Chapter 6

6 Implications for Archaeological Resource Evaluation

6.1 INTRODUCTION

The primary objective of this study has been to reconstruct the regional-scale morphology and internal sedimentary architecture of the offshore extension of the Arun River, offshore Sussex. We have focussed our efforts on geophysical and geological data collection and assimilation. This is a necessary requirement when investigating a new study area in the marine realm where the palaeogeomorphology and environmental history are poorly constrained. Chapters 3 to 5 have presented the results of the three main strands of research that we have undertaken. In addition Chapter 5 has presented a preliminary model of valley evolution that requires further testing. Nevertheless, our approach provides a firm data-led foundation for the development of mature, archaeologically focussed landscape evolution models. Moreover, we have made efforts in the preparation of this report to ensure that the details of the planning, execution and interpretation steps involved in our study have been as fully detailed as possible. We anticipate that this report will provide English Heritage with clear protocols on the methods and approach involved in future assessments of shelf palaeovalley systems and their enclosed prehistoric archaeology. One clear example of this is provided in Chapter 2, where we present our data management approach and execution. Given the large and varied datasets we have assimilated during the course of the project, construction of a sound data management strategy has been crucial to project development and success.

6.2 IDENTIFYING POTENTIAL SITES FOR DISCOVERING ARCHAEOLOGICAL RESOURCES

6.2.1 Locales associated with lithic resources

A secondary objective of our study has been to make provisional assessments of what geomorphic and sedimentary elements identified in our reconstruction of the palaeo-Arun might hold potential for containing prehistoric archaeological resources. We have not attempted to directly locate any archaeological resources. We stress that our evaluations are only for broad guidance. We cannot
predict with any degree of accuracy the actual presence and distribution of preserved archaeological sites, as our analysis is largely based on remote sensing data, and assumptions of prehistoric adaptive patterns. Clearly the only way to develop a more robust predictive capability is through careful groundtruthing as is the case for all remote sensed studies.

In the section below we present a synthesis of locations within our study area, that based on our reconstructions of seabed morphology and valley-fill stratigraphy, permit us to make predictions with regard to the potential for archaeological resources at that locale. Our interpretations are primarily based on reconstruction of the geological and topographic setting based on remote sensing data (swath bathymetry and sub-bottom profiling data). In general, in making predictions of the presence and distribution of archaeological site potential, reference should always be made to using onshore analogues (Pearson et al., 1986). This latter study used terrestrial models of riverine site location to develop a more precise understanding of high site probability areas. In particular, they focussed on identifying: (1) environments conducive to site establishment, and (2) the positions of sites relative to the landforms upon which they occur. Typically sites are found near lithic sources, near fluvial or lacustrine settings, and at the mouths of rivers in estuarine conditions. A number of authors have pointed out that “these features can be located underwater by delineating past drainage patterns of submerged river systems,…by finding chert rock outcrops, and by determining the locations of past sea-level stillstands and strandlines” (Faught and Donoghue, 1997).

Pearson et al. (1986) made the strong case that “within floodplain and coastal settings….there are certain physical constraints in the environment of sufficient importance to impart similarities in the process of settlement selection through all the prehistoric period”. We concur with this statement, and in the absence of more detailed information, we suggest that such analogues can provide useful guidance in site locale prediction. Pearson et al. (1986) further note “that this does not mean that site size or function or settlement densities were similar over time, simply that suitable places for settlement were restricted numerically and spatially such that similar locales were selected over a long period of time”.

Unfortunately, in the case of the palaeo-Arun river, we have little information on potential locales for site discovery based on the onshore record. This is primarily due to the lack of primary onshore ‘in situ’ archaeological sites; Boxgrove being a rare exception. The bulk of artefacts have been derived from gravely river terraces, and are generally considered to have been transported from the site of deposition, and thus form secondary context material (Hosfield, 2001). However, the term terrace does not represent a fluvial depositional environment, but a geomorphic feature developed due to subsequent river incision through older deposits. Thus whilst artefacts are commonly given a terrace source designation, it is generally unclear what type of fluvial facies and hence precise depositional environment they are derived from. This is partly because many of the collections were made many
years ago, prior to the development of sedimentological facies analysis methods. Moreover, the poor quality of onshore exposures, typically isolated quarry faces, means that it is difficult to reconstruct the three-dimensional geometry of the sedimentary bodies that enclose archaeological remains. In fact, working in the offshore environment, places no constraints on profile location and within the resolution of the geophysics technique used a 3D data volume is obtainable. Systematic data indicating precise geomorphic and sedimentary niches for artefact distribution are urgently needed to further develop predictive models of site distribution. An inventory of such data would be of considerable help in identifying sedimentary units with archaeological potential in the shallow offshore. Below we cite several examples where such data are available. Our predictions of zones with potential for discovery of archaeological resources should be treated as generalisations. It is based on general information from onshore or offshore site contexts. We have also taken the approach that in topographically constrained areas such as river valleys, there is a finite number of locales available for habitation. This broad general approach is necessary when conducting first order regional evaluation of offshore areas for assessment of archaeological resource potential.

The influence of the availability of raw materials for lithic technology is central to determining critical to findspot locations. This can include primary raw flint from Chalk bedrock or secondary raw flint from flint clasts in river gravels. The abundance of findspots can be clearly related to the presence of flint-rich landscapes. Maps showing the distribution of Lower and Middle Palaeolithic findspots clearly illustrates the abundance of findspots located on the Upper Chalk outcrop, which is where the bulk of flint is derived from (Roe, 1964). The important middle Pleistocene Palaeolithic site at Purfleet in Kent is associated with fluviatile sediments that were deposited near a river banked up against the eroded flank of Chalk ridge formed by the Purfleet anticline (Schreve et al. 2002). The proximity of the Chalk for mining flints is clearly an important locational factor. Similarly Hosfield (2001) has shown that the findspots of Dunbridge, Wood Green and Corfe Mullen (all producing at least 100 handaxes) are located immediately downstream of the transition from Chalk to Tertiary bedrock (Figure 6.1). This transition in bedrock geology between Chalk and Tertiary sediments appears to be an important factor in site location. This may partially represent a topographic control in that the rivers would have formed narrow valleys through the Chalk and then broadened as they entered the Tertiary syncline, where erosion of the softer Tertiary sandstones and shales will have cut broader valleys. A similar geological setting is present in our study area in the northern section of the palaeo-Arun valley.
Figure 6.1 Location of pre-Quaternary geology of southern England showing location of handaxe sites (Hosfield, 2001).
6.2.2 Potential site area in vicinity of Chalk bedrock in upper section of palaeo-Arun

In the northern part of the study area, the course of the palaeo-Arun downstream of its river mouth is incised into Upper Chalk bedrock, and then breaks through a prominent ridgeline to emerge in an area underlain by London Clay Formation (Figure 6.2 and 6.3). The incision of the valley into Upper Chalk, provides an excellent source of lithic material for producing flints. We propose that the sedimentary deposits within the Arun valley where it traverses the Chalk, and by analogy with sites at Wood Green and Dunbridge have a high potential to contain prehistoric artefacts that have not travelled considerable distances, and thus show some relationship with their original landscape of production.

6.2.3 Locales associated with potential for rock shelter sites

6.2.3.1 Tributary valleys

Our multibeam mapping of the western margin of the palaeo-Arun (Section 3.2.1.3, Chapter 3) reveals the presence of small tributary valleys incised into the margin of the cuesta (see Figures 3.80-3.87). We believe that these small, branching drainages would have provided locales for rock shelter habitations. The bedrock lithology is a hard calcareous sandstone. Sandstone rock shelters are common sites of Mesolithic occupation in the Weald, where they occur associated with the Greensand Group (Simon Parfitt, pers. comm.). Palaeolithic rock shelter sites in such materials are also reported. The calcareous sandstones on the western margin of the Arun may have similarly afforded an ideal opportunity for shelter in the valley. We interpret the origin of these valleys to spring sapping driven erosion following fluvial incision of the main valley. As a result, there may have been springs present at the mouth of the valleys that would provide useful water resources. We suggest that further investigation of these fascinating tributary channels is warranted, by using a higher-resolution multibeam sonar to map the topography in more detail, followed by diver investigation.

6.2.3.2 Potential rock shelter sites related to block toppling

Investigation of the multibeam bathymetry in the downstream section of the Arun topographic valley reveals what appears to be evidence for block toppling or gulling of resistant sandstone layers from the crest of the scarp (Figures 3.86 and 3.89). In the Weald Basin, Mesolithic rock shelters are commonly associated with zones of block toppling or gulling as it creates a natural rock shelter. Such sites onshore have yielded significant mammalian faunal materials (Parfitt, pers. com).

6.2.3.3 Locales protected by bedrock scarps

The downstream convergence of the Arun topographic valley and the swing in strike of the prominent cuesta that defines the western margin of the valley and then makes up the ridge that the Arun finally breaches. This zone provides potential for sheltered localities with the presence of topography providing the possibility for long-distance viewing of the surrounding landscape (Figure 3.96 and 3.98). There is potential for archaeological resources to be discovered at the foot of the scarp or in
crevices and gullies that indent it. Whilst it could be argued that any archaeological material present may have been reworked by transgressive processes, we think this unlikely in these protected locations. In any case, marine erosion may actually provide the mechanism by which materials become emergent at the seabed (Scuvee and . In particular, the area around the bedrock outlet of the Arun may be an important location to investigate further. Such bedrock constrictions are commonly good habitation zones, since they afford good shelter. It would be worth exploring this area further with a high-resolution sonar survey (Reson 8125) to define the topography in more detail. Subsequently, a systematic diver exploration program may be required for ground truthing.

6.2.4 **Locales associated with fluvial morphologic features**

Fluvial geomorphic and sedimentary macroforms provide the most likely elements to contain prehistoric resources. The bulk of finds onshore have been from such sources but these largely lack stratigraphic context, which an offshore study may potentially constrain.

6.2.4.1 *Determining fluvial geomorphic features from multibeam swath bathymetry*

The presence of a well developed terrace fill on the eastern margin of the topographic valley (in the downstream segment of the stratigraphic valley has been beautifully imaged on our sonar records (Figures 3.62, 3.75-3.77). Locating the margins of palaeochannels is critical not only for determining the spatial extent of these depositional systems but also for accurately determining the location and orientation of valley margins. Such valley margins, in particular bedrock valley margins, could have been potential sites of human activity. There may be some potential for discovering in situ sites at these marginal localities though marine transgression may have reworked material. Faught and Donohue (1998) successfully reported recovering palaeo-Indian lithic artefacts from valley margins, though this was in the low-energy Gulf of Mexico environment, where there has been little erosion during marine transgression.

6.2.5 **Fluvial terraces**

The fluvial terrace fill preserved at the eastern margin of the topographic valley (Figures 3.75-3.77) forming as it does an escarpment margin topographic feature is likely to have good possibility for findspot occurrence, especially in the finer-grained overbank deposits at the margin of the gravel-rich channel. Whilst Holocene transgressive erosion may have removed the uppermost sediments in the succession, the presence of in situ peats below the transgressive erosion surface indicates that in situ floodplain/estuarine saltmarsh findspots may exist within the sediments. The stratigraphic context suggests that any sites would be post-glacial, probably Mesolithic.

6.2.6 **Fluvial confluence points**

The fluvial terrace fill preserved at the eastern margin of the topographic valley (Figures 3.75-3.77) forming as it does an escarpment margin topographic feature is likely to have good possibility for
findspot occurrence, especially in the finer-grained overbank deposits at the margin of the gravel-rich channel.

### 6.2.7 Archaeological potential of fluvial sedimentary units

Chapter 5 has analysed in some detail the sedimentary architecture of the palaeo-Arun valley infill. With some of the high quality datasets (especially the 2000 dataset) it has been possible to identify well-developed fluvial architecture.

The basal channel fill has been particularly well imaged with our own seismic data. The sub-bottom profiling has demonstrated how the detailed geometry of the basal surface can be identified and mapped (Figures 4.53 and 4.54). This is important because prehistoric artefact findspots show occurrence in basal channel deposits, for example, the Stanton Harcourt channel in Oxfordshire.

Another excellent example comes from the work of Pavlov et al. (2001), where they describe the preservation of extensive artefacts and mammalian bones from basal channel deposits in a fluvial succession from the European Arctic. In some cases it is clear that these have not been transported considerable distances since the basal channel deposits can become buried rapidly. Coring through some of these basal channel units may yield important information from for example faunal remains which can become concentrated in these units.

Figures 5.14 and 5.20 show excellent examples of fluvial macroforms preserved in the valley. Particularly well-developed are the lateral accretion units (Facies III), which are interpreted to indicate sedimentation on possible lateral bar or point bar features. The surfaces of such bars represent depositional surfaces, and thus in their upper parts may contain evidence of occupation. Figure 6.5 shows an example of one of these lateral accretion units with an indication of where a findspot might be located. The figure also illustrates the well-developed fine-grained channel-fill at the margin of the bar feature. The contact between the bar and the fine-grained fill may permit preservation of in situ archaeological sites in the subsurface.

### 6.2.8 Archaeological potential of floodplain/saltmarsh peat deposits and the estuarine transgression

Analysis of the seismic stratigraphy and vibrocore data shows numerous examples where fine-grained sediments abruptly overlie probably fluvial gravels at the base of a channel (eg., Figures 4.53 and 4.54). This contact is likely to record the estuarine transgression of the valley resulting from base-level rise. Because the estuarine transgression does not involve major erosion and largely reflects low energy passive sedimentation in the progressively drowned former river valley, this contact may have to potential to preserve in situ archaeological materials. These are important potential sites for the discovery of archaeological resources because these estuarine transgression zones within the valley are protected from the effects of shoreface erosion during marine transgression.
6.2.9 Timing of inundation of the study area and its impact on Upper Palaeolithic/Mesolithic occupation on the shelf

Our radiocarbon ages on peats recovered during vibrocoring (section 5.9) provide important constraints on the timing of marine inundation in the area. The dates indicate that the palaeo-Arun area was still subaerially exposed at least 9.8kyr and at this time the marine conditions had yet to flood this area. Given that the late glacial reoccupation of southern Britain following the Last Glacial Maximum is considered to have occurred at about 13,000kyr (Barton et al, 2003), it is clear that the study area would have available as occupation space to Upper Palaeolithic and Mesolithic people. Further vibrocoring in the study area coupled with radiocarbon dating of peats within them will permit reconstruction of the inundation history of the south coast area. This when coupled with the topography data will permit models for identifying potential late glacial – early Holocene site locales.

6.2.10 Impact of marine transgression on archaeological preservation potential

Whilst the role of marine transgressive erosion is an important factor to consider in developing models of site preservation, we have shown that there is strong preservation of landforms at the seabed and excellent preservation of fluvial depositional units within the valley fill. We have found no evidence of major transgressive erosion occurring within the Arun valley, suggesting that findspot reorganisation due to marine transgression within the valley-fill is likely to be minimal. Figure 5.22 shows the distribution of major transgressive gravel deposits in the area of the 2000 survey and shows that this is limited to the margin of the Arun palaeovalley. The stratigraphy in the main part of the valley appears to be largely preserved and has not been majorly affected by marine transgressive processes. This is because the topography within valleys permits preservation of stratigraphy below the wave-base razor during transgression. We think there is excellent opportunity for archaeologically relevant materials to survive being disorganised by transgressive erosion. Moreover, it may be that transgressive erosion where it has been important, may actually expose buried archaeological materials to the resent day seafloor, as for example in the submerged Palaeolithic site off the coast of Brittany studied by Scuvee and Verague (1987).

6.3 TECHNICAL ASSESSMENT AND RECOMMENDATIONS

The primary objective of this project was to determine the geomorphology of submerged and buried landscapes within a section of the northern English Channel shelf in order to establish its geological history and archaeological potential. Whilst historical maritime archaeology is a mature discipline, prehistoric marine archaeology in an emerging field. Therefore, one of the aims of this project was to assess the usefulness of different geophysical methods to assist in the development of protocols for assessing archaeological resource potential and implementing conservation strategies for offshore areas in the future.
Land-based geophysical surveying for archaeological prospecting is well-established, and shares many of the factors that need to be considered when conducting a survey at sea. The following points should be specifically noted for marine work:

At sea the skipper is in command of operations at all times. Communication with and the experience/competence of the skipper are therefore critical for any survey. The skipper will generally have good knowledge of local tides/currents/port practices etc and be familiar with the type of geophysical operations planned.

Marine acquisition typically takes place on all days of the week. At the weekends, there may be additional navigational hazards due to recreational boats. It is often possible to survey at night, provided there is sufficient lighting for safety and manning.

Working a sea is more tiring than working on land due to the constant movement of the boat. Seasickness is a common problem on small vessels. Scientific manning schedules should be conducted with these factors in mind.

A detailed inspection of the vessel should be made well before the start of the survey. This is essential to decide how to load the equipment (not trivial when heavy leads are involved) and set up the equipment. In particular, it is important to designate deployment (putting the equipment into the water) and tow (underway profiling) protocols.

Small vessels have widely varying infrastructure. The quality of electrical power supplies is notoriously variable of small vessels and often it is necessary to provide additional generators to provide a clean supply. Navigation and helmsman display capabilities also widely vary and directly affect the accuracy of tracks sailed etc.

Where more than one acoustic device is to be used it is important to consider the possibility of electrical cross-talk between instruments operating at similar frequencies (the ping of one sonar being picked up and recorded by the other).

Working at sea is highly-dependence on weather and accidental damage to equipment (water flooding seals, snagging of submerged objects etc) is common. Any field plan therefore needs to have flexibility, with a number of alternate plans well thought out prior to commencement.

Seawater is highly corrosive and care should be taken to protect all “non-wet” equipment (such as computers). Data should be backed up and removed from the vessel at night. Where possible a daily
programme of data verification should take place on-shore (checking the data can be read and displayed).

As is the case for all remote sensing, some sort of ground truthing is needed for a robust interpretation of the geophysical data.

Modern digital acquisition generates huge data volumes. Suitable tools for archiving, analysis and visualization are a critical component of any programme.

Prior to any survey, it is very important to do a thorough review of all available datasets (desktop study). Care should be taken when converting between different geographical referencing systems. In this project we were fortunate to make personal contacts with other organizations who greatly helped the project by releasing data to us. Based on our experience, we would recommend at least 3 months for pre-planning. Successful survey design relies on being clear about the objectives of the survey and nature of the target. For example, what is the size of features to be imaged – e.g. survey the regional context of a whole river system like here, or a more detailed survey of a potential archaeological site at the junction of a main river valley and a tributary. The only way to get the resolution/accuracy required is to choose the correct equipment and survey design.

**6.3.1 Bathymetric profiling**

One result of this study is the demonstration that the impact of sea-level transgression during the Quaternary did not obliterate landforms. Certainly there has been modification, but geographical elements such as the main valley itself, tributaries, over-deepened and breach-point at its mouth are visible with surprising clarity. The swath bathymetry surveying was central to our study – not only in conveying the potential of offshore regions to a wide audience (the articles in the Sunday Observer and on the BBC 6 o’clock news largely focused on these data because of their visual impact) – but also by our team during throughout this research project. We strongly recommend that swath bathymetry be used as a primary tool for assessment for all future targeted offshore regions. In effect this method produces an equivalent of an Ordinance Survey Map on land, and is the first step for referencing all subsequent exploration/finds etc. In addition to revealing the landscape (which in time should be possible to convert directly into an pre-historic archaeological potential probability) the data collected was extremely effective at documenting present day activity such as trawler scars and aggregate extraction. Within any specially protected area swath bathymetry would be a helpful tool in monitoring the success of any exclusion orders etc.

**6.3.1.1 Selection of sonar hardware**
Shallow water swath bathymetry systems are relatively new, yet they have already proven their great advantage over conventional single beam systems in terms of efficiency of data coverage and resolution. In this study we used a Reson 8101, this is a mid-price range (the list price in 2001 when the equipment was purchased was £230 K) high-resolution system. The technical details of this system are as follows, where it is compared with an alternate ultra-high resolution Reson 8125 system.

<table>
<thead>
<tr>
<th></th>
<th>Reson 8101</th>
<th>Reson 8125</th>
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<tbody>
<tr>
<td>Centre frequency</td>
<td>240 Hz</td>
<td>455 Hz</td>
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<tr>
<td>Maximum water depth</td>
<td>300 m</td>
<td>120 m</td>
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<tr>
<td>Angular sector</td>
<td>150°</td>
<td>120°</td>
</tr>
<tr>
<td>Swath width (x water depth)</td>
<td>7.4</td>
<td>3</td>
</tr>
<tr>
<td>Update rate</td>
<td>30 /s</td>
<td>40 /s</td>
</tr>
<tr>
<td>Soundings per swath</td>
<td>101</td>
<td>240</td>
</tr>
<tr>
<td>For-aft beam width</td>
<td>1.5°</td>
<td>1.0°</td>
</tr>
<tr>
<td>Port-stbd beam width</td>
<td>1.5°</td>
<td>0.5°</td>
</tr>
<tr>
<td>Footprint in 20 m water</td>
<td>50 – 150 cm</td>
<td>18 – 36 cm</td>
</tr>
<tr>
<td>Bottom detection method</td>
<td>Amplitude (inner)</td>
<td>Amplitude (outer)</td>
</tr>
<tr>
<td>Sonar weight (dry)</td>
<td>27 kg</td>
<td>20 kg</td>
</tr>
<tr>
<td>Dimensions</td>
<td>600 x 320 mm</td>
<td>320 x 266 mm</td>
</tr>
</tbody>
</table>

Technical issues that should be considered when selecting a bathymetric system are:

**Frequency.** Sonar resolution (horizontal and vertical) generally improves with increasing frequency (the beams formed are narrower). In addition, the frequency affects the maximum working depth of the sonar (due to acoustic attenuation in seawater), but most commercially available systems will work well within the water depth range on the UK shelf.

**Coverage.** The coverage (width of strip of data collected beneath the ship) of any sonar is determined by its angular section (a function of the physical design of the sonar head). This factor determines how many ship passes are needed to totally image a given survey area. It therefore directly leads to the cost of a survey and the logistical feasibility of undertaking a particular with a given sonar.

**Bottom detection method.** This is an important consideration as it directly affects data quality (how reliable individual depth soundings are). The Reson sonars use a combination of split beam phase and amplitude methods for detection of seabed echoes. There are a number of "interferometric" sonar
systems on the market which are generally relatively cheap to buy/hire but are widely regarded to deliver generally poorer quality data.

Footprint. The footprint directly affects the size of objects that can be detected and governs the pixel size of the final bathymetric grid. In multibeam systems the footprint is a function of the beamwidth, grazing angle and water depth (it is largest for the outer beams in deeper water).

Portability (for non-hull mounted systems). A smaller, lighter sonar head needs a less sturdy mounting pole and is easier to deploy and recover. All systems need to be matched with the practicalities on installing on a given vessel (factors such as length of cable runs from the deck to the cabin; cranes/davits for equipment loading; pole installation)

Ease of use. All systems interface with a computer that operates/synchronises the system and logs the data. Some systems are PC-based, others UNIX-based. For all systems the software requires a high level of skill to operate, and in particular to set up. Personnel must attend specific training courses offered by the manufacturer. Different systems provide different levels of real-time quality data assessment (critical for making decisions related to changing weather conditions).

Motion sensor. The accuracy of the final bathymetry grid directly correlates with the quality of the ancillary motion sensor equipment used to correct for vessel motion (pitch, heave and roll).

Co-incident backscatter. Some swath bathymetry systems offer the possibility of co-incident backscatter. This was the case for the system used here, but the results proved disappointing due to technical issues of the sonar. In the future, as high-resolution systems become more established, it is likely that such problems will be solved by the manufacturers.

In the study reported on here the Reson 8101 was ideal to meet the objective of imaging the lower (unfilled) portion of the Arun in a timely manner. An area totaling 86 km² with water depths between 20 and 40 m was covered in 13 days working 8 hours of per day (the limitation came by having only one skipper on board). The survey produced a dataset that was manageable in terms of man-power and computing resources available. The single-beam bathymetry dataset obtained from the UKHO also show interesting features in the more-nearshore part of the study area (such as old dredging scars and bedrock outcrop structures) that a case could have been made to extend the multibeam survey further north. An issue with shallow water surveying is the narrowing of the beam means that the tracks have to be placed increasingly close together, making the process less efficient. On the other hand, in the channel the sea-state is generally better closer inshore so less down-time is generally lost during surveying. An option would therefore have been not to attempt to achieve 100% coverage in the whole study area, but to have complemented the 100% coverage obtained in the deeper water lower Arun.
sector with a set of reconnaissance profiles targeted on specific features identified in existing data in the north.

The Reson 8101 was a good choice for the regional survey here. We would recommend using a higher-frequency sonar such as the Reson 8125 (see specs in table above) for future analysis of specific sites within the lower-Arun prior to diver/ROV inspection for example.

When conducting a swath bathymetry survey the first thing to decide is what type of survey required e.g. do you need 100% coverage i.e. are you producing a map or are you looking for a specific feature. Marine surveying is highly weather dependant, and so usually one needs to compromise, have alternate plans at hand. In our case we had unusually good weather and collected data in a larger geographical area than planned. When making a map-type survey it is good idea to undertake a reconnaissance of the survey area before starting the survey proper to ensure that the navigational position information etc is correct i.e. that your survey on paper is in the right place (navigational accuracy and referencing cannot be taken for granted at sea). The track spacing should have been set beforehand – a function of both the water depth and the required amount of overlap. Overlap is needed as the data quality reduces for the outer beams so tracks are generally placed closer together than the theoretical limit. This requires a trade-off between data coverage and data quality. In the dataset collected here the tracks could have been sailed a little closer to remove the small mid-swath artifact of poorer data. When undertaking a site-survey, tracks can be designed in real-time. In this case more limited post-acquisition processing is needed, particularly if individual swathes totally cover the size of the feature under investigation. In this case, non-geophysical specialists could produce images of acceptable quality on-board for use subsequent geographical referencing.

6.3.2 Sub-bottom profiling

Sub-bottom profiling is a well-established technique, and is the main survey method used by the aggregate industry. Seismic operations can be sub-divided into analogue or digital, 2-D or 3-D, single channel seismic (SCS) or multichannel seismic (MCS). The choice of seismic source (chirp, boomer, sparker, water-gun, air-gun) is critical to the vertical resolution and depth of penetration achieved. The aggregates industry currently uses analogue, 2D boomer SCS. The aims of the seismic work conducted here were (i) to extend the coverage of data outside the licensed aggregate area (particularly to link the onshore-and offshore River Arun) and (ii) complement the large body of existing data. We chose to use a boomer system operating at 0.5-3 kHz similar to that routinely used within the licensed dredging area to give an expected penetration of 50-100m with 0.5-1m vertical resolution. The system uses a conventional boomer source together with a 60m, 60-channel hydrophone streamer and a digital recording system. We conducted 2D surveys in order to achieve the regional coverage required. Lines were orientated to be parallel to the strong tidal current for optimum towing. The shot point spacing
varies according to the state of the tide (it was hard to maintain the desired vessel speed when going either with or against the strongest tides). The near-shore lines were collected at high tide. The boomer system used was surface towed and so the quality of the data collected was highly sea-state dependant. The weather during April 2003 was significantly poorer than during March 2003 when the swath bathymetry data was collected.

The analysis of the boomer seismic dataset collected during the project is not complete. This is partly due to a change in personnel during the project, and partly because the bespoke academic boomer equipment used was new and so required a number of intermediate processing software routines to be written before starting the processing. The processing work completed however, shows the great improvement achieved by digital processing, particularly deconvolution at suppressing the ringy signal of the boomer plate. To-date the interpretation has focused on single channel records to map the location of incised valleys and the geometry and structure of the Tertiary and Cretaceous strata throughout the study area. The latter has been found to be the key to understanding the first-order nature of the river systems and so likely a major control on archaeological potential. Future work will complete the derivation of optimum processing parameters and critically assess the usefulness or otherwise of the multichannel hydrophone used in terms of improvements in signal-to-noise and provision of additional information such as stacking velocities.

6.4 REFERENCES


Figure 6.3 Perspective image of the singlebeam bathymetry viewed at an azimuth of 300°. Vertical exaggeration is x 6 and the sun-illumination is from the NW.

- **Bedrock ridge**
- **Mouth of the River Arun**
- **Gap in bedrock ridge** marks point where palaeo-Arun breaches ridge
- **Approximate course of the palaeo-Arun** as determined from seismic data
- **Chalk bedrock** – provides flint-rich landscape
- **Potential findspot in valley fill**, where valley cuts across outcropping Upper Chalk
- **Potential location of findspot in valley subsurface downstream of Chalk bedrock where valley widens**
Figure 6.4 Sketch from Pavlov et al. (2001) showing occurrence of extensive mammalian bones and artefacts in basal fluvial channel gravels of Middle Palaeolithic age in European Arctic.
Figure 6.5 Portion of seismic line from 2000 data showing cross-section across channel. Note lateral accretion bedding and fine-grained channel fill.

- **Ravinement surface**
- **Fine-grained sediments in channel-fill**
- **Valley Margin**
- **Basal erosion surface**
- **Tertiary bedrock**
- **Multiple**
- **Steeply-dipping reflectors**
  - = lateral accretion on migrating bar
- **Findspot?**
- **~5m**
- **~135**

- Basal erosion surface
- Valley Margin
- Fine-grained sediments in channel-fill
- Ravinement surface
- Tertiary bedrock
- Multiple
- Steeply-dipping reflectors = lateral accretion on migrating bar
- Findspot?