aim to explore and evaluate.

A model for coastal survey, based on environmental and cultural variables, should be sought in areas where there has been limited or no isostatic uplift or where crustal subsidence occurred during the Holocene. A holistic approach would include the investigation of land, inter-tidal, and submarine zones, and would be the most comprehensive way to evaluate the paleolandscape (especially given the tidal swings sometimes greater than 5 m). Particularly interesting are the numerous bays and inlets on the east coast of Outer Hebrides; the relatively low energy environments of these sheltered locations are likely to have aided in the preservation of prehistoric sites. Through the described methods of archaeological, geographical and ethnographic analysis, recommendations can be made for future

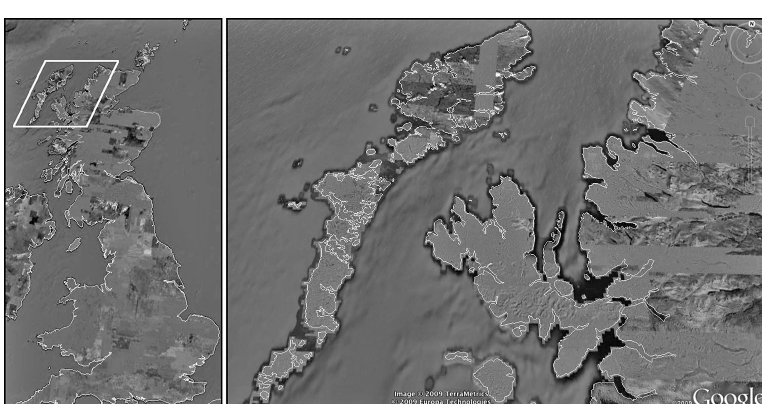

Figure 4. *An oblique satellite image of northwest Scotland and the Outer Hebrides islands. The east coasts of the Outer Hebrides offer a host of sheltered bays, inlets, and islets that should promote preservation of submerged and inter-tidal sites. Satellite imagery © Google Earth.*

research of coastal and submerged prehistory in northwest Scotland.

The geomorphological situation in Scotland is more complex than in the eastern Adriatic, since it was partially covered by an ice sheet in the late Pleistocene; the melting of the glacier caused substantial land rebound during the early Holocene, which was greatest in south-central Scotland, and occurred much less to the north and northwest (Ballantyne 2004). While there is some archaeological material from the southwest Scottish coasts, mainly on raised beaches (i.e., Ballantyne 2004: fig. 2.4), early Holocene coasts of the north and northwest of Scotland are now underwater. According to the sea-level model produced by Shennan and Horton (2002), the situation in the Outer Hebrides suggests that coastal Mesolithic sites existed in locations that are now inter-tidal or submerged landscapes. Sites on or near the shore pre-dating 7000 BP would have been transgressed and, given appropriate conditions, may now exist underwater. Theoretically, coastal sites contemporary with the earliest archaeological evidence from the Outer Hebrides, c. 8000 BP (Gregory et al. 2005), would now be below 5 m msl; however, it must be stated that this sea-level model is based on a single set of data (Ritchie 1985) and that the sea-level curve itself is only a prediction. Thus, it is clear that the margin of error is too large to determine a precise age of inundation for the islands' Mesolithic shores. Coastal landscapes dating into the late Mesolithic, or even early Neolithic may have been submerged, depending on local variation. More data are needed to clarify the coastal geomorphological and archaeological landscapes of the early-middle Holocene in the Outer Hebrides (see Figure 4).

CONCLUSION

Specific conditions in the southern Baltic have allowed for thousands of prehistoric archaeological discoveries underwater (Fischer 2004): the archaeological landscape of prehistoric hunter-fishers, cold water, relatively low salinity, sediment and marine flora that produced anaerobic conditions, and topography that allowed for the preservation of sites despite inundation and sometimes numerous transgressions. These variables all contribute to the success of underwater discovery in southern Scandinavia and it is not the intention of this paper to suggest that identical features will exist elsewhere. However, the *foundations* of the Scandinavian methods for the presupposition of submerged prehistoric sites can be productive on an international scale if they are considered alongside successful campaigns from other distinct marine environments (e.g., Galili et al. 1993; Ruppe 1988) and the necessary adaptations for regional variation are systematically evaluated prior to physical survey. Furthermore it is likely that some of the principles of the Danish model will be applicable, with limited or no modifications. It should come as no surprise to find that coastal peoples exploited fish in narrow inlets and straits where they are easily accessible. Given such likelihoods, the redefined survey model can be seen as an appropriate template, ready to be adapted and modified as required by region.

Although Price (1995: 424) states that "we should avoid predictive models; more complete intensive systematic surveys are essential to inform us about the range of variability that is present in the archaeological record," Bailey and Flemming (2008: 2159) remind researchers that since "visibility underwater is restricted to a range of the order of 1–20 m and careful examination of the seabed is relatively rare, the probability of finding prehistoric materials and terrestrial environmental indicators *in situ* by targeted survey is inevitably low." By expanding upon the 'presupposition model' employed in Denmark, however, prehistorians can improve the prospects of site discovery and investigate areas in a unified effort, adapting underwater archaeological methods for regional appropriateness and improving the techniques in the process. Furthermore, projects should include the acquisition of paleoenvironmental data, and archaeological survey should result in the reporting of material, regardless of age, from underwater, inter-tidal and onshore fieldwork in a cooperative effort. Through a system of careful consideration,

Figure 5. *The author with a freshly discovered Mesolithic flake axe, found offshore in western Funen, Denmark (photo by F. Feulner).*

prioritization, and a defined strategy for the study of submerged prehistoric landscapes, archaeologists will hopefully begin to find substantially more needles in a somewhat less-daunting haystack.

ACKNOWLEDGEMENTS

I would like to thank Geoff Bailey, Clive Bonsall, Robert Leighton, Catriona Pickard, Penny Spikins, and an anonymous reviewer for their helpful input and suggestions. Special thanks go to Anders Fischer for his comments on an earlier draft of this paper and for his continued advice. I would like to acknowledge all of the pioneering archaeologists referenced in this text for doing what many considered to be impossible. Errors, oversights, and shortcomings are entirely my own.

END NOTES

1. It should be noted that prehistoric underwater archaeology at inland lake sites has been practiced for decades, particularly in the Alpine region of central Europe (e.g., Ruoff 1976; Schlichtherle and Wahlster 1986) and at Crannog sites of Scotland and Ireland (e.g., Dixon 2004; Morrison 1985). Although some parallels may be drawn, particularly regarding methodology, prehistoric lake sites are not of primary relevance to the discussion of submerged *coastal* landscapes of the late Pleistocene and early-middle Holocene.
2. See also Werz and Flemming (2001) for a representative example from South Africa.
3. Grøn also cites examples of topographical areas generally more accessible, such as protected headlands, not subjected to such deposition. Møllegabet I and II, at Æro, Denmark are examples of such accessible locations (Grøn and Skaarup 1991).
4. For the purposes of submerged prehistoric landscape archaeology, the author suggests that the term 'nautical' in this passage be interpreted as synonymous with the term 'underwater'—this should be seen as a legislative distinction and is not meant to contradict earlier statements defining the various fields of archaeology conducted underwater.
5. There is also a need to consider human impact and the erosion of cultural material from seabed as a heritage management issue. This was recently discussed by Anders Fischer in *Stone Age Habitation on the European Continental Shelf—The Threatened Treasury*. Paper presented at the European Archaeologists Association 15th annual meeting, Riva del Garda, Italy, September 17, 2009.
6. It should be noted that there remains a significant gap in the data set used to produce the northern Adriatic sea-level curve, particularly in the early-middle Holocene. Although the model does serve as a coarse guideline for the depth, age ratio, more research, and environmental sampling is required.

REFERENCES

Andersen, S. H. 1980. *Tybrind Vig*. Foreløbig meddelese om en undersøisk stenalderboplads ved Lillebælt. *Antikvariske Studier* 4:7–22. Fredningsstyrelsen. København.

Andersen, S. H. 1985. Tybrind Vig—A preliminary report on a submerged Ertebølle settlement on the west coast of Fyn. *Journal of Danish Archaeology* 4:52–69.

Andersen, S. H. 1987. Mesolithic dug-outs and paddles from Tybrind Vig, Denmark. *Acta Archaeologica* 57:87–106.

Armit, I., and B. Finlayson. 1992. Hunter-gatherers transformed: The transition to agriculture in northern and western Europe. *Antiquity* 66: 664–676.

Bailey, G. 2004. The wider significance of submerged archaeological sites and their relevance to world prehistory. In *Submarine Prehistoric Archaeology of the North Sea. Research Priorities and Collaboration with Industry. CBA Research Report 141* (N. C. Flemming, ed.): 3–10. York: Council for British Archaeology.

Bailey, G. and J. Parkington. 1988. The archaeology of prehistoric coastlines: An introduction. In *Archaeology of Prehistoric Coastlines* (G. Bailey and J. Parkington, eds.): 1–10. Cambridge, UK: Cambridge University Press.

Bailey, G. N. and N. C. Flemming. 2008. Archaeology of the continental shelf: Marine resources, submerged landscapes, and underwater archaeology. *Quaternary Science Reviews* 27:2153–2165.

Ballantyne, C. K. 2004. After the ice: Paraglacial and postglacial evolution of the physical environment of Scotland, 20,000 to 5000 BP. In *Mesolithic Scotland and its Neighbours* (A. Saville, ed.): 21–38. Edinburgh: Society of Antiquaries of Scotland.

Bass, G. 1966. *Archaeology Underwater*. London: Thames and Hudson.

Benjamin, J. 2007. *The Submerged Prehistory of Europe: A Methodological Approach to Underwater Site Discovery with Special Reference to the Mesolithic and Neolithic of the Eastern Adriatic*. Unpublished Ph.D. Dissertation. Edinburgh: University of Edinburgh.

Benjamin, J. 2008. Underwater archaeological feasibility report for the Pre-Neolithic Aspros site, Western Cyprus. In *Island Dialogues: Proceedings of the POCA Conference, 2006* (A. McCarthy, ed.): 4–14. Edinburgh: University of Edinburgh Archaeology Occasional Papers 21.

Benjamin, J. and C. Bonsall. 2009. An underwater archaeological survey in the Northern Adriatic Sea. *International Journal of Nautical Archaeology* 38(1):163–172.

Benjamin, J., C. Bonsall, C. Pickard, and A. Fischer. 2011. *Underwater Archaeology and the Submerged Prehistory of Europe*. Oxford: Oxbow. In press.

Bennike, P., A. Fischer, J. Heinemeier, L. Kubiak-Martens, J. Olsen, M. Richards, and D. E. Robinson. 2007. The composition of Mesolithic food, evidence from a submerged settlement. *Acta Archaeologica* 78:163–178.

Blot, J. Y. 1996. *Underwater archaeology: Exploring the world beneath the sea.* London: Thames and Hudson.

Bonsall, C. 1996. The 'Obanian' problem: Coastal adaptation in the Mesolithic of western Scotland. In *The Early Prehistory of Scotland* (T. Pollard and A. Morrison, eds.):183–197. Edinburgh: Edinburgh University Press.

Bonsall, C., E. Anderson, and G. Macklin. 2002. The Mesolithic-Neolithic transition in western Scotland and its European context. *Documenta Praehistorica* 29:1–19.

Bowens, A., ed. 2009. *Underwater Archaeology. The NAS Guide to Principles and Practice* (2nd ed.) The Nautical Archaeological Society. Portsmouth, UK: Blackwell Publishing.

Christensen, C. (1995). The Littorina transgressions in Denmark. In *Man and Sea in the Mesolithic* (A. Fischer, ed.):15–21. Oxford: Oxbow.

Cox, C. 1992. Satellite imagery, aerial photography and wetland archaeology: An interim report on an application of remote sensing to wetland archaeology: The pilot study in Cumbria, England. *World Archaeology* 24:249–267.

Dawson, A. 1984. Quaternary sea-level changes in Western Scotland. *Quaternary Science Reviews* 3:345–368.

Dean, M. 1992. *Archaeology Underwater: The NAS Guide to Principles and Practice*. The Nautical Archaeology Society. Portsmouth, UK: Blackwell.

Delgado, J. P. 1997. *The Encyclopedia of Underwater and Maritime Archaeology.* London: British Museum Press.

Dixon, T. N. 2004. *The Crannogs of Scotland: An Underwater Archaeology*. Stroud, UK: Tempus.

Dunbar, J. S., S. D. Webb, M. Faught. 1992. Inundated prehistoric sites in Apalachee Bay, Florida, and the search for the Clovis shoreline. In *Paleoshorelines and Prehistory*:
An Investigation of Method (L. L. Johnson and M. Stright, eds.):177–146. Boca Raton, FL: CRC Press.

Erlandson, J. and S. Fitzpatrick. 2006. Oceans, islands, and coasts: Current perspectives on the role of the sea in human prehistory. *The Journal of Island and Coastal Archaeology* 1:5–32.

Erlandson, J. M. 2001. The archaeology of aquatic adaptations: Paradigms for a new millennium. *Journal of Archaeological Research* 9:287–356.

Fairbanks, R. G. 1989. A 17,000-year glacio-eustatic sea-level record: Influence of glacial melting rates on the Younger Dryas event and deep-ocean circulation. *Nature* 324:637–642.

Faught, M. 2004. The underwater archaeology of paleolandscapes, Apalachee Bay, Florida. *American Antiquity* 69:275–289.

Faught, M. K. (1988). Inundated sites in the Apalachee Bay area of the eastern Gulf of Mexico. *Florida Anthropologist* 41:185–190.

Flemming, N. C. 1968. Archaeological evidence for sea-level changes in the Mediterranean. *Underwater Association Report*: 9–13.

Flemming, N. C. 1983. Survival of Submerged Lithic and Bronze Age Artifact Sites: A Review of Case Histories. In *Quaternary Coastlines and Marine Archaeology* (P. Masters and N. C. Flemming, eds.). Orlando, FL: Academic Press.

Flemming, N. C. 2004. The prehistory of the North Sea floor in the context of Continental Shelf archaeology from the Mediterranean to Nova Zemlya. In *Submarine Prehistoric Archaeology of the North Sea. Research Priorities and Collaboration with Industry. CBA Research Report 141* (N. C. Fleming, ed.): 11–19. York: Council for British Archaeology.

Fischer, A. 1987. Stenalderbopladsen på Argusgrunden [The Stone-Age Site on the Argus Bank]. *Fortidsminder og Kulturhistorie, Antikvariske Studier* 8:11–58.

Fischer, A. 1993. *Stenalderbopladser på bunden af Smålandsfarvandet. En teori afprøvet ved dykkerbesigtigelse* [Stone Age settlements in the Småland Bight. A theory tested by diving]. Hørsholm: Skov- og Naturstyrelsen.

Fischer, A. 1995. An entrance to the Mesolithic world below the ocean. Status of ten years' work on the Danish sea floor. In *Man and Sea in the Mesolithic* (A. Fischer, ed.):371–384. Oxford: Oxbow.

Fischer, A. 1997. People and the sea-settlement and fishing along the Mesolithic coasts. In *The Danish Storebælt Since the Ice Age-Man, Sea and Forest* (L. Pedersen, A. Fischer, and B. Aaby, eds.):63–77. Oxford: Oxbow.

Fischer, A. 2004. Submerged Stone Age-Danish examples and North Sea potential. In *Submarine Prehistoric Archaeology of the North Sea. Research Priorities and Collaboration with Industry. CBA Research Report 141* (N. C. Flemming, ed.):23–36. York, UK: Council for British Archaeology.

Fischer, A. 2007. Coastal fishing in Stone Age Denmark—Evidence from below and above the present sea-level and from the bones of human beings. In *Shell Middens and Coastal Resources along the Atlantic Façade, Held in York September 2005* (N. Milner, O. E. Craig, G. N. Bailey, eds.): 54–69. Oxford: Oxbow.

Forenbaher, S. and P. Miracle. 2005. The spread of farming in the Eastern Adriatic. *Antiquity* 79:514–528.

Gaffney, V., K. Thomson, and S. Fitch. 2007. *Mapping Doggerland: The Mesolithic landscapes of the southern North Sea*. Oxford: Archaeopress.

Galili, E., D. J. Stanley, J. Sharvit, and M. Weinstein-Evron. 1997. Evidence for earliest olive-oil production in submerged settlements off the Carmel Coast, Israel. *Journal of Archaeological Science* 24;1141–1150.

Galili, E., M. Weinstein-Evron, I. Hershkkovitz, A. Gopher, M. Kislev, O. Lernau, L. Kolska-Horwitz, and H. Lernau. 1993. Atlit-Yam: A prehistoric site on the sea floor off the Israeli coast. *Journal of Field Archaeology* 20:133–157.

Hartz, S. and H. Lübke. 1995. Tauchprospektion in der Hohwachter Bucht—Zur Frage der Erhaltung submariner steinzeitlicher Küstenwohnplätze in der westlichen Ostsee. In *Archäologie unter Wasser 1. Forschungen und Berichte zur Unterwasserarchäologie zwischen Alpen-rand-Seen und Nordmeer* (Landesdenkmalamt Baden-Württemberg/Kommission für Unterwasserarchäologie im Verband der Landesarchäologen in der Bundesrepublik Deutschland, eds.):116–124. Stuttgart: Archäologische Informationen aus Baden-Württemberg 33.

Gianfrotta, P. A. and P. Pomey. 1981. *Archeologia Subacquea. Storia, Tecniche, Scoperte e Relitti*. Milano: A. Mondadori.

Goggin, J. 1960. Underwater archaeology: Its nature and limitations. *American Antiquity* 25:348–354.

Green, J. 1990. *Maritime Archaeology: A Technical Handbook* (2nd ed.). London: Elsevier.

Gregory, R. A., E. M. Murphy, M. J. Church, K. J. Edwards, K. B. Guttmann, and D. D. A. Simpson. 2005. Archaeological evidence for the first Mesolithic occupation of the Western Isles of Scotland. *The Holocene* 15:944–950.

Grøn, O. 1995. *BAR International Series*. Oxford: Tempus Reparatum.

Grøn, O. and J. Skaarup. 1991. Møllegabet II-A Submerged Mesolithic Site and a "Boat Burial" from Æro. *Journal of Danish Archaeology* 10:38–50.

Hudson, T. 1979. A charmstone from the sea off Point Conception, California. *Journal of California and Great Basin Anthropology* 1:363–367.

IFA. 2008. *Standards and Guidance for Nautical Archaeology Recording*. Institute for Archaeologists, University of Reading. IFA Practice adopted at the Annual General Meeting of the Institute held on October 15, 2008.

Jochim, M. 1976. *Hunter-Gatherer Subsistence and Settlement: A Predictive Model*. New York: Academic Press.

Johnson, L. and M. Stright, eds. 1992. *Paleoshorelines and Prehistory: An Investigation of Method*. Boca Raton, FL: CRC Press.

Josenhans, H., D. Fedje, R. Pienitz, and J. Southon. 1997. Early humans and rapidly changing Holocene sea-levels in the Queen Charlotte Islands-Hecate Strait, British Columbia, Canada. *Science* 277:71–74.

Lambeck, K., F. Antonioli, A. Purcello, and S. Silenzi. 2004. Sea-level change along the Italian Coast for the past 10,000 yr. *Quaternary Science Reviews* 23:1567–1598.

Lambeck, K., C. Smither, and P. Johnston. 1998. Sea-level change, glacial rebound and mantle viscosity for northern Europe. *Geophysics* 134:102–144.

Lambeck, K., Y. Yokoyama, and T. Purcell. 2002. Into and out of the Last Glacial Maximum: Sea-level change during Oxygen Isotope Stages 3 and 2. *Quaternary Science Reviews* 21:343–360.

Larsson, L. 1983. Mesolithic settlement on the sea floor in the Strait of Øresund. In *Quaternary Coastlines and Marine Archaeology* (P. Masters and N. C. Flemming, eds.): 283–301. Orlando, FL: Academic Press.

Larsson, L. 1990. The Mesolithic of Southern Scandinavia. *Journal of World Prehistory* 4:257–309.

Larsson, L. 1995. Man and sea in Southern Scandinavia during the Late Mesolithic. The role of Cemeteries in the view of society. In *Man and Sea in the Mesolithic* (A. Fischer, ed.):95–104. Oxford: Oxbow.

Larsson, L. 2004. The Mesolithic Period in Southern Scandinavia: With special reference to burials and cemeteries. In *Mesolithic Scotland and its Neighbours* (A. Saville, ed.): 371–392. Edinburgh: Society of Antiquaries of Scotland.

Lübke, H. 2001. Eine hohlendretuschierte Klinge mit erhaltener Schäftung vom endmesolithischen Fundplatz Timmendorf-Nordmole, Wismarbucht, Mecklenburg-Vorpommern. *NAU Nachrichtenblatt Arbeitskreis Unterwasserarchäolgie* 8:46–51.

Lübke, H. 2003. New investigations on submarine Stone Age settlements in the Wismar Bay area. In *Mesolithic on the Move: Papers Presented at the 6th International Conference on the Mesolithic in Europe, Stockholm 2000* (H. Kindgren, K. Knutsson, L. Larsson, D. Loeffler, and A. Åkerlund, eds.):633–642. Oxford: Oxbow.

Malm, T. (1995). Excavating submerged Stone Age sites in Denmark—The Tybrind Vig example. In *Man and Sea in the Mesolithic* (A. Fischer, ed.):385–396. Oxford: Oxbow.

Masters, P., 1983. Detection and assessment of prehistoric artifact sites off the coast of southern California. In *Quaternary Coastlines and Marine Archaeology* (P. Masters and N. C. Flemming, eds.):189–213. Orlando, FL: Academic Press.

Masters, P., and N. C. Flemming. 1983. *Quaternary Coastlines and Marine Archaeology.* Orlando, FL: Academic Press.

Miles, D. 2004. Preface by David Miles, Chief Archaeologist, English Heritage. In *Submarine Prehistoric Archaeology of the North Sea. Research Priorities and Collaboration with Industry. CBA Research Report 141* (N. C. Fleming, ed.):xiii. York: Council for British Archaeology.

Milner, N., ed. 2005. *Proceedings from the Conference Shell Middens and Coastal Resources along the Atlantic Façade, Held in York September 2005*. Oxford: Oxbow.

Momber, G. 2000. Drowned and deserted: A submerged prehistoric landscape in the Solent, England. *International Journal of Nautical Archaeology* 29(1):86–99.

Momber, G. 2005. Stone Age stove under the Solent. *International Journal of Nautical Archaeology* 34(1):148–149.

Morrison, I. 1985. *Landscape with Lake Dwellings: The Crannogs of Scotland*. Edinburgh: Edinburgh University Press.

Moseley, M. E., D. Wagner, and J. B. Richardson. 1992. Space shuttle imagery of recent catastrophic change along the arid Andean coast. In *Paleoshorelines and Prehistory: An Investigation of Method* (L. L. Johnson and M. Stright, eds.):215–235. Boca Raton, FL: CRC Press.

Muckelroy, K. 1978. *Maritime Archaeology.* Cambridge, UK: Cambridge University Press.

Pedersen, L. 1997. They put fences in the sea. In *The Danish Storebælt since the Ice Age-Man, Sea and Forest* (L. Pedersen, A. Fischer, and B. Aaby, eds.):124–143. Oxford: Oxbow.

Perlman, S. M. 1980. An optimum diet model. Coastal variability, and hunter-gatherer behavior. *Advances in Archaeological Method and Theory* 3:257–310.

Pirazzoli, P. A. 1985. Sea-level change. *Nature and Resources* 21(4):2–9.

Pirazzoli, P. A. 1996. *Sea-Level changes: The Last 20,000 Years*. Chichester: Wiley.

Pluciennik, M. 2008. The coastal Mesolithic of the European Mediterranean. In *Mesolithic Europe* (G. Bailey and P. Spikins, eds.):328–356. Cambridge: Cambridge University Press.

Price, T. D. 1991. The Mesolithic of Northern Europe. *Annual Review of Anthropology* 20:211–233.

Price, T. D. 1995. Some perspectives on prehistoric coastal adaptations and those who study them. In *Man and sea in the Mesolithic* (A. Fischer, ed.):385–396. Oxford: Oxbow.

Raban, A. 1965. Tel Harez: Chalcolithic and Persian remains in the Sea. *Bematzuloth Yam* 3(4):6–9.

Raban, A. 1983. Submerged prehistoric sites off the Mediterranean coast of Israel. In *Quaternary Coastlines and Marine Archaeology* (P. Masters and N. C. Flemming, eds.):189–214. Orlando, FL: Academic Press.

Ritchie, W. 1985. Inter-tidal and sub-tidal organic deposits and sea-level changes in the Uists, Outer Hebrides. *Scottish Journal of Geology* 21:161–176.

Rowley-Conwy, P. 1983. Sedentary hunters: The Ertebølle example. In *Hunter-Gatherer Economy in Prehistory* (G. Bailey, ed.):111–126. Cambridge, UK: Cambridge University Press.

Rowley-Conwy, P. 1995. Making first farmers younger: The West European evidence. *Current Anthropology* 36:346–353.

Ruoff, U. 1976. Eight years of diver excavation in Switzerland. *Underwater 75. Proceedings of the Fourth World Congress of Underwater Activities*: 149–154. Stockholm: Almquist & Wiksell International.

Ruppé, C. and J. Barstad. 2002. *International Handbook of Underwater Archaeology*. New York: Kluwer Academic / Plenum.

Ruppe, R. J. 1980. The archaeology of drowned terrestrial sites: A preliminary report. In *Coes Landing, Jackson County, Florida: A Fort Walton Campsite on the Apalachi-Cola River* (Bulletin No. 6.; D. S. Brose, ed.):35–45. Tallahassee, FL: Bureau of Historic Sites and Properties.

Ruppe, R. J. 1988. The location and assessment of underwater archaeological sites. In *Wet site archaeology* (B. A. Purdy, ed.):55–68. Telford, PA: Telford Press.

Saville, A. 2004. Introducing Mesolithic Scotland: The background to a developing field of study. In *Mesolithic Scotland and its Neighbours* (A. Saville, ed.):3–24. Edinburgh: Society of Antiquaries of Scotland.

Schlichtherle, H. and B. Wahlster. 1986. *Archäologie in Seen und Mooren. Den Pfahlbauten auf der Spur*. Stuttgart: Theiss.

Shackleton, J. C., T. H. van Andel, and C. Runnels. 1984. Coastal paleogeography of the central and western Mediterranean during the last 125,000 years and its archaeological implications. *Journal of Field Archaeology* 11: 307–314.

Shennan, I. and B. Horton. 2002. Holocene land-and-sea-level changes in Great Britain. *Journal of Quaternary Science* 17:501–526.

Skaarup, J. 1983. Submarine stenalderbopladser I Det sydfynske øhav [Submarine Stone-Age Settlement Sites in the South Funen Archipelago]. *Antikvariske Studier* 6:137–162.

Skaarup, J. 1995. Hunting the hunters and fishers of the Mesolithic—Twenty years of research on the sea floor south of Funen, Denmark. In *Man and sea in the Mesolithic* (A. Fischer, ed.):397–402. Oxford: Oxbow.

St. John Wilkes, B. 1971. *Nautical Archaeology, A Handbook*. Newton Abbot, UK: David and Charles Publishers. Ltd.

Sørensen, S. 1996. *Kongemosekulturen i Sydskandinavien*. Færgegården: Egnsmuseet.

Werz, B. E. J. S., and N. C. Flemming. 2001. Discovery in Table Bay of the oldest hand axes yet found underwater demonstrates preservation of hominid artefacts on the continental shelf. *South African Journal of Science* 97:183–185.

Westley, K. and J. Dix. 2006. Coastal environments and their role in prehistoric migrations. *Journal of Maritime Archaeology* 1:9–28.

van Andel, T. *H.* 1989. Late Quaternary sea-level changes and archaeology. *H.* 63:733–745.

van Andel, T. *H.* 1990. Addendum to 'Late Quaternary sea-level changes and archaeology'. *H.* 64:151–152.

Volpe, G. 1999. *Archeologia Subacquea. Come Opera L'archeologo Sott'Acqua Storie Dalle Acque*. Siena: Siena University.

Zvelebil, M., ed. 1998. *Harvesting the Sea, Farming the Forest: The Emergence of Neolithic Societies in the Baltic Region*. Sheffield: Sheffield Academic Press.

Journal of Island & Coastal Archaeology, 5:271–273, 2010

ISSN: 1556-4894 print / 1556-1828 online
DOI: 10.1080/15564894.2010.506624

FORUM COMMENTS

The Danish Model Gets Us Going: Comment On Jonathan Benjamin's 'Submerged Prehistoric Landscapes and Underwater Site Discovery: Reevaluating the 'Danish Model' for International Practice'

Michael Faught
Panamerican Consultants, Inc.; and Archaeological Research Cooperative (ARCOOP.org), Tallahassee, Florida, USA

Having initiated graduate research specific to submerged prehistoric sites in Florida way back in 1986, teaching the subject later at university (for both graduate and undergraduate students), and now being a private sector consultant with projects specific to the topic, I can say I was enthused to read, and feel privileged to comment on Benjamin's (2010) well rounded article. It is a great example that submerged prehistoric archaeology's time has come to Europe, if not the Americas. Benjamin's review and commentary provides a useful list of projects, researchers, principles, and potentials that serve students and scholars interested in the subject, or in need of its methods and theories, or both.

One thing that shows from Benjamin's compilation of projects, and from my own experiences, is that the submerged prehistoric sites that are known so far, and those with most potential in the future, are mostly middle Holocene in age. These kinds of sites are found in paleolandscape settings that

Address correspondence to Michael Faught, 703 Truett Drive, Tallahassee, FL 32303, USA. E-mail: mfaught@comcast.net

are exposed and shallow buried, and, of course, in lower energy marine settings—as with the Danish Model. These sites can be located by bathymetric analysis, evaluated by terrestrial analog modeling, and tested with SCUBA divers hand fanning, or perhaps small dredge excavating (see also Gusick and Faught n.d.). I use the phrase "terrestrial analog modeling" in my work, and I include it here to mean the evaluation of local prehistory, local geology, and local apparent sea-level transgression conducted in order to identify likely-to-produce archaeological remains familiar to that particular region.

This aspect of how one goes about doing prehistoric archaeology underwater is very different from shipwreck archaeology, by the way, where targets are perceivable with magnetometers and on or just in marine sediments, and specialists can work in any setting without necessarily knowing the local geology or prehistory. The complexities and difficulties of modeling, remote sensing, and testing for submerged prehistoric sites may be offset by the probability that prehistoric sites are more frequent over large areas of submerged bottom than shipwrecks—and some sites might be large and therefore more likely to be encountered.

Another comment I would like to make, and emphasize, is that remote sensing devices like the subbottom profiler, side scan sonar, multibeam sonar, and fathometer, are critical tools to map large areas, reconstruct paleolandscape settings, and identify high probability locales for sites. These are the tools I use as a consultant that allow me to identify situations conducive to archaeological site location, and these are the tools that researchers are going to need to advance the discipline.

In North America there is a growing list of projects that I would like to add to Benjamin's that reconstruct paleolandscapes specifically to find prehistoric sites, and these have been enabled by MMS and NOAA funding. Some projects have been initiated because of theoretical questions that need answers (Adovasio and Hemmings 2009; Gusick and Davis 2007; Josenhans et al. 1997), and perhaps most importantly, projects benefit by advances in marine technology that allow for the digital reconstruction of paleolandscapes (Claesson et al. 2010; Coleman and McBride 2008). On the other hand there are fewer examples of testing or excavating sites (although see Evans 2010; Faught 2002–2004, 2004; Pearson et al. 1989); also, cooperation between industry and researchers, as is more apparently true for Europe than America (Faught and Flemming 2008).

As technology advances I will bet that ROV and AUV technologies with various manipulators will approach those depths that are problematic with SCUBA. Other looming issues are those buried and sometimes truncated situations where paleolandscape reconstruction is more complex and sampling will necessarily be large-scale sediment exploration. Major portions of the eastern coast of North America come to mind as just this problem, interfering with evidence of Clovis origins (Faught 2008).

Hopefully, Benjamin's contribution will nudge more American archaeologists to become interested in the offshore because coastal states need to know how much prehistoric record is offshore, and critical research questions of process and cultural history linger.

REFERENCES

Adovasio, J. M. and A. Hemmings. 2009. *Inner Continental Shelf archaeology in the northeast Gulf of Mexico*. Paper presented at the 74th Annual Meeting of the Society for American Archaeology, Atlanta, Georgia.

Claesson, S., J. Kelley, and D. F. Belknap. 2010. *Preservation potential of submerged Prehistoric archaeological landscapes on the Maine Shelf*. Paper Presented at the 43rd Annual Conference on Historical and Underwater Archaeology, Amelia Island.

Coleman, D. F., and K. McBride. 2008. Underwater prehistoric archaeological potential on the Southern New England continental shelf off Block Island 200. In *Archaeological Oceanography* (R. Ballard, ed.):200–223. Princeton, NJ: Princeton University Press.

Evans, A. 2010. *Testing submerged landscapes for evidence of prehistoric archaeological sites: Preliminary results from the northwestern Gulf of Mexico*. Paper presented at the 43rd Annual Conference on Historical and Underwater Archaeology, Amelia Island.

Faught, M. 2008. Archaeological roots of human diversity in the New World: A compilation of accurate and precise radiocarbon ages from earliest sites. *American Antiquity* 73:670–669.

Faught, M. K. 2002–2004. Submerged Paleoindian and Archaic sites of the Big Bend, Florida. *Journal of Field Archaeology* 29:273–290.

Faught, M. K. 2004. The underwater archaeology of paleolandscapes, Apalachee Bay, Florida. *American Antiquity* 69:235–249.

Faught, M. K. and N. Flemming. 2008. Submerged prehistoric sites: 'Needles in haystacks' for CRMs and industry. *Sea Technology* 49(10):37–38, 40–32.

Gusick, A. E. and L. G. Davis. 2007. *Mal de mer no mas: Searching for early underwater sites in the Sea of Cortez*. Paper presented at the 72nd Annual Meeting for the Society for American Archaeology, Austin.

Gusick, A. E. and M. K. Faught. n.d. Prehistoric archaeology underwater: A nascent subdiscipline critical to understanding early coastal occupations and migration routes. In *Trekking the Shore: Changing Coastlines and the Antiquity of Coastal Settlement* (N. Bicho, J. Haws, and L. G. Davis, eds.). New York: Springer. In press.

Josenhans, H., D. Fedje, R. Pienitz, and J. Southon. 1997. Early humans and rapidly changing Holocene sea levels in the Queen Charlotte Islands-Hecate Strait, British Columbia, Canada. *Science* 277:71–74.

Pearson, C. E., R. A. Weinstein, and D. B. Kelley. 1989. Evaluation of Prehistoric site preservation on the outer Continental Shelf: The Sabine River area, offshore Texas and Louisiana. In *Underwater Archaeology: Proceedings of the Society for Historical Archaeology Conference* (J. Barton Arnold III, ed.):6–11. Baltimore, MD: Society for Historical Archaeology.

Journal of Island & Coastal Archaeology, 5:274–276, 2010

ISSN: 1556-4894 print / 1556-1828 online
DOI: 10.1080/15564894.2010.506625

Comment on Jonathan Benjamin's 'Submerged Prehistoric Landscapes and Underwater Site Discovery: Reevaluating the 'Danish Model' for International Practice'

Nic Flemming
National Oceanography Centre, Southampton, UK

Two ambitious questions are raised and partially answered in this thoughtful paper. First, is it possible to develop a generalized logical model for the search for prehistoric occupied site relicts offshore on the continental shelf by broadening the concepts from successful Danish research? Second, how do we maximize the chances of finding submerged prehistoric deposits and integrating finds into a consistent picture of the submerged occupied landscape and the adjacent land? The response to both questions confronts the problem that if too much is expected from such searches, and if too little is discovered, then the cost will deter funding and the subject may stagnate.

These are big issues, and inevitably almost every point alluded to could be investigated much more thoroughly. Within the justified and reasonable constraints of a paper of this length, and the creditable fact that so many key points are raised and discussed, this must be accepted. But we must check that no critical factors have been omitted.

I know both the author and Anders Fischer as personal friends. I hope that any comments that might seem critical are taken in good spirit as they are intended to build on the good work described here, and to advance the subject in a constructive way. I will not refer my comments textually to the original paper, since that would take up more space. I hope the contexts can be seen to be fair.

Before detailed comments I will quote two proverbs which have influenced my approach to this subject. The first is attributed to Louis Pasteur but was also used strongly by Alexander Fleming. It says simply—"Fortune favors the prepared mind". The second, which is anonymous as far as I know, is even shorter—"Hope clouds judgement."

Address correspondence to Nic Flemming, National Oceanography Centre, European Way, Southampton SO14 3Z4, UK. E-mail: n.flemming@sheetsheath.co.uk

My points follow:

1. The success of the Danish Model is so overwhelming, with thousands of submerged sites found and masses of supporting environmental data, that it is tempting to see how this experience can be exported to other seabed environments, where some, but rather few, prehistoric deposits have been located. This is feasible, but the governing factor is that the search criteria in the new locations must be recalibrated to fit at every time and space scale with the new cultural conditions and the new palaeo-oceanographic/climate conditions, and with the new taphonomic and present-day oceanographic conditions.
2. The role of chance must never be neglected, and we must not be too proud to accept this. It is strategically reasonable to construct detailed palaeo-environmental data sets describing some ancient terrestrial areas now inundated, on the assumption that one way or another sites will turn up. Fishermen, sports divers, dredgers, pipe-layers are lifting prehistoric and palaeontlogical materials all the time, and artefacts or bones have, in the past, usually been unnoticed. By preparing our minds, and liaising with offshore workers, chance discoveries become recognized, and academic groups can respond immediately, identifying finds, plotting them in known palaeo-landscape, and conducting follow-up research. This is an unpredictable process, but maximizing the benefits of chance is quite cheap.
3. The processes of primary deposition of anthropogenic materials on land, then burial on land, then the taphonomy of survival, the process of inundation, movement of seabed sediments, possible burial under marine sediments, rising sea level, possible erosion and exposure, and the forces of modern oceanographic conditions, need to be analysed in radically different environments. The circumstances in the Baltic are ideal on almost every count. Other environments are much less favorable, but in almost every case one can see a micro-niche, rock crevice, cave concretion, peat layer, or coral terrace, where something can survive.
4. Assuming a landscape approach, every anthropogenic signal, whether a burnt forest, a single stone tool, a wooden post, or a concentrated deposit of bones, shells, and charcoal in a midden, can be taken into account and plotted or archived in a routine way. There are petabytes of seabed data obtained for economic and military purposes which could be re-analysed to support prehistoric research. Finding the big sites is important, and will hit the academic headlines, but the minor finds and the background of the palaeo-terrestrial landscape put everything into context. Then when the big find comes, it is even more significant.
5. The Danish Model is based on a wetland, inundated, archipelago environment, and is constrained to roughly the last 10,000 years. In these circumstances, since no settlement could geometrically be more than a few tens of km from the shore, environmental forces influencing site location are strongly marine. Where continental shelves are much broader, and less indented, submerged sites of any age may be located many tens of km from the palaeo-shore. The ecological determinants for maximizing the presence of hominins are then similar to those on an inland site: proximity to a river or spring, shelter from rain or excessive sun, food, security from predators, etc.
6. In the present stage of the subject we hope to find archaeological deposits in deeper water than before, further offshore, and in new environmental and ecological contexts. Since there are now significant finds dating before the Last Glacial Maximum, and a few in deep water towards the edge of the continental shelf, it is reasonable, at least at the intellectual level, to consider the potential for the whole continental shelf, and for the last million years.

Concluding, Benjamin demonstrates that the Danish Model, suitably extended to make assumptions explicit, can be adapted to a wide range of environmental and ecological conditions, with the proviso that the system should include non-coastal sites, and Palaeolithic timescales. Research design must accept the role of chance, and maximize the likelihood of rapid response, detection and action. All finds or "hot-spots" need to be interpreted within the context of the now submerged terrestrial palaeo-landscape; and projects should be structured in such a way that there is a "fail-safe" default component, plus a slightly risky "hopeful" component, plus, if the project is big enough, a small "blue-skies wild guess" component. In this way, the risk of deterring funding can be reduced.

Journal of Island & Coastal Archaeology, 5:277–279, 2010

ISSN: 1556-4894 print / 1556-1828 online
DOI: 10.1080/15564894.2010.506626

A North American Perspective: Comment on Jonathan Benjamin's 'Submerged Prehistoric Landscapes and Underwater Site Discovery: Reevaluating the 'Danish Model' for International Practice'

Ben Ford[1] and Jessi Halligan[2]

[1]*Department of Anthropology, Indiana University of Pennsylvania, Indiana, Pennsylvania, USA*

[2]*Department of Anthropology, Texas A&M University, College Station, Texas, USA*

From the outset, we would like to thank Benjamin (2010) for a well-conceived and executed paper. As interest in submerged prehistoric landscapes increases, it is important to begin an international and interregional dialogue on methods and findings. Benjamin does an excellent job of describing the methods used to identify submerged landscapes in Northern Europe and provides a framework for discussing these methods in an international context. While he does reference recent North American literature, our comments are aimed at adding a southern and eastern North American perspective to the described methods in order to expand his discussion to the regions in which we work.

Benjamin clearly acknowledges that differences in environment and sea-level rise will lead to differences in methods. We feel this deserves a bit more explication. In North America, submerged shorelines can be many kilometers offshore and more than 100 m beneath the surface or less than a kilometer offshore and only a meter or two deep (Balsillie and Donoghue 2004; Erlandson and Fitzpatrick 2006; Fedje and Christensen 1999). Surely there is a continuum of time, depth, and human utilization from the modern shore out to these submerged shores. This means that "submerged" and "exposed" landscapes are representative of waterline positions at an instant in time and need to

Address correspondence to Ben Ford, Department of Anthropology, Indiana University of Pennsylvania, McElhaney Hall G-1, Indiana, PA 15701, USA. E-mail: benjamin.ford@iup.edu

be considered in their temporal context. With few exceptions, waterlines limit the extent of habitation and often have some bearing on the level of marine utilization. Given the general, although non-linear, rise of sea levels since the late Pleistocene in most of North America, the longer the remnants of a culture have been beyond the waterline, the harder they will be to access through the methods described by Benjamin (Dixon 2001; Mandryk et al. 2001). In particular, the usefulness of the ethnographic component (phase II) and near-shore survey techniques (phases III–V) require some consideration.

During periods when the shoreline was far removed from its current location, the analogy of inland groups of the same period may not be particularly informative. Nor should coastal groups from more recent time periods be used to help define the parameters for older sites without extreme caution (Cassidy et al. 2004). One of the arguments for submerged prehistoric archaeology is that it has the potential to provide new information about previously ignored or inaccessible aspects of prehistoric life. Reliance on models derived from former upland areas may lead archaeologists astray. Conversely, analogies to coastal communities of other periods may provide indications of landforms that were attractive to groups with settlement strategies and technologies not necessarily applicable in deep time. During periods of rapid sea-level rise, it is very likely that marine and coastal species behavior would differ significantly from that existing since sea-level stabilization. Benjamin addresses this issue, but we feel this point could be more explicit given the plethora of archaeological literature discussing ethnographic analogy (Mason 2000; Peregrine 1996; Simms 1992). Analogy should be approached with cautious optimism, and in deep-water areas, may be secondary to geological considerations.

Deep-water environments, where some of the earliest sites in North America are likely situated, require variations on the techniques described in phases III, IV, and V. To effectively identify these sites it is necessary to combine detailed multi-beam sonar or side-scan sonar and sub-bottom profiler mapping with sediment cores and advanced means of inspecting potential sites (submersibles, remotely operated vehicles, autonomous underwater vehicles, and/or technically trained diving archaeologists) (Ballard 2008; Faught 2004). The logistics and planning for this type of survey are far different from that described for Northern European sites. The application of advanced technology and training, however, is not limited to deep-water surveys; it also has a place in shallow-water investigations. Light detection and ranging (LIDAR) remote sensing technology, for example, has the ability to penetrate up to 25 m of water and, when combined with satellite and aerial imagery, can provide valuable information on potential site locations.

Benjamin points out that these methods are expensive and in some cases unnecessary, but sometimes it is impossible to properly investigate submerged landscapes without advanced technology, and, in others, the outlay of money for technology may pay dividends by allowing for a less time-consuming search. One means to balance the demands and costs of proper survey is to integrate Benjamin's first five phases into other forms of survey. Much of the submerged prehistoric archaeology in the United States is conducted in the context of cultural resource management (CRM), where archaeology is one part of a larger effort to construct, extract, or manage another resource (e.g., oil wells and pipelines, wind turbines, or dredge materials). In these cases, construction hazards, subsurface resources, obstructions, shipwrecks, and landscapes are all of interest, and it is possible for archaeologists to combine their efforts with other scientists (Aubry and Stright 1999). Through pre-planning and communication, archaeologists can have access to otherwise expensive data at little additional cost. These mutually beneficial partnerships are not unique to the United States and have correlates in Europe, such as the relationship between some English archaeologists and the aggregate industry.

Whether the first five phases are conducted singularly or are incorporated within multidisciplinary research, Benjamin's phases IV and V seem very likely to be intertwined in the field. Observation of survey areas is the way in which potential sites would be located and is almost certainly concurrent with GPS marking of these locations. Therefore, we would suggest a slight modification of phases IV and V, which we argue makes for a clearer division between each phase. This modification is: Phase IV—Observation of potential survey locations, physically and with sonar, marking potential site locations with GPS; Phase V—Observation of potential site locations (with divers when feasible), and site delineation and evaluation (period, depth, areal extent of deposits, etc.)

Finally, and perhaps most importantly, we would add conservation to Benjamin's final phase. One of the major benefits of submerged landscapes is that they have the potential to contain organic artifacts seldom found on land (Adovasio et al. 2001). Once exposed to air, these finds will deteriorate without proper conservation. Consequently, a conservation plan and budget should be an integral part of any investigation that intends to recover artifacts from submerged landscapes. These minor modifications will make Benjamin's well-written suggestions more applicable to the areas in which we work.

REFERENCES

Adovasio, J. M., R. L. Andrews, D. C. Hyland, and J. S. Illingworth. 2001. Perishable industries from the Windover Bog: An unexpected window into the Florida Archaic. *North American Archaeologist* 22(1):1–90.

Aubry, M. C. and M. Stright. 1999. Beneath the waters of time: Interior's submerged cultural resource programs. *CRM* 4:54–56.

Ballard, R. D., ed. 2008. *Archaeological Oceanography*. Princeton: Princeton University Press.

Balsillie, J. H. and J. F. Donoghue. 2004. *High Resolution Sea-Level History for the Gulf of Mexico Since the Last Glacial Maximum*. Florida Geological Survey. Tallahassee, FL: State of Florida, Department of Environmental Protection, Florida Geological Survey Report of Investigations 103.

Cassidy, J., L. M. Raab, and N. A. Kononenko. 2004. Boats, bones, and biface bias: The Early Holocene mariners of Eel Point, San Clemente Island, California. *American Antiquity* 69:109–130.

Dixon, E. J. 2001. Human colonization of the Americas: Timing, technology and process. *Quaternary Science Reviews* 20:277–299.

Erlandson, J. and S. M. Fitzpatrick. 2006. Oceans, islands, and coasts: Current perspectives on the role of the sea in human prehistory. *Journal of Island and Coastal Archaeology* 1:5–32.

Faught, M. 2004. Submerged Paleoindian and Archaic sites of the Big Bend, Florida. *Journal of Field Archaeology* 29:273–290.

Fedje, D. W. and T. Christensen. 1999. Modeling paleoshorelines and locating Early Holocene coastal sites in Haida Gwaii. *American Antiquity* 64:635–652.

Mandryk, C. A. S., H. Josenhans, D. W. Fedje, and R. W. Mathewes. 2001. Late Quaternary paleoenvironments of Northwestern North America: Implications for inland versus coastal migration routes. *Quaternary Science Reviews* 20:301–314.

Mason, R. J. 2000. Archaeology and native North American oral traditions. *American Antiquity* 65:239–266.

Peregrine, P. N. 1996. Ethnology versus ethnographic analogy: A common confusion in archaeological interpretation. *Cross-Cultural Research* 30:316–329.

Simms, S. R. 1992. Ethnoarchaeology: Obnoxious Spectator, Trivial Pursuit, or Keys to a Time Machine? In *Quandaries and Quests: Visions of Archaeology's Future* (L. Windsnider, ed.): 186–198. Occasional Paper 20. Carbondale, IL: Southern Illinois University Press.

Journal of Island & Coastal Archaeology, 5:280–281, 2010

ISSN: 1556-4894 print / 1556-1828 online
DOI: 10.1080/15564894.2010.506627

Comment on Jonathan Benjamin's 'Submerged Prehistoric Landscapes and Underwater Site Discovery: Re-Evaluating the 'Danish Model' for International Practice'

Alex Hale
Royal Commission on the Ancient and Historical Monuments of Scotland, Edinburgh, Scotland, UK

Benjamin's (2010) paper is clear, pertinent, and attempts admirably to expand upon a number of models of submerged archaeological landscape investigation methods which have been developed over the past thirty years and in different locations across Europe. The crux of the paper depends on whether the 'Danish' model can be applied to other parts of the world, or should practitioners in this difficult field build new models (i.e., re-invent the wheel to suit the local conditions)? Benjamin has been sensible in suggesting that it would be best to apply the best of previous models (for examples see Muckelroy 1978 and Fischer 1995) and add to them methodological solutions, such as applying an ethnographic component and undertaking a broader regional familiarization phase.

My main area of interest in this paper focuses on the specific approach taken with regard to the potential submerged prehistoric landscapes offshore from Scotland and specifically North West Scotland. One aspect I am interested in this review is why did Benjamin choose the Western Isles (as they are known administratively, rather than the Outer Hebrides) of Scotland, rather than another part of the country—perhaps this needs expanding upon?

As we know, the areas out with major crustal compression by glacial ice (and hence less affected by eustatic rebound, although certainly affected by isostasy), are those areas around the Northern Isles (Orkney and Shetland archipelagos) and the Western Isles. Therefore, the potential for submerged archaeological landscapes lie in all the areas out with crustal compression and ice coverage, which could include other areas of the northern North Sea, for example offshore in the Pentland Firth and Scotland's northern

Address correspondence to Alex Hale, Royal Commission on the Ancient and Historical Monuments of Scotland, John Sinclair House, 16 Bernard Terrace, Edinburgh EH8 9NX, Scotland, UK. E-mail: Alex.Hale@rcahms.gov.uk

mainland coast from Gairloch in the west, around the Sutherland coast to Caithness, in the north and as far south as Helmsdale on the east coast.

Benjamin focuses on the Western Isles, and specifically on the east coast of the island archipelago. These locations, contra to his assertion regarding low energy environments, are subject to storm events, a tidal range of 3.5 m and maximum tidal streams of up to 1 ms-1 (UKDMAP, 1998). Hansom states 'along the east coast of the Western Isles, the irregular coastline produces a highly variable wave climate. Offshore of Lochmaddy (on the east coast of North Uist), the outer coast of the Minch experiences moderate wave energies, particularly from the south and north-east, between Weaver's Point and Leac Na Hoe where the 20 m depth contour comes within 300 m of the shore. The inner parts of the shoreline are very sheltered and are subject only to small locally produced waves' (May and Hansom, 2003).

The other aspect of research that Benjamin, rightly, includes is sea-level reconstruction. Sea-level data for the Western Isles of Scotland has advanced since Shennan and Horton (2002) and Benjamin should reference one of the latest contributions that define the various proposed sea-level curves, and hence could be used in his identification of areas and specific tide levels with radiocarbon dated locations. This does not detract from his choice of location, and would rather give it additional support. One particular paper entitled '*Holocene Relative Sea-Level Changes in Harris, Outer Hebrides, Scotland, UK*' (Jordan et al. 2010) lends weight to Benjamin's approach. The Jordan et al. (2010) paper is based on primary field evidence and develops a sea-level curve for two locations on the west coast of the island of Harris. The sea-level curve proposed shows that for the period that Benjamin is concerned with (8000–6000 BP), sea-level points at ca. 8000 BP were between −1.5 m and −5.5 m below MHWS Stornoway, Lewis, and by 6,000 BP were between −2 m and −4 m below MHWS Stornoway. This re-calibration of the sea-level curve could enable Benjamin to reassess his assertion that sites around 8000 BP would be below 5m msl. In addition, it would then allow him to model the locations of offshore locations that would have been exposed land surfaces dependent on these new sea levels.

To conclude, I enjoyed Benjamin's paper and the overall assessment of the 'Danish' model, with his approach to developing it for further research is estimable. Benjamin has a valid case for his choice of location in North West Scotland; however, his demonstration as to how he arrived at the location could be expanded upon, which would strengthen his choice of pilot areas for testing his developed model. Once tested, the model could be reviewed in order that the question as to whether re-inventing the wheel for each specific location is necessary, in the furtherance of submerged prehistoric research across Europe and beyond.

REFERENCES

Fischer, A. (ed.). 1995. *Man and Sea in the Mesolithic*. Oxford: Oxbow.

Jordan, J., D. Smith, S. Dawson, and A. Dawson. 2010. Holocene relative sea-level changes in Harris, Outer Hebrides, Scotland, UK. *Journal of Quaternary Science* 25:115–134.

May, V. J., and J. D. Hansom. 2003. *Coastal Geomorphology of Great Britain*. Peterborough, UK: Geological Conservation Review Series, No. 28, Joint Nature Conservation Committee.

Muckleroy, K. 1978. *Maritime Archaeology*. Cambridge, UK: Cambridge University Press.

Shennan, I. and B. Horton. 2002. Holocene land- and sea level changes in Great Britain. *Journal of Quaternary Science* 17:511–526.

UKDMAP. 1998. *United Kingdom Digital Marine Atlas*, 3rd ed. Liverpool, UK: British Oceanographic Data Centre, Proudman Oceanographic Laboratory.

Journal of Island & Coastal Archaeology, 5:282–284, 2010

ISSN: 1556-4894 print / 1556-1828 online
DOI: 10.1080/15564894.2010.506628

Comment on Jonathan Benjamin's 'Submerged Prehistoric Landscapes and Underwater Site Discovery: Reevaluating the 'Danish Model' for International Practice'

Patricia Masters
Scripps Institution of Oceanography, University of California at San Diego, San Diego, California, USA

Jonathan Benjamin (2010) offers a well-reasoned and tested procedure to maximize the discovery of prehistoric underwater sites, building on the work of Fischer along the coast of Denmark, and then extends the focus to the northeast Adriatic and the lee of the Outer Hebrides off northwest Scotland.

In addition to the regions discussed by Benjamin, additional marginal sea coasts that lie in temperate and subtropical zones with limited fetch and resultant low wave energy are attractive areas for prehistoric site exploration. These include the Gulf of Mexico, Black Sea, Mediterranean, and the seas bordering southeast Asia and China. All of these areas provide opportunities to apply the approach proposed by Benjamin, and some already have confirmed sites.

For a truly international "systematic search strategy," however, other types of coasts—see Inman (2005) for a classification of the world's coasts—must be considered. Each has its own potential for underwater archaeology, and I would like to expand Benjamin's discussion to include the coast of Southern California.

Having relatively few rivers, inlets, estuaries, and nearshore islands, but significantly higher wave energy (Inman 2005:597), the west coasts of the Americas would appear to be unpromising regions for preservation of underwater sites. Yet high-energy collision coasts such as the Pacific margins of the Americas do have potential for the discovery of submerged prehistoric sites, particularly where topographic features can shelter sites from wave energy.

Among the forty underwater prehistoric sites recorded along the San Diego County coast, three appear to be drowned terrestrial sites. One lies at the head of the La Jolla Submarine Canyon upon layers of estuarine clay and peat. Another is a stream-side midden that is now partially submerged within San Diego

Address correspondence to Patricia Masters, Inman and Masters Consultants, 2604 Ellentown Road, La Jolla, CA 92037, USA. E-mail: pmaster1@san.rr.com

Bay. The third consists of a cluster of artifacts found in a pocket of a rocky reef off northern San Diego County.

Submarine canyons along collision coasts should be of special interest to underwater archaeologists. At lower sea level, the canyon heads were inlets or estuaries that would have attracted prehistoric settlement. Because deep water close to shore reduces wave heights, the canyons aided in launching small watercraft during prehistoric occupation. Ready access to deep water near shore allowed fishing for midwater species without the risks of open ocean conditions. Lower waves also contributed to site preservation during transgression. In consequence, a number of factors favor the heads of submarine canyons for location and preservation of underwater sites.

Other submarine canyons in the Southern California Bight have underwater site potential, as do drowned stream valleys. Of particular interest, given the late Pleistocene/early Holocene dates at Daisy Cave on San Miguel Island (Erlandson et al. 1996), is Santa Cruz Submarine Canyon that cuts into the sill between Santa Rosa and Santa Cruz Islands.

Returning to Benjamin's recommendations, the value of local ethnographic and historical records on fishing localities for predicting sites is corroborated here on the Southern California coast, at least for the past 4000–5000 years. Other than the three drowned sites mentioned above, the remainder of the mapped underwater artifact sites off the San Diego coast are thought to represent fishing gear lost from watercraft during and after the middle Holocene (Masters 1983). The artifacts coincide with fishing localities in kelp beds and shallow rocky reefs that are still actively used by sport fishers today. Furthermore, the presence of similar types of ground stone artifacts on and just offshore the California Islands supports the interpretation of their use in fishing activities (Masters and Schneider 2000). Although the function of these artifacts is not known to Native Americans living in the San Diego region today, the underwater distribution of the artifacts provides insight on the early fishing technology.

Marine mammal hunting is another practice not documented in the ethnographic record. Stable isotope analyses on 6,000–9,000-year-old cemetery remains (Schoeninger et al. 2009) indicate a reliance on marine mammal hunting that is not represented in the terrestrial-based diet, folk history, or material culture of the people living here at the time of European contact. Migrations, resource depletion, and environmental change can alter earlier coastal hunting and fishing strategies, which then must be rediscovered through archaeological research.

As a final note, Benjamin briefly mentions the "heritage management issue". Here in Southern California, the typical location of underwater artifacts—exposed on the sea floor in kelp beds and shallow rocky reefs—leaves them vulnerable to collecting by sport divers. Too many of these artifacts have disappeared during the last fifty years following the introduction of scuba gear. Such losses emphasize the need for professional underwater archaeologists to record and report sea floor sites and educate others in the diving community.

Due to its risks and costs, there must be a compelling reason to undertake underwater archaeological projects. Preserving a previously unrecognized cultural heritage may be another such reason. Thanks to the interest of new generations of underwater archaeologists and efforts such as Benjamin's paper, important research and discovery of submerged prehistoric sites will continue.

REFERENCES

Erlandson, J. M., D. J. Kennett, B. L. Ingram, D. A. Guthrie, D. P. Morris, M. A. Tveskov, G. J. West, and P. L. Walker. 1996. An archaeological and paleontological chronology for Daisy Cave (CA-SMI-261), San Miguel Island, California. *Radiocarbon* 38:355–373.

Inman, D. L. 2005. Littoral cells. In *Encyclopedia of Coastal Science* (M. Schwartz, ed.):594–599. Dordrecht, Netherlands: Springer.

Masters, P. 1983. Detection and assessment of prehistoric artifact sites off the coast of southern California. In *Quaternary Coastlines and Marine Archaeology* (P. Masters and N. C. Flemming, eds.):189–213. London: Academic Press.

Masters, P. M., and J. S. Schneider. 2000. Cobble mortars/bowls: Evidence of prehistoric fisheries in the Southern California Bight. In *Proceedings of the Fifth Channel Islands Symposium* (D. R. Browne, K. L. Mitchell and H. W. Chaney, eds.):573–579. Camarillo, CA: Minerals Management Service, U.S. Department of the Interior.

Schoeninger, M. J., P. Masters, C. M. Kellner, J. Bada, J. Peck, and A. Crittenden. 2009. Subsistence strategies of the early inhabitants of southernmost California. In *Abstracts of the 78th Annual Meeting, American Association of Physical Anthropologists, Chicago* (L. Madrigal, ed.). Lawrence, KS: American Association of Physical Anthropologists.

Journal of Island & Coastal Archaeology, 5:285–287, 2010

ISSN: 1556-4894 print / 1556-1828 online
DOI: 10.1080/15564894.2010.506629

Comments on Submerged Prehistoric Site Discovery: A Response

Jonathan Benjamin
School of History, Classics & Archaeology, University of Edinburgh, Edinburgh, Scotland, UK

Many thanks to Scott Fitzpatrick and Jon Erlandson for inviting me to take part in the *JICA* forum. I would like to acknowledge all of the respondents who have contributed their expertise to this conversation, in which I am grateful to participate. I particularly appreciate the involvement of Patricia Masters and Nic Flemming, whose edited volume *Quaternary Coastlines and Marine Archaeology* (1983) has inspired so many students and researchers' work, including my own.

The ideas presented in this manuscript were intended to provide a basis for identifying variables and evaluating coastal regions for potential prehistoric underwater archaeological site discovery. Within the confines of a short response, I would like to reply to the commentaries provided and touch on a few points I believe merit reinforcement and inclusion. Before I respond to each individual commentary, there is one point to be made from the onset: *awareness is critical*. From the archaeological community to the public, knowledge of the global phenomena of submerged landscapes is extremely important. Within the greater marine and maritime archaeology community, prehistory has just begun to be prioritized. Increasingly, attention will be paid to site indicators, such as worked lithics on or from the seabed (possibly found near wrecks, or washed up on shore). It is our responsibility to ask the right questions, educate the public, and protect a cultural heritage currently threatened with destruction.

Masters (2010) emphasized a need to further define and evaluate different physical shorelines. This is absolutely true and should be a part of looking deeper into any given region or local area. It is a positive sign that Masters finds that (at least aspects of) the Danish model is applicable in California. Indeed the Pacific Coast of North America provides its own set of challenges, especially given its often high-energy coastal environments. However, as Masters (2010) points out, there has been success in California, and further investigations, particularly in sheltered environments, and known areas of wetland occupation (e.g., Dietz et al. 1988; Jones and Jones 1992) may provide clues or locations for future research in intertidal and submerged environments. Areas that are currently eroding and have not been completely destroyed by modern development must also be identified and prioritized (see Erlandson and Moss 1999).

Flemming (2010) has rightly highlighted the enormity of the task of modern archaeologists in researching and managing the

Address correspondence to Jonathan Benjamin, School of History, Classics & Archaeology, University of Edinburgh, Doorway 4, Teviot Place, Edinburgh EH8 9AG, Scotland, UK. E-mail: jonathan.benjamin@ed.ac.uk

submerged paleolandscapes on the continental shelf. He also points out the very practical matters at hand, particularly regarding funding, awareness, and legislation. I take Nic Flemming's concerns to heart: optimism alone is not enough. That said, I think we would both agree that we should retain a healthy balance of both optimism *and* realism. On this note, I would like to raise a point regarding a desire to go deeper and look for earlier sites and landscapes: while technology has enabled SCUBA diving to investigate early prehistoric sites underwater, this investigation is limited to relatively shallow waters. Diving to 100 m is not yet possible for archaeological fieldwork, and deeper investigations require submersibles, ROVs, or other remote sensing. However, there is currently an abundance of undiscovered and potentially important shallow (<20 m) areas of the continental shelf that could answer critical questions relating to early human prehistory. This is a subject that deserves greater discussion and debate, but there are topics (e.g., within Mesolithic and Neolithic studies) that would benefit greatly from the funding of realistic projects in waters that are relatively accessible and cost-effective for research by underwater archaeologists. In my opinion we must not spread ourselves too thin if the field is to have a lasting impact within prehistoric studies.

Ford and Halligan (2010) made several excellent points in their response. I appreciate the addition of their suggested modification of the final phases of the program I have laid out: the inclusion of conservation. This topic is incredibly important and worthy of its own dedicated discussion. I will however, reiterate my intention that management was not my original theme for a manuscript that focused on discovery and identification of variables for archaeological evaluation. I will also add that the use of new technologies such as LIDAR, as Ford and Halligan have pointed out, are being discussed within the archaeological community for the study of submerged prehistoric landscapes; this point was brought up in a discussion at the 2009 Aerial Archaeology Research Group Meeting. As technology increases and the field expands, more data will emerge, designed specifically for the identification of new locations and archaeological discovery.

Faught (2010) described "terrestrial analog modeling" which he has used in his own work, and it seems that among underwater archaeologists, comparable methods have been developed, sometimes independent of one another. Now this is likely to change, given the international interest and discussion of this topic. There will be more opportunities for researchers to come together, share methods, publish results, and discuss management strategies for submerged prehistory. Faught comments on the differences between this subfield and shipwreck archaeology—an important point that is rightly emphasized. He also adds that his own work has involved remote sensing devices. I believe that more information available about a submerged landscape is always positive, and any data provided by remote sensing methods will contribute to survey modeling. There will always remain a compromise, however, in the effective use of time, budget, and available equipment. In certain cases, the archaeological evaluation is impossible without such technology described by Faught, while other environments and situations may allow for successful survey based on information from commercially available charts and local knowledge.

Hale (2010) requested the expansion of my example from northwestern Scotland. My chosen example of the Western Isles was based primarily on the isostatic situation, which is limited in the Outer Hebrides, as compared with mainland Scotland. Although the minch (the strait between mainland Scotland and the Western Isles) may contain high-energy coastlines along the eastern shores of the Western Isles, there also exist inlets, bays, coves, and other sheltered features that could lead to the type of preservation conditions conducive to intertidal and submerged site protection. Nevertheless, sites that are not threatened by erosion (or other forms of destruction) are probably not to be considered a high priority apart from their potential contribution to specific scientific research questions. Second, Hale reminds us of the importance of regionally specific and updated information on relative sea-level changes. The example cited (Jordan et al. 2010) was published after this manuscript was originally submitted to *JICA* (in May of 2009), but Hale's point remains: data will continue to surface and become available to archaeologists interested in submerged environments and we benefit from research by earth scientists related to coastal change and sea-level rise.

I conclude by adding that I have had the good fortune of being able to write part of this response while on board the Danish vessel *Mjølner* (property of the Langelands Museum) for a training mission as part of the SPLASHCOS project (funded by the European Cooperation in Science and Technology [COST] and held by Prof. Geoff Bailey of the University of York). The training mission allowed a group of international researchers to come together, share ideas, and learn some of the basic methods used in the Danish Baltic. We were able to survey under conditions of the model that inspired this paper, and with positive results; local knowledge and the topographical model both played a part in the survey's success. It is no surprise that the 'Danish Model' works in Denmark, but the importance of input from the local community and public awareness cannot be underestimated.

ACKNOWLEDGEMENTS

I wish to thank Otto Uldum and the crew of the Mjølner from the Langelands museum, as well as Ehud Galili and Kieran Westley for their spirited conversation and sharing of ideas during the SPLASHCOS training mission in Denmark. For more information on the Langelands Museum see: http://www.langelandsmuseum.dk/. Thanks to the European COST for its support; for more information about the SPLASHCOS project, see: http://php.york.ac.uk/projects/splashcos/

REFERENCES

Dietz, S., W. Hildebrandt, and T. Jones. 1988. *Archaeological Investigations at Elkhorn Slough: CA-MNT-229, A Middle Period Site on the California Coast*. Berkeley: Papers in Northern California Anthropology 3.

Erlandson, J. M., and M. L. Moss. 1999. The systematic use of radiocarbon dating in archaeological surveys in coastal and other erosional environments. *American Antiquity* 64:431–443.

Faught, M. 2010. The Danish model gets us going: Comment on Jonathan Benjamin's 'Submerged prehistoric landscapes and underwater site discovery: Reevaluating the 'Danish model' for international practice'. *Journal of Island and Coastal Archaeology* 5(2):271–273.

Flemming, N. 2010. Comment on Jonathan Benjamin's 'Submerged prehistoric landscapes and underwater site discovery: Reevaluating the 'Danish model' for international practice'. *Journal of Island and Coastal Archaeology* 5:274–276.

Ford, B., and J. Halligan. 2010. A North American perspective: Comment on Jonathan Benjamin's 'Submerged prehistoric landscapes and underwater site discovery: reevaluating the 'Danish model' for international practice'. *Journal of Island and Coastal Archaeology* 5:277–279.

Hale, A. 2010. Comment on Jonathan Benjamin's 'Submerged prehistoric landscapes and underwater site discovery: Reevaluating the 'Danish model' for international practice'. *Journal of Island and Coastal Archaeology* 5:280–281.

Jones, T. and D. Jones. 1992. Elkhorn Slough revisited: Reassessing the chronology of CA-MNT-229. *Journal of California and Great Basin Anthropology* 14:159–179.

Jordan, J., D. Smith, S. Dawson, and A. Dawson. 2010. Holocene relative sea-level changes in Harris, Outer Hebrides, Scotland, UK. *Journal of Quaternary Science* 25:115–134.

Masters, P. 2010. Comment on Jonathan Benjamin's 'Submerged prehistoric landscapes and underwater site discovery: Reevaluating the 'Danish model' for international practice'. *Journal of Island and Coastal Archaeology* 5:282–284.

Masters, P., and N. C. Flerning (eds.). 1983. *Quaternary Coastlines and Marine Archaeology*. London: Academic Press.