Part B

COASTAL CONDITIONS

The aim of developing Shoreline Management Plans is to provide the basis for sustainable coastal defence policies and setting objectives for the future management of the shoreline.

The key to achieving effective and sustainable coastal defence management is through knowledge of the ongoing coastal processes and their interaction along the coast.

These processes are largely driven by natural forces which impact upon the shoreline, ie winds, waves, tides and currents, influencing erosion, flooding and sediment transport, as well as being the conditions against which defences must be designed to withstand.

Consequently, the following Section provides valuable information on coastal conditions operating within Poole and Christchurch Bays.

COASTAL CONDITIONS

CONTENTS

Appendices

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1 INTRODUCTION

1.1 Approach

The analysis of coastal conditions for Stage 2 of the Poole and Christchurch SMP has followed the methodology recommended in the Stage 1 study report. Mathematical modelling and analysis specifically undertaken for this report have supplemented a review of previous work on coastal conditions.

Supplementary work to improve the present understanding of coastal conditions has included modelling of wave transformation and analysis of tidal and surge water level variations.

1.2 Structure of this Section

Where possible, the conditions relating specifically to each of the seven Coastal Process Units, 5F-1 to 5F-7 have been assessed and are reported in Sections 3.1 to 3.7. However, prior to discussion of this detailed information it is of interest to establish the general variation of conditions across the whole of the study area, sub-cell 5F. Indeed, information such as the offshore wave conditions is applicable across virtually the whole study area and of course, this was one of the principles behind the original division of the UK coast into the primary coastal cells.

The first part of Section 2 therefore firstly describes sources of information and the general variations of wind, waves, water levels and tidal currents across coastal cell 5F. This is followed by a presentation of the most recent knowledge on coastal conditions within each of the main sub-cells.

2 ASSESSMENT OF CONDITIONS

2.1 Sources of Information

Information has been obtained from the many previous study reports for this subcell. Most of these studies have been for specific beach management or coastal defence schemes, so there is little coherence along the coastline. Even when comparing for example nearshore wave conditions, the differing methodologies and different depths used for the nearshore points means that there is little correlation. To overcome this difficulty, nearshore wave conditions have been derived for the whole of the study coastline using a five year timeseries of offshore wave data.

Several particularly useful reports from earlier studies that have been referenced include:

- The Coastal Strategy Study report for Borough of Poole by Hydraulics Research Ltd (HR 1995)
- The Seabed Sediment Mobility Study covering the area west of the Isle of Wight (CIRIA 1998)

2.2 Wind

The main influence of the wind upon the shoreline is indirect, through the generation of waves, water surface currents and water level set-up. These indirect influences are generally included in records of water level and waves.

In addition, the wind can physically mobilise light sediments and thus have a direct impact upon the movement of beach sands and the formation of dunes. Where applicable this is commented on further in the Shoreline Evolution and Conceptual Sediment Process Sections of this report.

In coastal studies, wind data is frequently used for the estimation of wave heights using hindcasting techniques. Hindcasting generally utilises measured wind fetch lengths over open water from the site in question and locally measured wind data. Sources of measured wind data relevant to the study area include Lee-on-Solent, Poole Harbour, Portland and Hurn (Bournemouth Airport).

For wave hindcasting, the wind data from Portland is reasonably representative for derivation of offshore wave conditions for most of the study area, subject to minor modifications. The Portland data have the advantage that a reasonably long record (about 15 years) is available as hourly mean values from the UK Meterological Office (UKMO). The Portland wind data have previously been used for the assessment of offshore wave conditions on several occasions by several organisations including Hydraulics Research (HR), for example HR (1987) and HR (1989). The Portland wind data has been calibrated against summary observations from the Shambles Light Vessel, which would be more representative of wind conditions out at sea. Because the Portland wind anemometer is located on high ground above cliffs, different factors were derived for different direction sectors and wind speeds, see Table 2.1. These factors have been verified through comparison of hindcast waves to measured wave data.

TABLE 2.1 Wind speed adjustment factors for Portland Wind Data

	Direction Sector							
Wind Speed (m/s)	N	NE	E	SE	S	SW	W	NW
2.0	1.0	1.1	0.9	1.0	1.1	1.0	1.1	1.1
4.0	0.9	1.0	0.9	0.9	1.0	0.9	0.9	1.0
6.0	0.9	1.0	0.8	0.8	1.0	0.9	0.9	1.0
8.0	1.0	1.1	1.0	1.0	1.1	1.0	1.1	1.1
10.0	1.1	1.2	1.0	1.0	1.2	1.1	1.2	1.2
12.0	1.1	1.2	1.0	1.0	1.2	1.1	1.2	1.2
14.0	1.1	1.2	1.1	1.1	1.2	1.1	1.2	1.2
16.0	1.2	1.3	1.1	1.1	1.3	1.2	1.2	1.3

Source: HR(1989)

An additional source of wind data that is directly relevant to the offshore waves is modelled data contained within output from the UKMO European waters wave model. These data have the advantage that they are modelled over the open sea and therefore representative of the wave generating conditions.

2.3 Offshore Wave Climate

2.3.1 Normal Wave Climate

Most previous studies of offshore waves within the study area have relied on wave hindcasting to derive offshore waves, usually using locally measured wind data from Portland. This has the slight disadvantage that it does not account for swell waves (longer period waves with flatter crests that have travelled out of their generating area), which by definition are generated out of the area. Notable exceptions to this are the Halcrow (1994) study and the recent CIRIA sediment mobility study (CIRIA 1998). The Halcrow study was based on modelled wave data from the Northern European Storm Study (NESS) study.

The CIRIA study and this SMP study used simulated wave data from the UKMO European waters wave model. This is a wave model covering the whole of the UK coast at a resolution of about 25km. The model is operated in real time by the UKMO and the results are archived at 3 hour intervals. The model uses spatially and temporally varying wind conditions, allowing waves to build up, propagate and decay in a realistic manner. The boundaries of the model are driven by conditions generated by a coarser model (about 150km resolution) that covers all of the Earth's oceans. The models have been operating in their present state since approximately 1988, but the global model was revised to include satellite altimetry data in 1992.

For this SMP study, five years of data from a model node offshore from Poole Bay has been purchased from the UKMO. This five-year period of wave data is sufficient to provide a overview of the wave conditions for planning purposes, but should be treated with caution, particularly when considering extrapolation, due to the inherent variability of the climate. However, this is discussed further in Section 2.3.2 below.

The location of the UKMO offshore point used is at 50.5 degrees North, 1.66 degrees West. Table 2.2 and 2.3 show bivariate scatter tables for direction versus wave height and period versus wave height from the five years of offshore data. The numbers in the tables refer to the occurrences of three hourly wave conditions over the five-year period.

TABLE 2.2 Normal Offshore Wave Climate, Height vs Direction

	Wave Direction Sector (Degrees)																		
	30 - 10	50 - 30	70 - 50	90 - 70	110 - 90	130 - 110	150 - 130	170 - 150	190 - 170	210 - 190	230 - 210	250 - 230	270 - 250	290 - 270	310 - 290	330 - 310	350 - 330	10 - 350	Totals
Wave height (m)																			
7 - 7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.5 - 7	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
6 - 6.5	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	3
5.5 - 6	0	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0	0	0	6
5 - 5.5	0	0	0	0	0	0	0	0	0	7	16	4	1	0	0	0	0	0	28
4.5 - 5	0	0	0	0	0	0	0	0	0	8	35	5	4	0	0	0	0	0	52
4 - 4.5	0	0	0	0	0	2	0	1	5	16	54	32	17	5	0	0	0	0	132
3.5 - 4	0	0	0	0	0	2	1	1	6	27	113	99	20	1	0	0	0	0	270
3 - 3.5	0	0	1	8	0	15	9	5	14	95	211	99	14	4	1	0	0	1	477
2.5 - 3	3	5	0	54	41	23	2	9	20	125	196	118	77	26	13	1	0	1	714
2 - 2.5	2	11	27	33	80	68	28	12	42	176	370	206	71	36	15	4	3	4	1188
1.5 - 2	25	59	67	130	103	53	48	42	63	243	489	251	151	86	32	19	7	11	1879
1 - 1.5	102	174	244	277	155	103	78	68	67	428	889	423	214	132	78	82	80	73	3667
0.5 - 1	116	160	165	208	154	75	69	42	37	478	1271	976	130	98	96	125	167	149	4516
0 - 0.5	44	41	46	52	54	11	4	11	10	150	479	478	47	48	38	31	34	34	1612
% in sector	2	3.1	3.8	5.2	4	2.4	1.6	1.3	1.8	12	28	19	5.1	3	1.9	1.8	2	1.9	14546

Source: Analysis of 1993 to 1997 offshore data from UKMO model
Numbers show occurrences of three hourly wave events over the five-year period

TABLE 2.3 Normal Offshore Wave Climate, Height vs Period

	Wave Period (Tz, s)											
	1.0 - 0.0	2.0 - 1.0	3.0 - 2.0	4.0 - 3.0	5.0 - 4.0	6.0 - 5.0	7.0 - 6.0	8.0 - 7.0	9.0 - 8.0	10.0 - 9.0	11.0 - 10.0	12.0 - 11.0
WaveHeight (m)												
7 - 7.5	0	0	0	0	0	0	0	0	0	0	0	0
6.5 - 7	0	0	0	0	0	0	0	0	2	0	0	0
6 - 6.5	0	0	0	0	0	0	0	0	3	0	0	0
5.5 - 6	0	0	0	0	0	0	0	0	6	0	0	0
5 - 5.5	0	0	0	0	0	0	0	8	20	0	0	0
4.5 - 5	0	0	0	0	0	0	0	35	17	0	0	0
4 - 4.5	0	0	0	0	0	0	0	129	3	0	0	0
3.5 - 4	0	0	0	0	0	0	41	229	0	0	0	0
3 - 3.5	0	0	0	0	0	1	397	79	0	0	0	0
2.5 - 3	0	0	0	0	0	91	614	9	0	0	0	0
2 - 2.5	0	0	0	0	8	1013	165	2	0	0	0	0
1.5 - 2	0	0	0	51	593	1132	80	20	3	0	0	0
1 - 1.5	0	0	0	659	2373	453	120	42	16	2	2	0
0.5 - 1	0	0	0	1886	1723	529	213	99	42	13	5	6
0 - 0.5	4	0	0	820	443	177	86	46	20	11	5	0

Source: Analysis of 1993 to 1997 offshore data from UKMO model
Numbers show occurrences of three hourly wave events over the five-year period

As may be seen from Table 2.2, the dominant offshore wave direction is the south to south west. This corresponds to the direction of the longest fetches and strongest winds. Due to the sheltering effect of the coast between Durlston Head and Poole Harbour, much of the wave energy from this direction will not reach the study frontage, and it will be considerably attenuated due to refraction and diffraction. An illustration of the refraction and diffraction of longer period waves from the south west into the study area is shown in Figure 2.1.

The inclusion of swell wave data in the offshore wave conditions leads to a bi-modal wave height to wave period relationship, as shown in Table 2.3. This indicates that the longest wave periods of the record are associated with wave heights of 0.5 to 1m, demonstrating the importance of inclusion of swell waves in the analysis of coastal conditions.

2.3.2 Extreme Offshore Wave Conditions

While the normal offshore wave conditions should be well represented by data from the UKMO model, estimation of extreme conditions from this data set is subject to uncertainty due to the relatively short period of available data. The alternative is the use of longer-term estimates of the offshore waves that have been derived from wind data from Portland. Table 2.4 and 2.5 give extreme wave conditions from the two data sets. For the recent UKMO data, extremes have only been estimated for the all direction case to enable comparison.

TABLE 2.4 Offshore Extreme Waves from Wind Hindcast

	Direction Sector											
	135		150		180		210		240		All	
Return Period (yrs)	Hs (m)	Tm (s)	Hs (m)	Tm (s)	Hs (m)	Tm (s)	Hs (m)	Tm (s)	Hs (m)	Tm (s)	Hs (m)	Tm (s)
1	3.7	6.5	3.9	6.5	4.9	7.1	4.8	7.3	5.8	8.5	5.9	8.6
5	4.6	7.1	4.5	6.9	5.7	7.5	5.5	7.7	6.6	8.9	6.7	8.9
15	5.3	7.4	4.9	7.1	6.2	7.8	6.0	7.9	7.1	9.2	7.1	9.2
20	5.5	7.5	5.0	7.1	6.4	7.8	6.1	8.0	7.2	9.3	7.3	9.3
50	6.0	7.8	5.3	7.3	6.8	8.0	6.4	8.2	7.6	9.5	7.7	9.5
100	6.4	8.0	5.6	7.4	7.1	8.1	6.7	8.3	7.9	9.6	7.9	9.6

Source: HR(1989); based on 15 year hindcast from Portland Wind data

TABLE 2.5 Offshore Extreme Waves from UKMO Model Data

	All Direction	
Return Period (yrs)	**Significant Wave Height Hs (m)**	**Standard Error (m)**
1	5.5	0.2
5	6.3	0.4
10	6.7	0.6
20	7.0	0.8
50	7.4	1.2

Source: Analysis of 5 year timeseries of UKMO wave data

The extreme storm waves which are required for the analysis and design of coastal defences are likely to be reasonably represented by the waves hindcast from Portland wind data. This is the rationale behind the previous modelling for coastal studies that have ignored swell waves, and appears to be well borne out by the comparison of the all direction extremes in Tables 2.4 and 2.5, which are generally well within one standard error. It should be noted that the inclusion of the swell waves will lead to a higher proportion of 0.5 to 1.5m wave heights and this may account for the slightly lower extremes of Table 2.5 compared to the all direction extremes in Table 2.4. However, it is more correct to include the swell waves in the analysis and they need to be considered in the analysis of sediment movements,

2.3.3 Effects of Global Warming on Offshore Wave Conditions

The effects of the predicted future global warming on the UK wave climate are very uncertain at present. Average wind speeds over the UK are expected to increase, and the frequency of gales may increase by up to 30% (IPCC 1996). It is

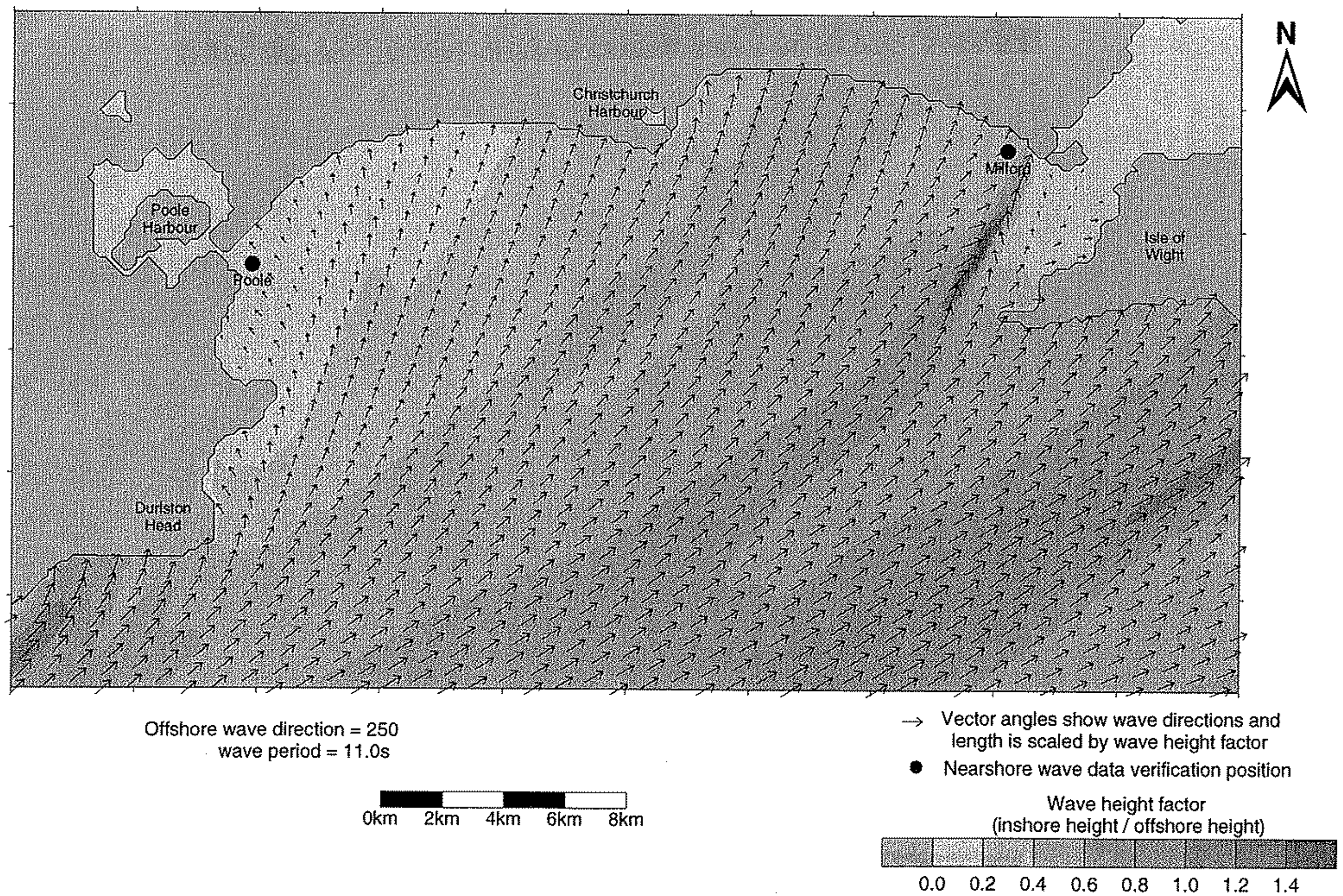

Figure 2.1 Example of wave transformation model results for waves from the south west.

possible that there may be an increase in the number of depressions affecting the south of the country, potentially leading to more swell wave energy and higher surge levels. However, the most significant changes are expected for the northern UK with little change in return period of daily mean wind speeds expected in the south. Studies of historical wave data have shown a 1 to 2% per year increase in wave energy in the North Atlantic. The impacts of wave climate change on UK coastal management was studied by HR (1991). They found that mean wave heights in the North Atlantic had been increasing over the last 30 years, but there was no corresponding increase in mean wind speeds. It has been suggested that the observed changes are unrelated to global warming, and according to HR (1991), there is no particular reason to expect that the changes should continue or accelerate in the future.

Prediction of the impacts of wave climate change is by no means trivial. Changes in offshore wave period alone will modify the nearshore wave directions due to the strong relationship between period and refraction / diffraction.

While there is no clear evidence for increasing storm intensity, the impact of the increasing wave energy in the North Atlantic may have significant effects on some parts of the open coast frontage. The western part of Poole Bay is largely sheltered from swell wave energy, whilst the more westerly facing eastern section near Hengistbury Head and most of Christchurch Bay is relatively more exposed to this increasing wave energy. In terms of beach sediment movements, any changes in wave direction may be more significant than increases in wave height. The present alignment of the study shoreline is strongly related to the dominant wave direction. Changes in the offshore wave directions could cause a re-alignment of the equilibrium beach shapes. As an example, HR (1991) showed that a 6° change in offshore wave direction over 14 years at Littlehampton has nearly doubled the rate of easterly drift. The modelling for the Borough of Poole (BoP) Coastal Strategy Study (HR 1995) showed that there has been an increasing rate of easterly alongshore drift along the BoP open coast frontage over the last 15 years.

At present, it is not possible to recommend allowances for future wave climate variability. The Coastal Group should remain aware of ongoing research into global warming and climate change and keep abreast of study results. The Shoreline Management Plan must recognise the possibility of future climate variability and be flexible to adapt in response. At the time of writing a recent publication from the UK Climate Impacts Programme (Technical Report 1) of October 1998 has become apparent. The findings are reviewed within Volume 1 of this SMP.

2.4 Nearshore Wave Climate

Nearshore waves and their variability are probably the most significant factor for driving sediment transport and coastal evolution. The strong indentation of Poole and Christchurch Bays has largely been caused by historical erosion of soft cliffs. However, the inshore wave conditions depend on the diffraction and refraction caused by the evolving shape of the coast and the seabed. The formation of stable bays and equilibrium bay shapes has been studied by a number of people such as Silvester (1972, 1976), Hsu and Evans (1989). It is well known that the equilibrium bay shape is closely linked to the dominant offshore swell wave direction and the position of relatively non-erodible hard points. The historical alignment of Poole and Christchurch Bays is strongly related to the swell waves from the south west and thus it is important that wave analysis take the offshore wave conditions into account.

The nearshore wave climate consists of transformed swell and storm waves that have been generated offshore from the study frontage together with 'local' waves that are generated over the relatively short fetches within the confines of Poole and Christchurch Bays. In general, the transformed waves from offshore will be dominant at positions on the open coast. Inside Poole and Christchurch Harbours the local wind generated waves will dominate. At some relatively sheltered locations on the open coast, for example Studland Bay, the contribution of the local and offshore waves to the nearshore wave climate will vary depending on the wind and offshore wave directions. Swell wave energy that propagates into the study area from the North Atlantic will have most influence on the western facing parts of Poole and Christchurch Bays, whilst Swanage and Studland Bays are relatively sheltered from swell and instead are exposed to the longest southeast fetches within the English Channel.

There have been a considerable number of studies to derive nearshore wave climates within the SMP area. Figure 2.2 reproduced from Ramsay and Harford (1995) and Figure 3.22 of CIRIA (1998) shows the approximate location of previous wave prediction points. Nearshore wave data has also been collected for several points and these are listed in Table 3.3 of CIRIA (1998). Digital data for two of these nearshore points were obtained for verification of the mathematical wave transformation modelling that has been undertaken for the development of this SMP.

TABLE 2.6 Nearshore Wave Data used for Verification of Modelling

Location	Dates	Mean water depth	Easting, Northing
Milford-on-Sea	May 1996 to October 1997	14.5m	E 427297 N 90361
Poole Bay	Nov 1990 to May 1991	9m	50deg 40.8N 1 deg 54.7W

Source: Data provided for this study

As discussed previously, the majority of the nearshore analysis points shown in Figure 2.2 have been undertaken for ad-hoc beach management or coastal defence studies. Almost all of the studies did not include swell wave energy in the offshore data since they relied on hindcasts, generally using wind data from Portland. The decision was therefore made to undertake a detailed wave modelling exercise for this study in order to derive the nearshore wave climate along the whole of the study frontage using a consistent method. Halcrow's grid based regional wave model has been used to provide wave transformation data for a range of water levels, wave directions and wave periods bracketing the offshore wave data timeseries. This has allowed the transformation of the five-year timeseries of offshore wave data from the UKMO model to nearshore points for subsequent analysis. The model takes into account the shallow water processes of refraction, shoaling, diffraction and depth limited wave breaking.

Previous wave modelling studies for this area have relied on the use of point based wave models that determine the effect of refraction and shoaling on the nearshore climate. These models do not account for the effects of diffraction of wave energy into shadow areas behind headlands and islands. Grid based wave models that can allow for these effects have become available relatively recently,

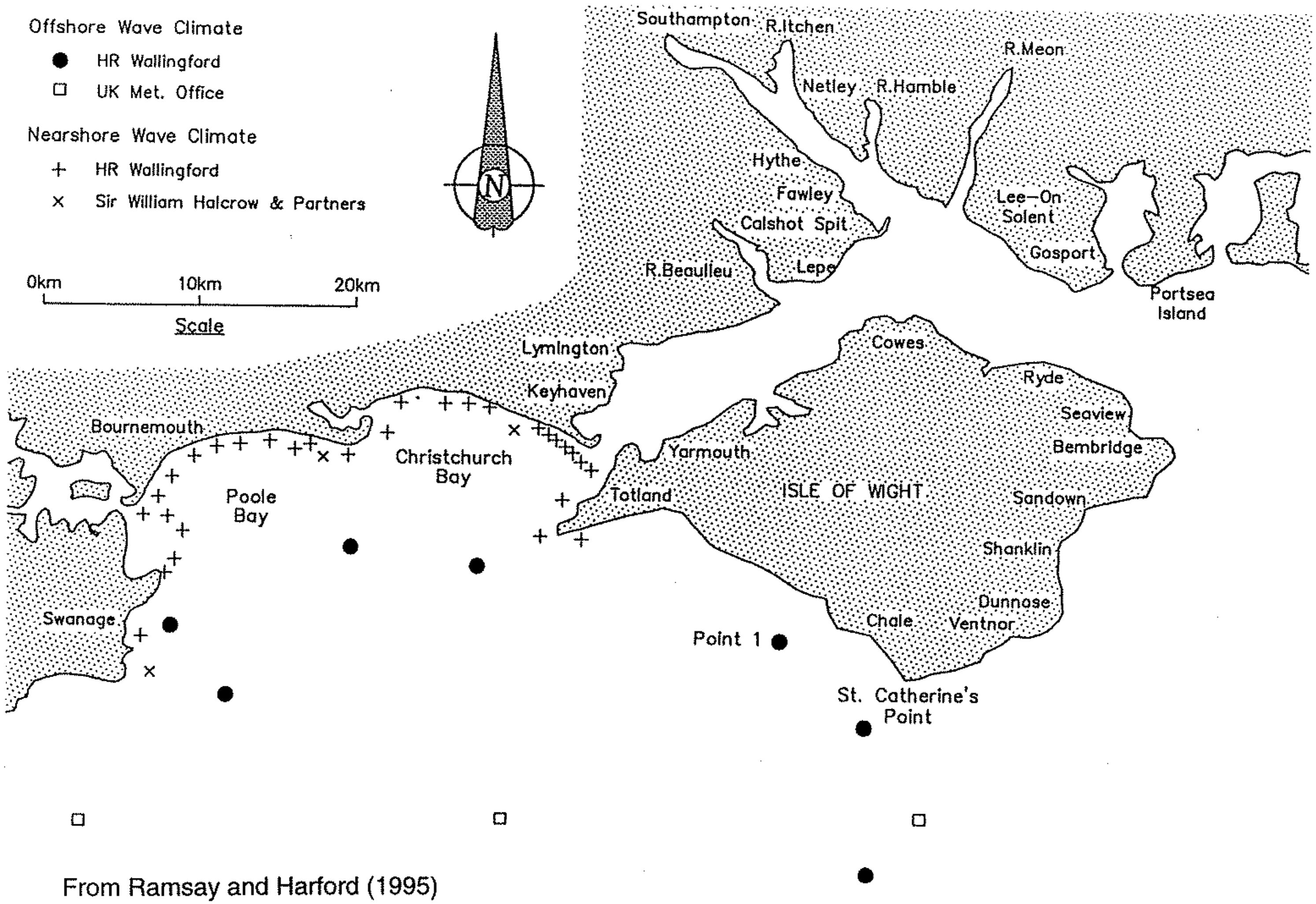

Figure 2.2 Locations of inshore wave analysis point from previous studies.

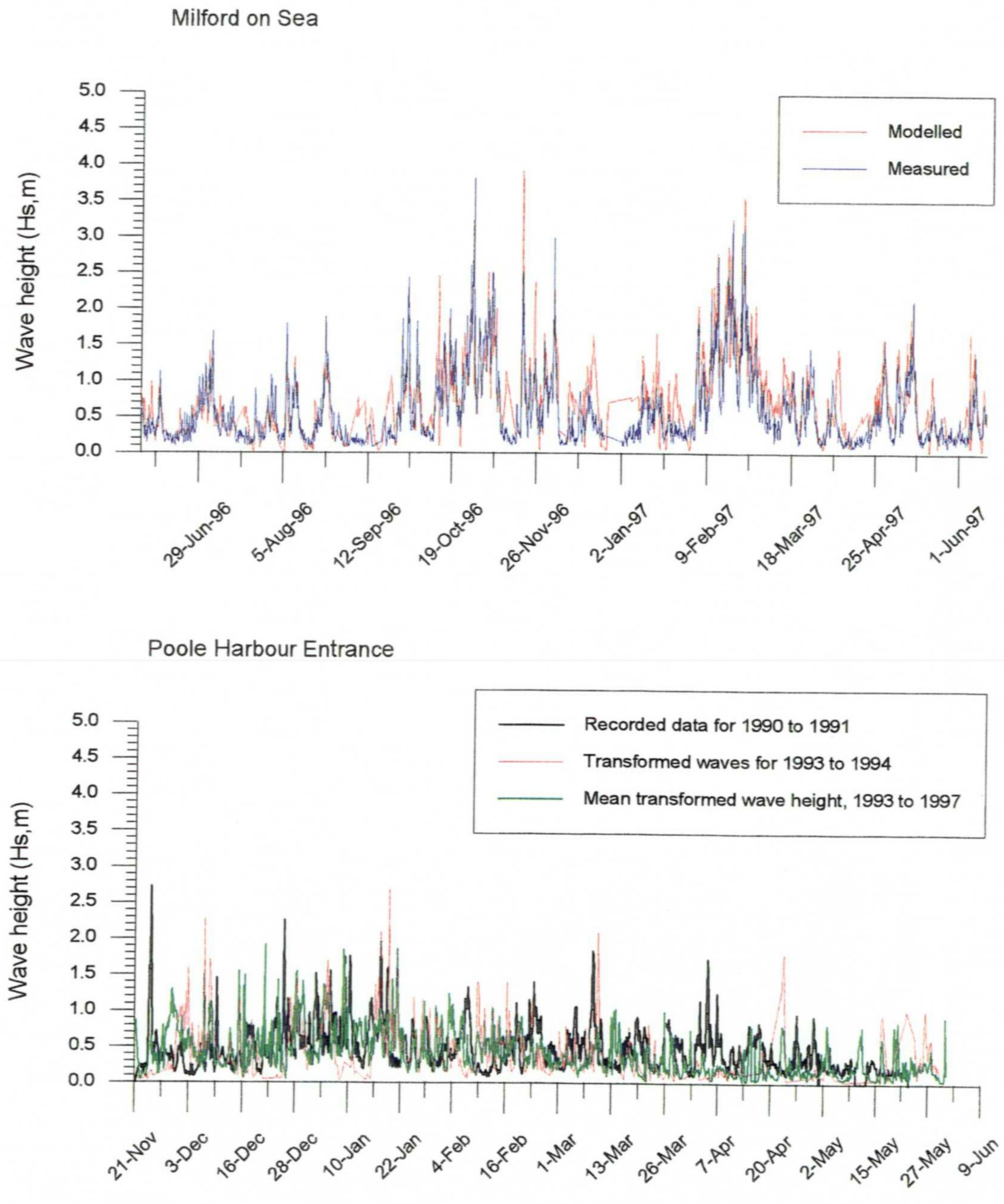

Figure 2.3 Comparison of modelled to measured nearshore waves.

although Halcrow's regional wave model, described in Li (1994), is well proven. The strong indentation of the study coastline and hence the diffraction of offshore waves from the dominant south west sector can only be studied with this type of model, (see Figure 2.1).

The spatial resolution of the regional wave model used was 200m, thus Poole Harbour and Christchurch Harbour are not adequately represented on this grid. The 200m grid spacing was chosen so that the whole study area could be represented with a single application of the model, allowing a regional perspective of the wave climate. The modelling that has been undertaken is of sufficient detail for this review of coastal conditions across the whole of sub-cell 5F. However, more detailed modelling would be required for the design analysis of any proposed coastal engineering schemes.

The bathymetry data on which the model is based was derived from data available on Admiralty Charts, supplemented by nearshore survey data for Poole Harbour provided by PHC. While it is recognised that the Admiralty data is somewhat outdated in some areas of the bay, it is considered sufficiently accurate for this regional study.

The five years of offshore wave data have been transformed to a total of 41 nearshore points using the regional wave model results and predicted water levels. All of the wave model runs were undertaken for three water levels in order to account for tidal level in the wave transformation. To verify the wave transformation modelling, comparison has been made with the nearshore wave measurements near Poole Harbour entrance and at Milford-on-Sea. For Milford-on-Sea, the period of available data lies within the period of offshore data purchased, and so direct comparison is possible. Figure 2.3a shows that the agreement between measured and modelled waves is very good over the whole comparison for June 1996 to June 1997. The Poole Bay measured wave data period is from November 1990 to May 1991 and thus is before the offshore data, which starts in January 1993. Therefore, Figure 2.3b shows a comparison between the measured data and the mean transformed wave height for the available four winters. It should be noted that the averaging processes smooth the transformed waves and in order to demonstrate the variability, Figure 2.3b also shows the transformed waves for November 1993 to May. It can be concluded that the wave model results show very good agreement to nearshore measurements, verifying the methods used.

The regional wave model results have been used to derive timeseries of nearshore waves distributed along the entire study frontage. The nearshore locations analysed are generally on the 2 to 4m below Chart Datum contour, depending on the model bathymetry. These timeseries have been analysed to derive:

- wave height against direction and period scatter tables
- extreme nearshore wave heights and
- the distribution of alongshore wave energy, to assist in the analysis of beach processes.

It should be noted that, due to the relatively short length of the offshore wave time series used for the analysis there is considerable uncertainty over the estimated wave heights for the longer return periods. Since it is usually recommended not to extrapolate beyond 3 to 5 times the record length, this would mean that the maximum return periods predicted should not exceed 25 years. However, in order to enable comparison with other estimates the 1 in 50 year value has been included in the analysis. It is recommended that the wave analysis should be extended in the future, when say ten years of offshore wave data become available from the Met-Office model. However, for many coastal structures the nearshore wave conditions will be depth limited, hence it is most important to make adequate allowances in design conditions for the tide level and surge heights. In this situation the wave period is as important a design parameter as the unbroken wave height, and so example scatter tables for wave height against direction and wave period have been provided in the text of the report on the sub-areas.

The mean and 1:50 year nearshore wave heights from the transformed data are summarised in Figure 2.4 for the whole of the study frontage. This Figure also shows the nearshore location numbers referred to later from Section 3. The nearshore points have been located on the 2 to 4m below Chart Datum Contour, this depending on the resolution of the model bathymetry. It should be noted that although depth limitation of waves was taken into account in the transformation of the waves to the nearshore points, the extrapolation of the waves heights to extreme return periods does not.

Further details on wave heights for other return periods are given in Sections 3.1 to 3.7. Generally, the extreme waves are larger on the more westerly facing parts of the frontage, although the southern part of Swanage Bay, which is exposed to the south east has quite severe exposure.

The total mean annual wave energy for the nearshore analysis points is shown in Figure 2.5. The alongshore wave energy is proportional to the potential alongshore drift rate. The alongshore wave energy is almost always directed from west to east along the study coastline. The only exception being near Sandbanks, east of Poole Harbour entrance, where slight westerly drift (due to wave energy, not including tidal currents) is predicted. This is in conflict to the HR (1995) alongshore drift analysis, but conforms to some earlier predictions (Ward, 1992). On the other hand, the case for an easterly drift is supported by a number of authors (eg Robinson, 1955). The reason for the difference may be due to the present modelling including the swell wave energy. However, the analysis is clearly quite sensitive to the choice of beach azimuth direction and it can only be concluded that the drift rate is very low and variable here.

The alongshore wave energy is maximized where the coast orientation is at an oblique angle to the predominant wave energy direction and also increases with more exposed conditions. Figure 2.5 shows high alongshore wave energy at the eastern part of Poole Bay and near Christchurch Harbour entrance.

2.5 Water Levels

2.5.1 Background

The sea water level is the result of combining the astronomical tide and the meteorological surge. The astronomical tide level can be accurately predicted far in advance for locations where harmonic analysis of recorded data have been made. However, tidal surges depend largely on movements of air pressure systems and the resulting wind variations and can only be predicted in the short term.

Poole and Christchurch Bays Coastal Group

POOLE AND CHRISTCHURCH BAYS
Durlston Head to Hurst Spit (Subcell 5F)
SHORELINE MANAGEMENT PLAN – STAGE 2

Halcrow 1999

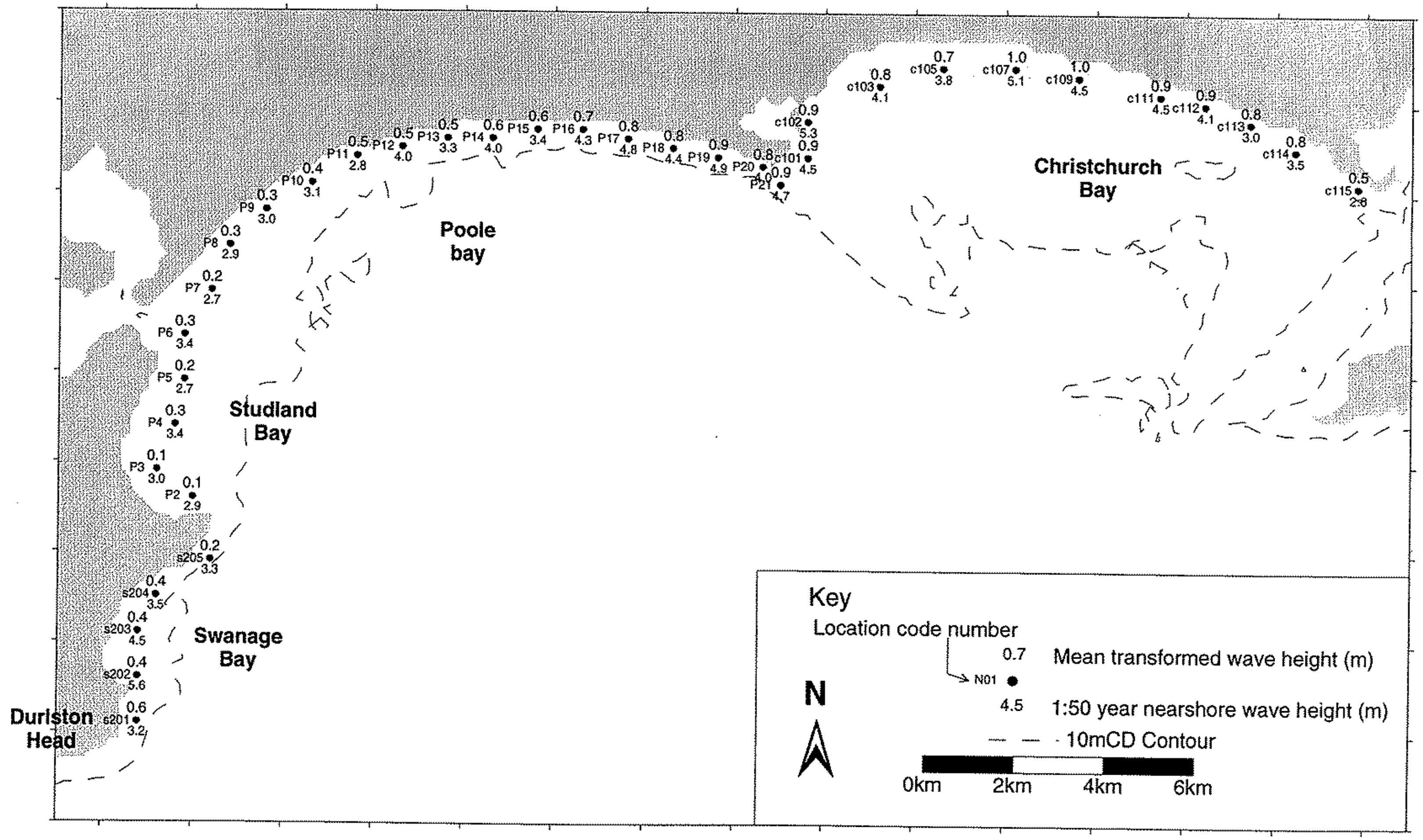

Figure 2.4 Distribution of mean and 1 in 50 year transformed waves.

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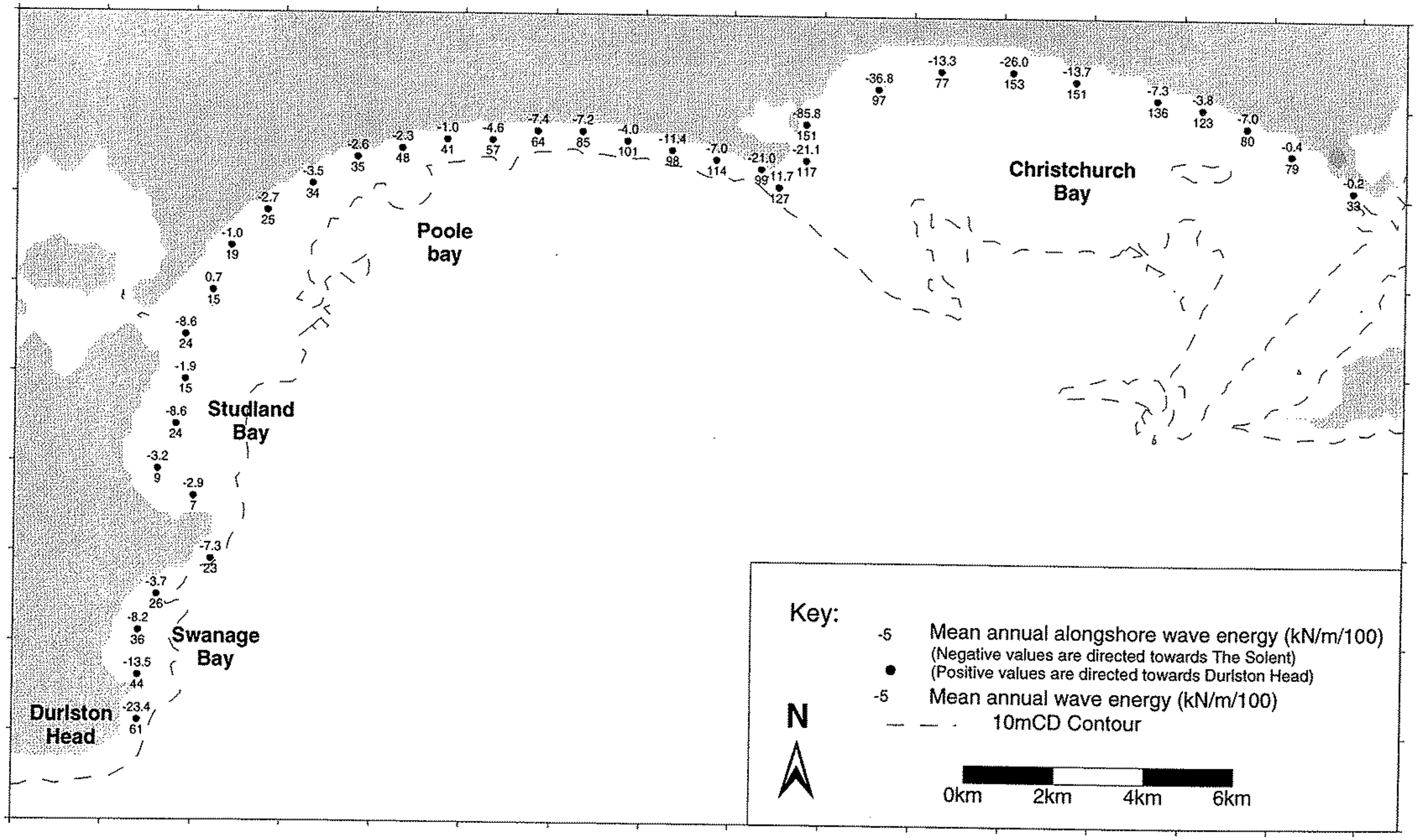

Figure 2.5 Total and alongshore wave energy.

The astronomical tides are primarily caused by the gravitational effects of the Moon and Sun and their relative orbits. The dominant harmonic tidal component is caused by the Moon's orbit relative to the Earth. This is known as the M2 constituent and it has a period of 12.4 hours. The bathymetry of the English Channel causes distortion of the M2 component and creation of additional sub-harmonic oscillations. The complex interaction of the harmonic constituents and effects such as the Coriolis force due to the Earth's rotation cause large variations in the tidal range in the English Channel. There is a 'node' point (small tidal amplitude but large tidal currents) in the region of the study area (CIRIA 1998). The tidal curve is particularly complicated with double high and low waters for some locations see Figure 2.6.

Detailed investigations into the timing and heights of the tidal levels have been undertaken by Riley (1995) using tide pole data collected by Southampton University. The analysis found that the incoming tide from the west splits in the region of Hengistbury Head with flood tidal levels along the rest of Poole Bay occurring slightly later. A tendency for double high waters was found along the whole frontage. These are more pronounced between Alum Chine and Mudeford, whilst between Highcliffe and Milford on Sea there is a tendency for a stand at high water with the second high water being higher than the first. The variation in tidal range and its asymmetry results in complex patterns of tidal flow, see Section 2.6. The spring tidal range generally decreases across the study area from 2.6m at Hurst Spit to 1.5m at Swanage.

The estimation of extreme storm surge levels, or total water level, traditionally relies on the analysis of historical records from particular coastal sites. More recently, Proudman Oceanographic Laboratory (POL) have used sophisticated mathematical models for prediction of tide and surge water levels around the UK coast. However, the data sources did not provide sufficient accuracy to resolve levels within estuaries, inlets and natural harbours. Details of the specific analyses are discussed in below.

2.5.2 Tidal Levels

An important source of information on water levels across the region is the Admiralty Tide Tables (ATT), which are published annually. In recent years, Poole Harbour (Ro-Ro Terminal) has become a Standard Port since Poole Harbour Commissioners make data that they collect available to the Admiralty for analysis. Poole Harbour is the only Standard Port in the study area. The other tide prediction points that are available on the coast of the area are Secondary Ports, referred to Portsmouth. These include Swanage, Poole Harbour Entrance, Bournemouth, Mudeford Quay, Christchurch Harbour and Hurst Point. It is possible to estimate tidal levels at these Secondary Ports by using time and height differences from Portsmouth, or using the Admiralty Simplified Harmonic Method and their published constituent values. Most of the tidal curves drawn for the secondary ports in Figure 2.6 were derived using the Simplified Harmonic Method and data from the ATT, but Bournemouth and Poole Harbour were based on harmonic analysis undertaken as part of this study.

It should be noted that predicted tidal levels for Poole Harbour derived from the data in the ATT have been found to under-predict the tidal range for Poole Harbour by PHC. The harmonic analysis for Poole Harbour has investigated this further. Predictions based on the tidal harmonic constituents given in Appendix A give a larger range than those of the ATT, see Figure 2.7.

Tidal current and water level modelling has previously been undertaken for the whole of the study area by HR, see HR (1995), CIRIA (1998). The mathematical model used uses tidal water levels generated from harmonic constituents at the boundaries. The modelling derives concurrent water levels over the whole of the model area in order to compute the tidal currents. It is therefore possible to use the model results to estimate the time and height differences of tidal levels across the study area.

For this project, an analysis of surge levels in Poole Harbour and Poole Bay has been undertaken. This required a comparison of accurately predicted tidal level to actual measurements. Suitable measured water level data were available for three locations:

- North Haven (Poole Harbour Entrance),
- Poole Ro-Ro Terminal,
- Bournemouth Pier.

The data for Poole Harbour were provided by Poole Harbour Commissioners. The Bournemouth data were purchased from POL. The data from these three stations has been analysed using Halcrow's in-house tidal analysis software. Although there were data available from Christchurch Harbour difficulties with the variable timing of the recorded data meant that a similar surge level comparison was not possible. The resulting harmonic tidal constituents for the three stations are included in Appendix A. Using these harmonics for subsequent predictions, reasonable correlation of timing of high and low waters was found with the ATT (1998) predictions, but the tidal ranges were generally higher, see Figure 2.7.

Harmonic tidal constituents for Mudeford Quay, Christchurch have been previously calculated (Gao, 1993) based on a short term record.

2.5.3 Surge Levels

As discussed above, actual water levels vary from the tidal predictions due to the meteorological surge component, which may be positive or negative. Additionally, near rivers high fluvial flows can also significantly influence the tidal levels and cause flooding. For example extreme water levels at the inner part of Christchurch Harbour relate to high fluvial flows in the Stour and Avon rather than meteorological surges.

Consideration of surges is particularly important for the establishment of coastal design conditions in this area, due to the small tidal range. For example, a 1m surge would be around 50% of the tidal range for much of the study area.

It is of considerable interest for coastal defence design to have knowledge of any correlation between surge levels and large waves. However, the values that are required for design and assessment are joint probabilities of total water level and wave height combinations. To estimate total water levels it is possible to use predicted tide levels for the given location, together with surge levels for a local site where long records of surge residual exist. This technique assumes that the topographic effects on the surge heights are the same. Several previous studies for the area (eg HR 1995) have assumed that surge heights will be the same in Poole Bay as within Poole Harbour. Analysis of the recorded water level from Bournemouth has therefore been undertaken to determine if this assumption is correct.

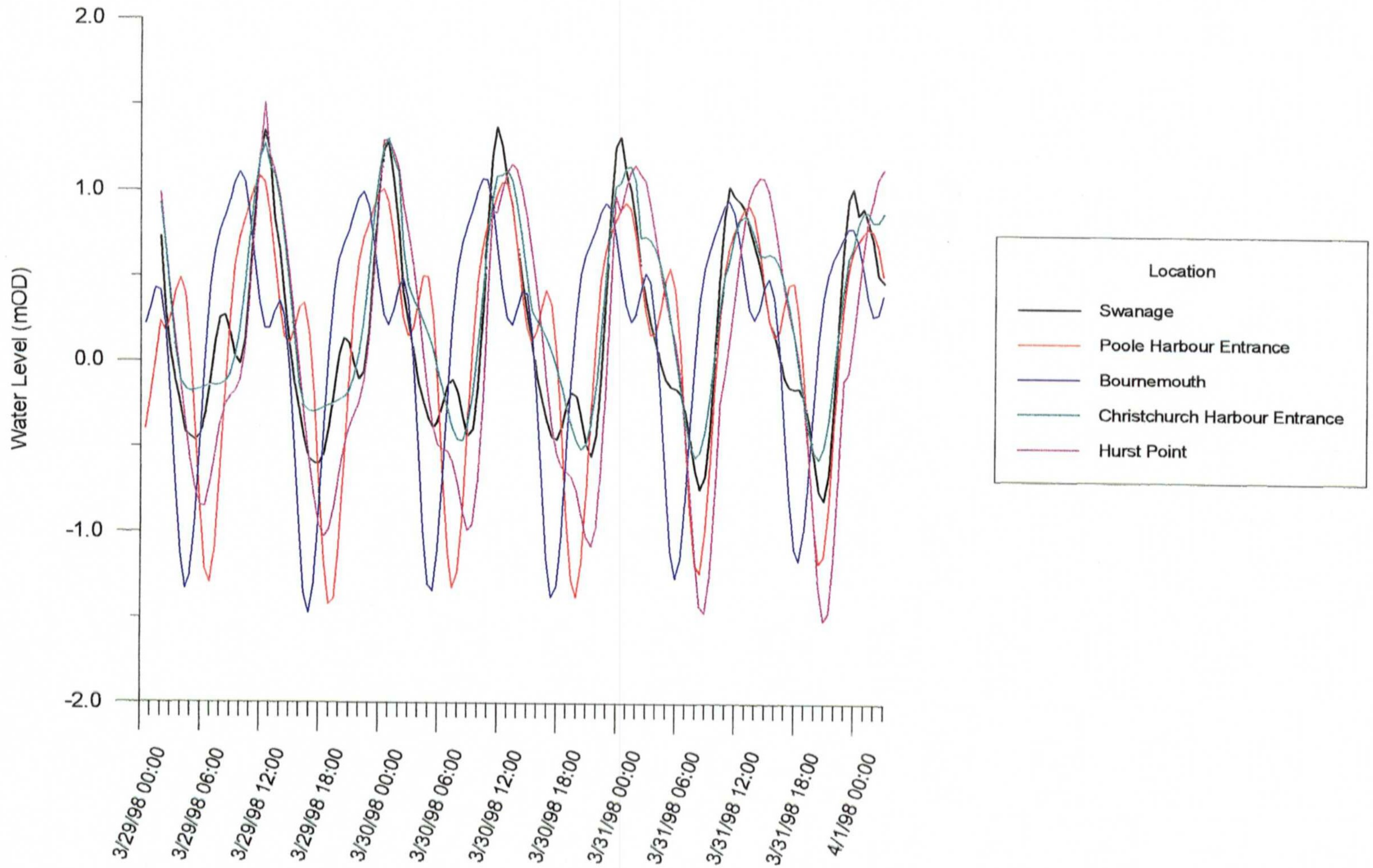

Figure 2.6 Example tidal curves from secondary ports.

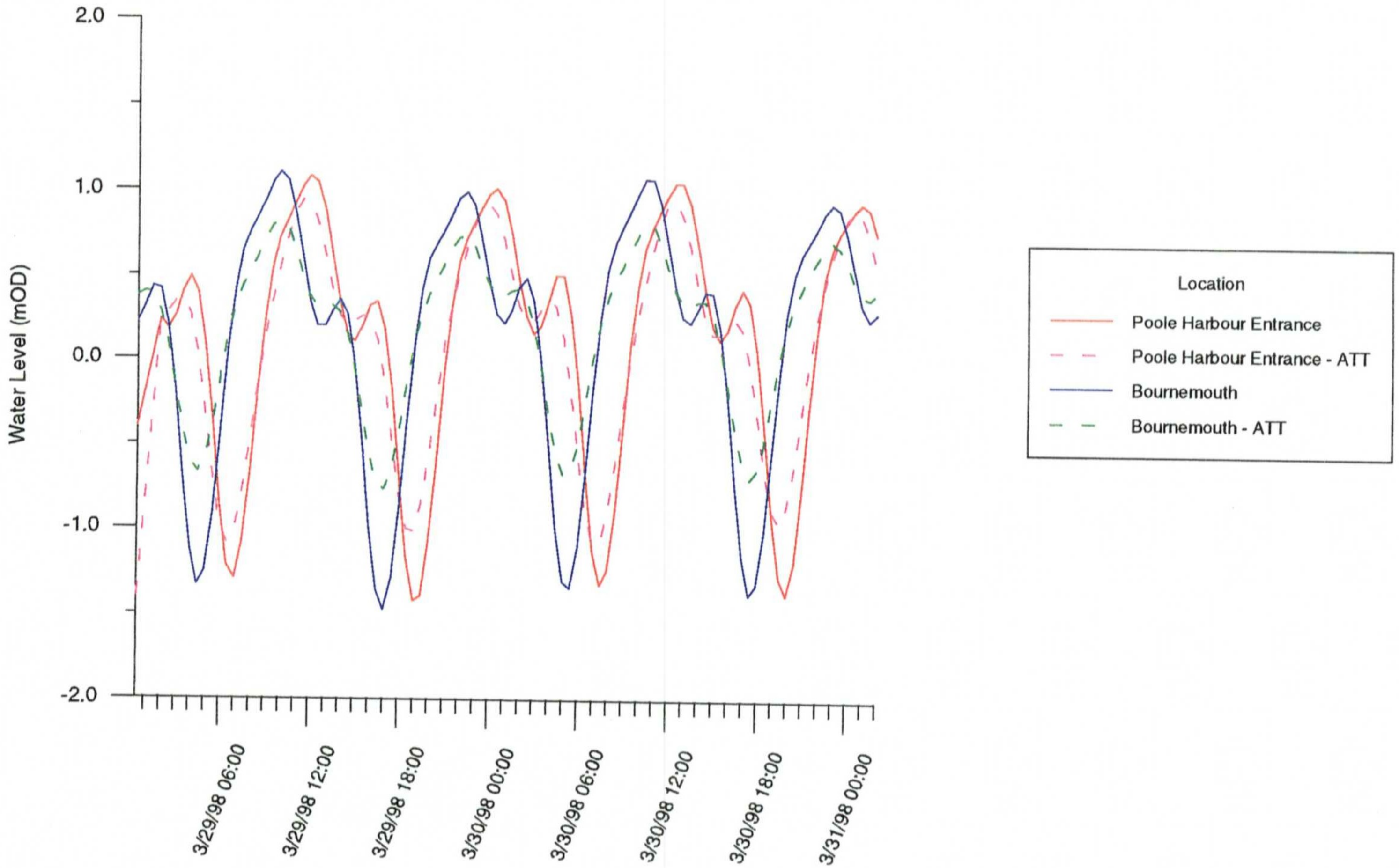

Figure 2.7 Comparison of tide predictions at Poole and Bournemouth.

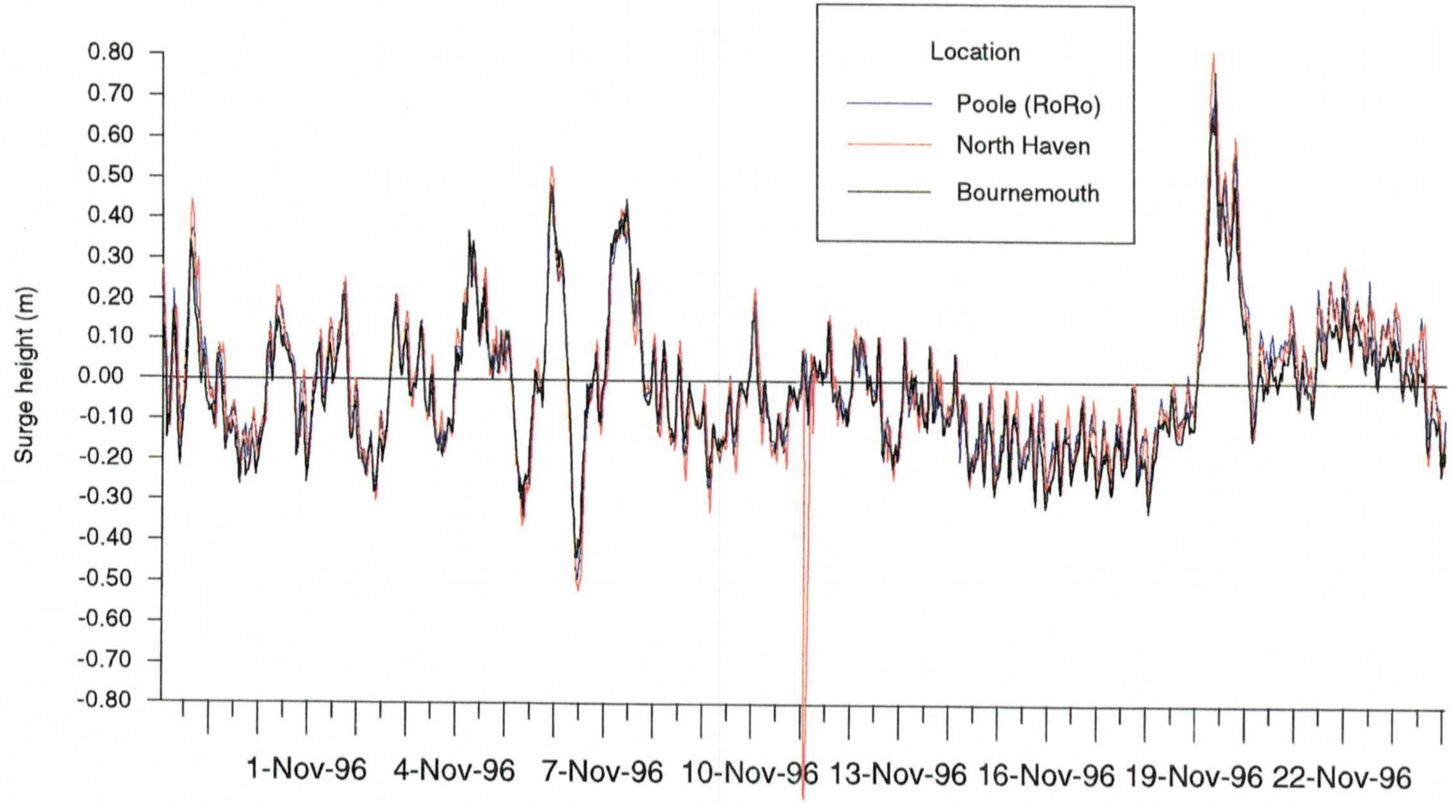

Figure 2.8 Surge heights in Poole Harbour and Poole Bay.

Following derivation of the harmonic constituents, the predicted tide levels have been compared to the measured data in order to evaluate non-tidal surge levels. The results show that there is indeed a very close correlation between surge height at the three locations analysed as illustrated in Figure 2.8. There is only a minor difference between the surge levels at the three sites, with Poole Harbour having slightly larger peaks.

2.5.4 Extreme Total Water Levels

For design and management of coastal defences, it is necessary to have probability information on the total water level as opposed to the surge heights. Total water level analysis may be based on either synthesised or measured data. Table 2.7 shows a comparison of extreme water levels throughout the study area, based on previously reported analyses. In addition extreme estimates for Yarmouth, have been derived as part of this study.

The values do not allow for long term changes in mean sea level or changes in storminess due to global warming. The values reported by Dixon and Tawn (1997) should be treated with some caution, since they are based on analysis of the results of POL's tide and surge model for the continental shelf, which has a resolution of about 30km. Therefore, their data cannot represent the complex bathymetry of Poole Harbour, Christchurch Harbour or the Western Solent and is only appropriate to be used offshore.

The extreme water level values given in Table 2.7 have not been adjusted to allow for long term changes due to relative sea level rise or trends in extreme water levels. Based on historical data, allowance should be made for 1.1 to 1.5mm/yr rise in mean sea level, see Bray et al (1994). In addition, it is widely predicted that current rates of sea level rise will accelerate due to the greenhouse effect and global warming. This is discussed further in the next sub-section.

TABLE 2.7 Extreme Water Levels from Previous Studies

Location	Source	Analysis Period (yrs)	Extreme Sea level (mOD) & Return Period (years)						
			MHWS[1]	1	2	5	10	50	100
Portland	Graff (1981)	1923-1977 (20)	1.2				-	-	2.1
Portland	Coles and Tawn (1990)	1923-1977 (20)	1.2				1.9	-	2.1
Lulworth	Dixon and Tawn (1997)	39	-	1.8	-	-	2.1	2.4	2.6
Swanage	Halcrow (1994)[2]		0.6	-	1.5	1.7	1.8	2.0	2.1
Swanage	D&T(1997), interpolated			1.7	-	-	2.0	2.3	2.5
Poole Harbour Ent	Halcrow (1994)[2]	25	0.6	-	1.5	1.7	1.8	2.0	2.2
Poole Harbour	HR (1995)	1991-1993 (2.5)	0.8	1.4	1.5	1.5	1.6	1.8	1.8
Poole Harbour	Reading University	1979-1997(43)	0.8		-	-	1.6	1.8	1.8
Bournemouth	Halcrow (1996)	1974-1989 (15)	0.6		1.3	1.4	1.4	1.5	1.5
Bournemouth	HR (1995)						1.7	1.8	1.9
Hengistbury Head	Dixon and Tawn (1997)	39	-	1.6	-	-	1.9	2.2	2.4
Christchurch Harbour	Hague (1992)	1978-1989 (14)	0.9	-	-	-	1.4	1.5	1.6
Offshore Christchurch Harb	Halcrow (1994)[2]	25	0.9	-	1.8	2.0	2.1	2.3	2.4
Hurst Point	Halcrow (1994)[2]	25		-	1.8	1.9	2.0	2.3	2.4
Yarmouth	Halcrow[3]	7			1.6	1.8	1.9	2.2	2.3
Southampton	Graff (1981)	1924-1975 (47)	1.8				2.6	2.8	2.8
Southampton	Coles and Tawn (1990)	1924-1975 (47)					2.7	-	2.9
Portsmouth	Graff (1981)	1813-1975 (104)	2.0				2.7	2.9	3.0
Portsmouth	Coles and Tawn (1990)	1813-1975 (104					2.8	-	3.1

1= Based on data in Admiralty Tide Tables (1998)
2 = Based on analysis of tide and surge data from POL model
3 = Analysis for this study

2.5.5 Relative Mean Sea Level Rise and Global Warming

It is now widely accepted that changing atmospheric composition is causing slowly rising temperatures due to the greenhouse effect. There is uncertainty over the precise future climatic effects and the likely rates of change. However, the fact that global warming could cause melting of land-based ice and thermal expansion of the oceans suggests that accelerating rates of sea-level rise may be expected in future. It is known that mean sea levels have been rising globally from many tide gauge records. This rise is exacerbated in the south of England by land subsidence due to post-glacial effects. It is important that the SMP take due account of likely future changes in both normal and extreme sea levels.

The most reliable predictions on future climatic changes come from the Inter-Governmental Panel on Climate Change (IPCC). The allowances currently recommended by MAFF (1993) for use in coastal engineering scheme appraisals take account of IPCC recommendations for eustatic sea level rise and isostatic land level changes, largely due to rebound following the last ice-age. The MAFF (1993) document recommends an allowance of 6mm/yr for Southern EA Region and 5mm/yr for South West EA Region, the boundary between the areas lying at Chewton Bunny, the Dorset / Hampshire border. These recommendations were largely based on studies undertaken in 1989/90 so more recent publications have been considered to determine if the present allowances should be modified for the SMP.

In 1994 the River and Coastal Environments Group of the University of Portsmouth undertook a study of relative sea level rise for the south coast of England for SCOPAC (Bray et al 1994). Historical rates of sea level rise were reviewed and are summarised below:

- Geological sources (past 5000 years) : 1.1 to 2.4 mm/yr
- Archaeological sources (past 2,500 years) : 1.7 to 3.0 mm/yr
- Tide Gauges (1916 – 82, Sheerness and Newlyn) : 2.0 mm/yr (1962 – 82, Portsmouth and Newhaven) : 4.0 to 5.0 mm/yr

At the time of the SCOPAC study the future best estimate of sea level rise due to future global warming was 4mm/yr up to 2050. Addition of this to the background rate of rise gave a recommendation for an allowance for future sea level rise of 6 to 9mm/yr for the SCOPAC coast. For the present study area, sub-cell 5F, the recommendation would be 6mm/yr on this basis.

The IPCC (1996) Review of the Potential Effects of Climate Change in the United Kingdom suggests that the global mean sea level by the 2020s will be 19cm higher than the average over the 1961-90 period. By the 2050s it is estimated to be about 37cm higher, a typical rise rate of about 5mm/yr as recommended previously by the IPCC(1992). The possibility of these global rates being reduced due to the effect of sulphate aerosols is considered, and may reduce the global mean sea level rise by the 2050s to 23cm. These rates will be exacerbated for the study area due to the sinking isostatic land levels.

Extreme water levels form the tails of the statistical probability distribution, and therefore should rise in accordance with the changing mean sea levels. However, this is a simplistic assumption. Clearly the tidal levels will be directly affected by the mean water level change, but the surge levels are related to atmospheric pressure differences and wind speeds, so future climatic trends due to global warming are important. The analysis of POL modelled storm surges by Dixon and Tawn (1997) identifies a trend in the extreme levels of about 1.6mm/yr, roughly coinciding with the estimated recent historical isostatic rate of change. However, a larger rate of 5mm/yr was found for Poole Harbour annual maxima data by Reading University in their recent unpublished analysis.

The likely future changes in the UK climate have been addressed by IPCC(1996). The forecasts are very uncertain, but suggest that average seasonal wind speeds will increase over most of the country in both summer and winter. The largest increases are expected in the north of the UK, with little change in the south. The frequency of gales over the UK is likely to increase by up to 30% by the 2050s.

On the basis of the above, it is therefore recommended that at present an allowance of 6mm/yr should be allowed for across the whole of sub-cell 5F for the design and assessment of coastal defence or beach management schemes.

A new report has been published, namely the UK Climate Impacts Programme Technical Report No 1 (October 1998). First indication from this report suggest that sea level rise rates have previously been underestimated. It is likely that SCOPAC will investigate the local implications. The 6mm recommendation for this SMP should therefore be reviewed in the 5 year SMP review / update.

2.6 Tidal Currents

2.6.1 Background

A good understanding of the tidal flow patterns is important for shoreline management. The tidal currents can transport silts and finer sands, particularly when assisted by waves to stir the sediment into suspension. Tidal currents also transport and disperse pollutants such as discharges from outfalls or spillages from ships.

The complicated and asymmetric tidal level variations and the linked complex patterns of tidal flow in the study area have previously been studied in some detail. Tidal currents have been modelled on several occasions by HR using 2-dimensional depth integrated mathematical models. Earlier studies used a conventional finite difference model (HR 1990), whilst more recently a finite element model has been used (HR 1995). The CIRIA (1998) seabed sediment mobility relies heavily on the computational results of HR's model of the coast between Portland Bill and the Isle of Wight. The mathematical models have been driven by tidal elevations derived from harmonic constituents for nearby Secondary Ports and calibrated against tidal current observations by the Hydrographic Office as presented on the Admiralty Charts of the area. Mathematical modelling of tidal currents in Poole Harbour has been undertaken by Falconer (1983, 1984) and more recently by HR (1995). Modelling of currents, tidal and fluvial flood levels in Christchurch Harbour has been undertaken by BMT (1993).

In addition to the mathematical modelling there have been a number of studies that have collected current data in the study area. Of particular significance, due to the good spatial coverage are the studies for BP in western Poole Bay, (Osborne 1991, Ng 1993) that used the OSCR system to measure surface currents. The OSCR measurement area covered the area offshore from Poole, Studland and Swanage Bays. Surface drifter studies have also been undertaken, (Boxall 1989) and sea bed drifter studies were carried out for Bournemouth Council (Tyhurst 1976). However, the drifter studies do not provide information on the path taken by the drifters, just the end points and so can only be used to infer residual flow directions.

2.6.2 Description of Tidal Flows for the study area

The main tidal streams are generally parallel to the coast offshore. During the flood tide the flow is in an easterly direction and on the falling tide the flow is westwards offshore. Closer to the coast the tidal flows are complicated by eddies off Swanage and Studland in the lee of Durlston Head and the flows into and out of Poole Harbour, Christchurch Harbour and the Western Solent.

The latest depth integrated mathematical modelling of the study area was undertaken by HR and is described in CIRIA (1998). This modelling was undertaken using a depth averaged finite element model, based on the depth-integrated continuity and momentum equations. The model used was developed by Laboratoire National d'Hydraulique of Electricite' de France. The area covered by the model was approximately centred on Portland, with the Isle of Wight on the eastern boundary. Within the area of Poole and Christchurch bays, the model resolution was approximately 1km.

For a general description of the regional tidal currents, two Figures have been reproduced from CIRIA (1998). Figures 2.9 shows peak spring tidal flood currents for most of the study area. During the flood tide there are strong flows in the Western Solent due to the acceleration of flows by the constriction caused by Hurst Spit and the Isle of Wight. There is another area of high velocity off Durlston Head. However, within the majority of the Poole and Christchurch embayment the currents are moderate, typically 0.5m/s.

Typical ebb tidal currents are shown in Figure 2.10 with peak currents occurring in similar places to the flood. The two figures reproduced here do not have sufficient resolution to show the strong tidal currents that occur in the entrances to both Poole and Christchurch harbours. These are discussed in more detail in Section 5.

The residual tidal currents are important with regard to the dispersal of pollutants and the movement and settling of silts. Figure 2.11 shows the modelled residual tidal discharge pattern over the study area on spring tides. For most of the study frontage, the residual discharge is small. However, there is a strong westerly residual out of the western Solent and also south west past Durlston Head. Off Swanage Bay there is a southerly residual. There appears to be a weak clockwise gyre in the outer part of Christchurch Bay between the south west end of the Shingles Bank and a point south of Hengistbury head.

The flow patterns from the modelling described above were calibrated against current measurement data presented on the Admiralty Charts of the area. There is also reasonable agreement with the surface current patterns that have been measured using the OSCR system offshore from Poole, Studland and Swanage bays (Osborne 1991). An example flood tide current map from Osborne (1991) is shown in Figure 2.12, together with residual currents from the OSCR survey. The OSCR data also show a south westerly residual in the region of Durlston Head and Swanage Bay. During the OSCR deployment there were also three current moored meters in Poole Bay to monitor the vertical current structure and verify the OSCR data. A good correlation between the data from the OSCR system and the moored meters was found.

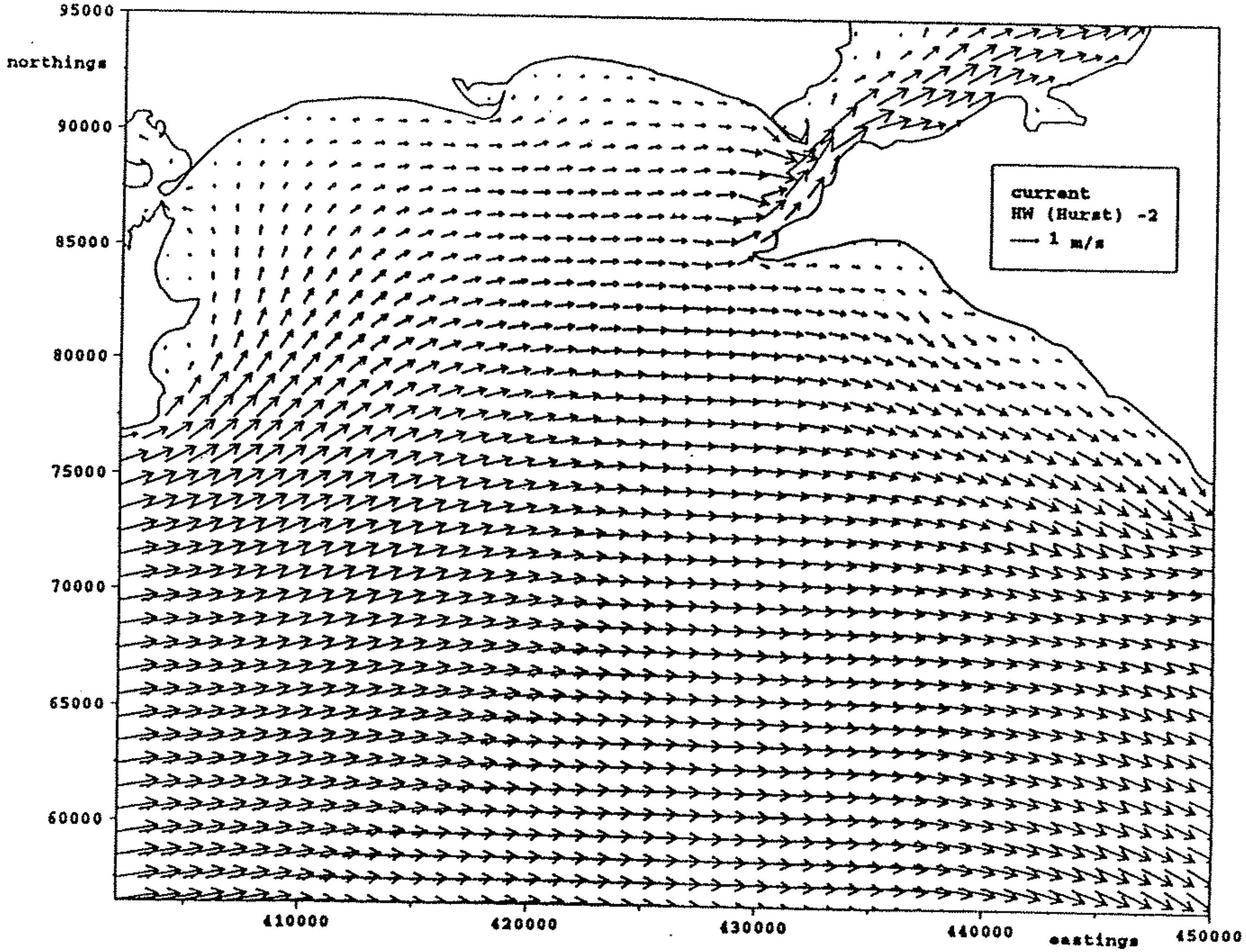

Figure 2.9 Peak flood currents on spring tides.

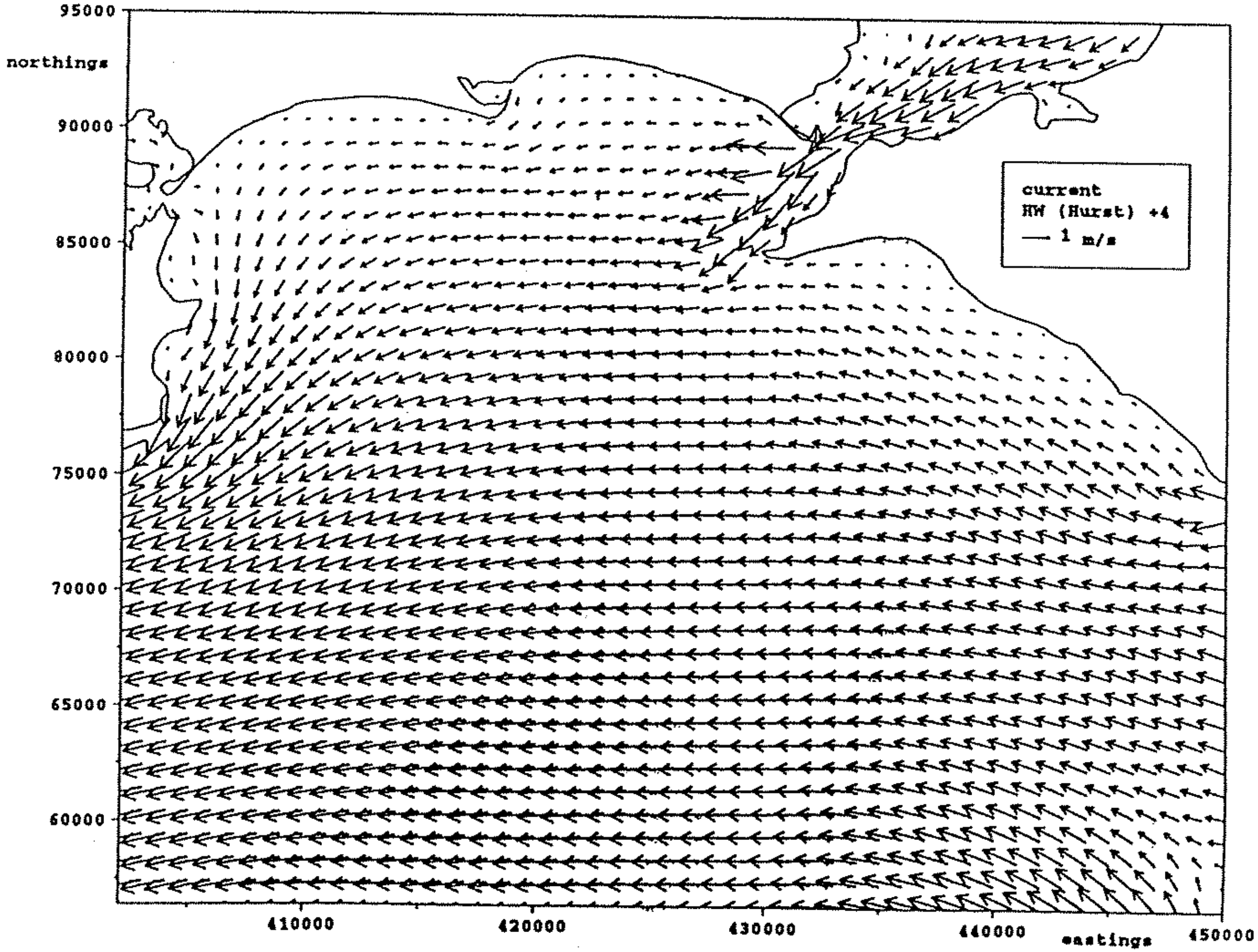

Figure 2.10 Peak ebb currents on spring tides.

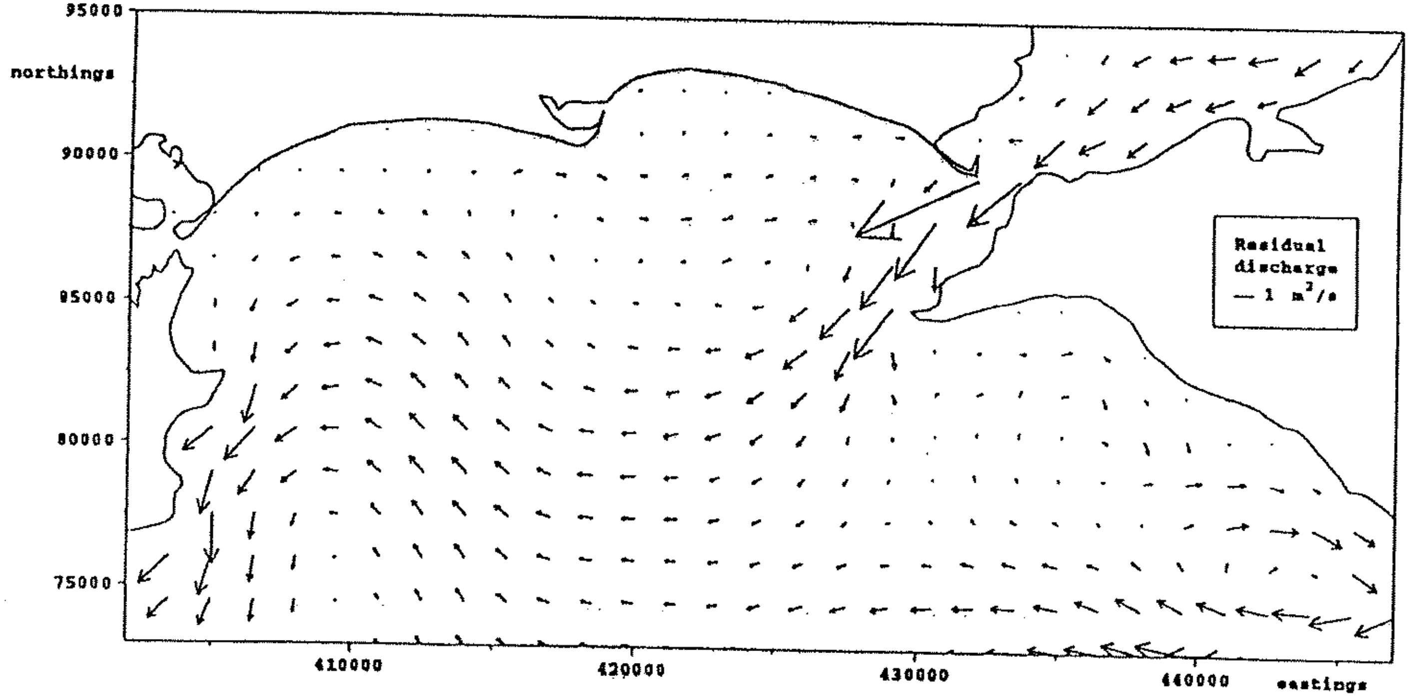

Figure 2.11 Tidal residual discharges on spring tides.

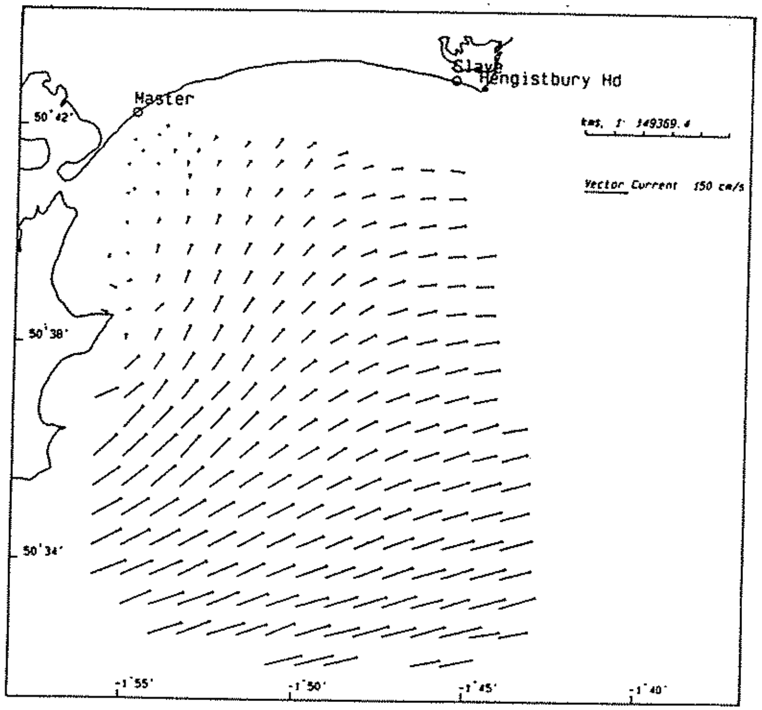

Figure A Typical current map in Poole Bay from OSCR II

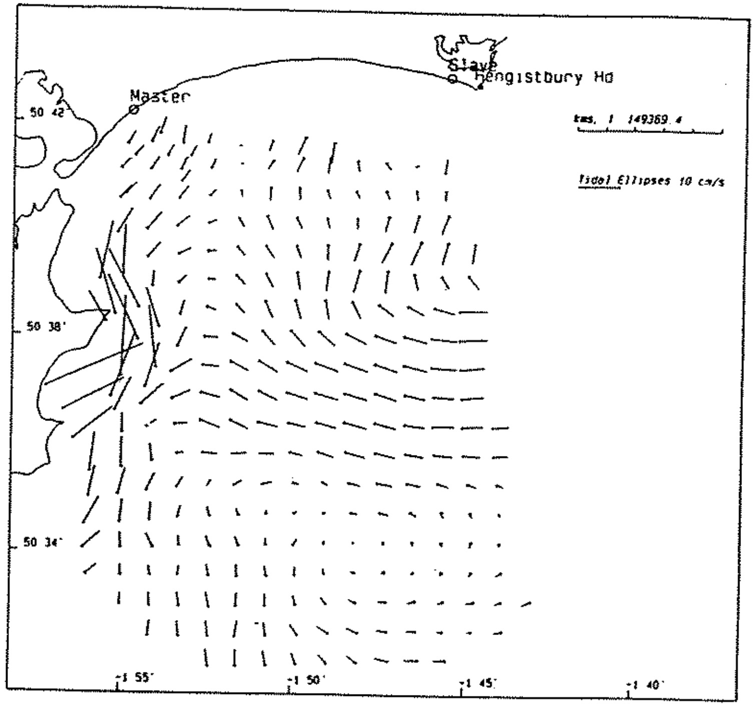

Figure B Mean residual circulation in Poole Bay from OSCR II

Figure 2.12 Flood tide surface currents and tidal residuals from OSCR survey.

3 DETAILED DESCRIPTION OF CONDITIONS BY SECTOR

3.1 Area 5F-1 Hurst Spit to Hengistbury Head Long Groyne (Christchurch Bay)

3.1.1 Wave Climate

Details of the offshore wave climate for Christchurch Bay were previously derived by hindcasting from wind data by Hydraulics Research (1989). The wind data was from Portland and covered 15 years. The hindcast data were used to derive the extreme values shown in Table 2.4. These offshore extremes are averaged over a period of an hour.

Wave transformation modelling has been undertaken using UKMO data. Nearshore wave date has been collected off Milford on Sea by New Forest District Council and some of this data has been used in verification of the wave transformation modelling, see Figure 2.3. Scatter tables for the modelled nearshore wave climate for position C7, which is in central Christchurch Bay and position C114 at the west end of Hurst Spit are shown in Tables 3.1 to 3.2 below.

TABLE 3.1a Wave height scatter table for Hurst Beach

Position C114	Wave Direction (Degrees)			
Number of occurrences	150 - 180	180 - 210	210 - 240	Totals
Wave height (m)				
3.5 - 4.0	0	0	0	0
3.0 - 3.5	0	3	7	10
2.5 - 3.0	0	8	36	44
2.0 - 2.5	0	36	122	158
1.5 - 2.0	1	94	665	760
1.0 - 1.5	3	166	1551	1720
0.5 - 1.0	10	245	2950	3205
0 - 0.5	539	201	3043	3783
% in sector	5.71	7.78	86.51	9680

Source: Wave modelling for this study
Numbers show occurrences of three hourly wave events over the five-year period

TABLE 3.1b Wave period scatter, Hurst Beach

Position C114	Wave Period (s)					
	0 - 2	2 - 4	4 - 6	6 - 8	8 - 10	10 - 12
Wave height (m)						
3.5 - 4.0	0	0	0	0	0	0
3.0 - 3.5	0	0	0	5	5	0
2.5 - 3.0	0	0	0	21	23	0
2.0 - 2.5	0	0	3	138	17	0
1.5 - 2.0	0	2	199	553	6	0
1.0 - 1.5	0	46	1124	550	0	0
0.5 - 1.0	0	362	2464	350	22	7
0 - 0.5	0	874	2328	485	85	11

Source: Wave modelling for this study
Numbers show occurrences of three hourly wave events over the five-year period

TABLE 3.2a Wave height scatter table for Barton on Sea

Position C107 Number of occurrences Wave height (m)	Wave Direction (Degrees) 150 - 180	180 - 210	210 - 240	Totals
5.5 - 6.0	0	0	0	0
5.0 - 5.5	0	2	0	2
4.5 - 5.0	0	12	0	12
4.0 - 4.5	0	42	0	42
3.5 - 4.0	0	71	0	71
3.0 - 3.5	1	115	0	116
2.5 - 3.0	1	339	0	340
2.0 - 2.5	17	494	0	511
1.5 - 2.0	41	876	0	917
1.0 - 1.5	154	1356	21	1531
0.5 - 1.0	338	2160	563	3061
0 - 0.5	299	1225	1553	3077
% in sector	8.8	68.6	22.1	9680

Source: Wave modelling for this study
Numbers show occurrences of three hourly wave events over the five-year period

TABLE 3.2b Wave period scatter for Barton on Sea

Position C107 Wave height (m)	Wave Period (s) 0 - 2	2 - 4	4 - 6	6 - 8	8 - 10	10 - 12
5.0 - 5.5	0	0	0	0	2	0
4.5 - 5.0	0	0	0	3	9	0
4.0 - 4.5	0	0	0	17	25	0
3.5 - 4.0	0	0	0	62	9	0
3.0 - 3.5	0	0	0	112	4	0
2.5 - 3.0	0	0	6	332	2	0
2.0 - 2.5	0	0	113	398	0	0
1.5 - 2.0	0	5	623	287	2	0
1.0 - 1.5	0	58	1188	273	11	1
0.5 - 1.0	0	393	2290	330	37	11
0 - 0.5	0	828	1898	288	57	6

Source: Wave modelling for this study
Numbers show occurrences of three hourly wave events over the five-year period

Example estimates of extreme nearshore wave conditions at Hurst Point, Barton on Sea and Christchurch Harbour entrance are summarised in Table 3.3 below.

TABLE 3.3 Estimates of Extreme Wave Conditions in 5F-1

	Christchurch Harbour Entrance C102	Barton on Sea C107	Hurst Point C115
Return Period (Years)	Hs (m)	Hs (m)	Hs (m)
1	4.1	4.8	1.6
5	4.8	5.0	1.9
10	5.0	5.0	2.1
20	5.2	5.1	2.3
50	5.3	5.1	2.6

Source: wave modelling for this study

Extreme nearshore wave heights for other locations in this sub cell are shown together with the rest of the area on Figure 2.4. The wave heights are smaller at Hurst beach due to the sheltering afforded by the Shingles Bank.

The easterly facing coast between Hengistbury Head Long Groyne and Christchurch Harbour entrance may be expected to be more sheltered than the rest of Christchurch Bay from waves from the south west. However, it is relatively more exposed to the south east, resulting in very similar extreme waves. The transformed nearshore wave climate for position C102 is given in Tables 3.4a and 3.4b.

TABLE 3.4a Wave height scatter, offshore Christchurch Harbour entrance

Position C102 Number of occurrences	Wave Direction (Degrees)			
	120 - 150	150 - 180	180 - 210	Totals
Wave height (m)				
5.0 – 5.5	0	1	0	1
4.5 – 5.0	0	4	0	4
4.0 – 4.5	1	6	0	7
3.5 – 4.0	7	10	0	17
3.0 – 3.5	6	22	0	28
2.5 – 3.0	14	29	1	44
2.0 – 2.5	27	75	1	103
1.5 – 2.0	79	149	2	230
1.0 – 1.5	159	253	40	452
0.5 – 1.0	235	560	199	994
0 – 0.5	136	2157	5507	7800
% in sector	6.9	33.6	59.4	9680

Source: Wave modelling for this study
Numbers show occurrences of three hourly wave events over the five-year period

TABLE 3.4b Wave period scatter offshore Christchurch Harbour entrance

Position C102	Wave Period (s)					
	0 - 2	2 - 4	4 - 6	6 - 8	8 - 10	10 - 12
Wave height (m)						
5.0 - 5.5	0	0	0	1	0	0
4.5 - 5.0	0	0	0	4	0	0
4.0 - 4.5	0	0	0	7	0	0
3.5 - 4.0	0	0	0	16	1	0
3.0 - 3.5	0	0	0	27	1	0
2.5 - 3.0	0	0	22	21	1	0
2.0 - 2.5	0	0	57	40	6	0
1.5 - 2.0	0	0	163	63	4	0
1.0 - 1.5	0	17	273	152	10	0
0.5 - 1.0	0	119	526	341	8	0
0 - 0.5	0	1148	5077	1430	127	18

Source: Wave modelling for this study
Numbers show occurrences of three hourly wave events over the five-year period

3.1.2 Water Levels

Tidal water level predictions for this sub-cell are available from the data in the Admiralty Tide Tables for Hurst Point. The Mudeford Quay tide prediction location is inside the bar and not representative of tidal levels in the bay at low water. Principal tidal levels for Hurst Point are given in Table 3.5 below.

TABLE 3.5 Tide Levels for Hurst Point

Tidal State	Level at Hurst Point (mOD)
MHWS	+0.9
MHWN	+0.5
MSL	-0.1
MLWN	-0.5
MLWS	-1.3

Source: Admiralty Tide Tables

As shown in Table 2.7, extreme water levels analysis have been undertaken at Hurst point and Hengistbury Head and these are reproduced in Table 3.6 below. There is little difference between these two estimates, probably because they are based on almost the same data set.

TABLE 3.6 Extreme Water Levels for Christchurch Bay

Return Period (years)	Level at Hurst Point (mOD)*1	Level at Hengistbury Head (mOD)*2
1	-	1.7
2	1.8	-
5	1.9	-
10	2.0	2.0
20	2.2	-
50	2.3	2.2
100	2.4	2.4

Source: *1=Halcrow (1994) (based on 25 years of tide and surge from POL model);
*2=Dixon and Tawn (1997)

New Forest District Council has installed a recording tide gauge at the offshore breakwater that forms part of the coastal defences to Hurst Spit. At present the length of record from the gauge is too short for analysis to derive extreme levels or surge heights. However, it is recommended that this analysis should be undertaken in the future to extend the knowledge of both tidal levels in Christchurch Bay.

3.1.3 Tidal Currents

As described in Section 2.6, the tidal currents are strongest in the region of Shingles Bank and the Western Solent entrance due to the flow constriction causing local acceleration. Typical peak flood and ebb tide spring currents near Shingles Bank are of the order of 1m/s. Strong currents, >1.5m/s are experienced around the entrance to Christchurch Harbour, see 3.2.3 below. Elsewhere within Christchurch Bay tidal currents are relatively weak, with peak spring currents less than 0.5m/s. The modelling for the CIRIA (1998) study found a weak clockwise gyre in the tidal residuals for Christchurch Bay.

3.2 Area 5F-2 Christchurch Harbour

3.2.1 Wave Climate

Within Christchurch Harbour the wave climate is dominated by locally generated waves. Using wind data, local hindcasts have been used to estimate extreme wave conditions for several locations. Extreme wave heights are all less than 0.8m at high tide due to the short fetch lengths. The results are shown in Figure 3.1.

The local hindcasts that were undertaken used the timeseries wind data that accompanies the offshore wave data from the Met-Office. However, should hindcasts of extreme waves be required for other locations within Christchurch Harbour, use of the wind data statistics for Poole Harbour, see Table 3.14 will give sufficiently accurate results for analysis of coastal defences.

3.2.2 Water Levels

Tidal level data for Christchurch Harbour are available for the entrance, Mudeford Quay and at the inner part of the harbour, Christchurch Quay. Principal levels are given in Table 3.7.

TABLE 3.7 Tide Levels for Christchurch Harbour

Tidal State	Level at Christchurch Quay (mOD)	Level at Mudeford Quay (mOD)
MHWS	+0.9	+0.9
MHWN	+0.5	+0.5
MSL	+0.3	+0.2
MLWN	+0.0	-0.2
MLWS	-0.1	-0.3

Source: Admiralty Tide Tables (1998)

The Admiralty Tide Tables (1998) comments that the tidal levels for Christchurch Harbour entrance are for a point inside the bar, and that outside the bar the water level falls about 0.6m lower on spring tides.

Estimates of extreme water level for Christchurch Harbour were derived by Hague (1992) based on local tide predictions and transferral of 14 years of surge data from Portsmouth. The results are given in Table 2.7 together with the Halcrow (1994) estimates for outside the harbour entrance. It is recommended that the more conservative Halcrow estimate, based on the POL surge data be adopted.

The fluvial and tidal influence on water levels was investigated by BMT (1993). During high river flows, the fluvial discharge apparently prevents the ingress of the flood tide into the harbour and the flow is constantly ebbing in The Run. Under such flood conditions water levels can back up in the harbour, leading to flooding at Christchurch. From a brief analysis of relatively recent significant flooding events, BMT (1993) concluded that extreme water levels and flooding was primarily tidally controlled at Mudeford Quay, whilst at Christchurch Quay fluvial flooding was more likely.

3.2.3 Tidal Currents

Mathematical modelling of tidal currents in Christchurch Harbour and in the adjacent part of Christchurch Bay was undertaken by BMT(1993). The study also included collection of field data in the Run for calibration of the model. Peak tidal currents occur in The Run and are around 1.6m/s on a spring tide. Currents are much lower elsewhere within the Harbour and the adjacent part of Christchurch Bay.

There is a significant fluvial input into Christchurch Harbour. Average daily river input for the Stour is 50 cumecs and for the Avon 20 cumecs. The Avon gives fairly consistent flows, whilst flow in the Stour varies considerably in response to periods of heavy rainfall. The maximum recorded instantaneous flow in Stour was 310 cumecs in Dec 1979, and the peak discharge in the Avon on the same day was 120 cumecs (BMT 1993). Estimates of flow rates for various return periods are shown in Table 3.8.

TABLE 3.8 Extreme Freshwater Inputs to Christchurch Harbour

	Daily Mean Flow (cumecs)	
Return Period (yrs)	**Stour (Throop)**	**Avon (Knapp Mill)**
2	102	51
5	137	57
10	163	61
25	199	66
50	229	70
100	262	74

Note: Indicative only, based on data from 1990 to 1993. Source: BMT (1993)

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Durlston Head to Hurst Spit (Subcell 5F)
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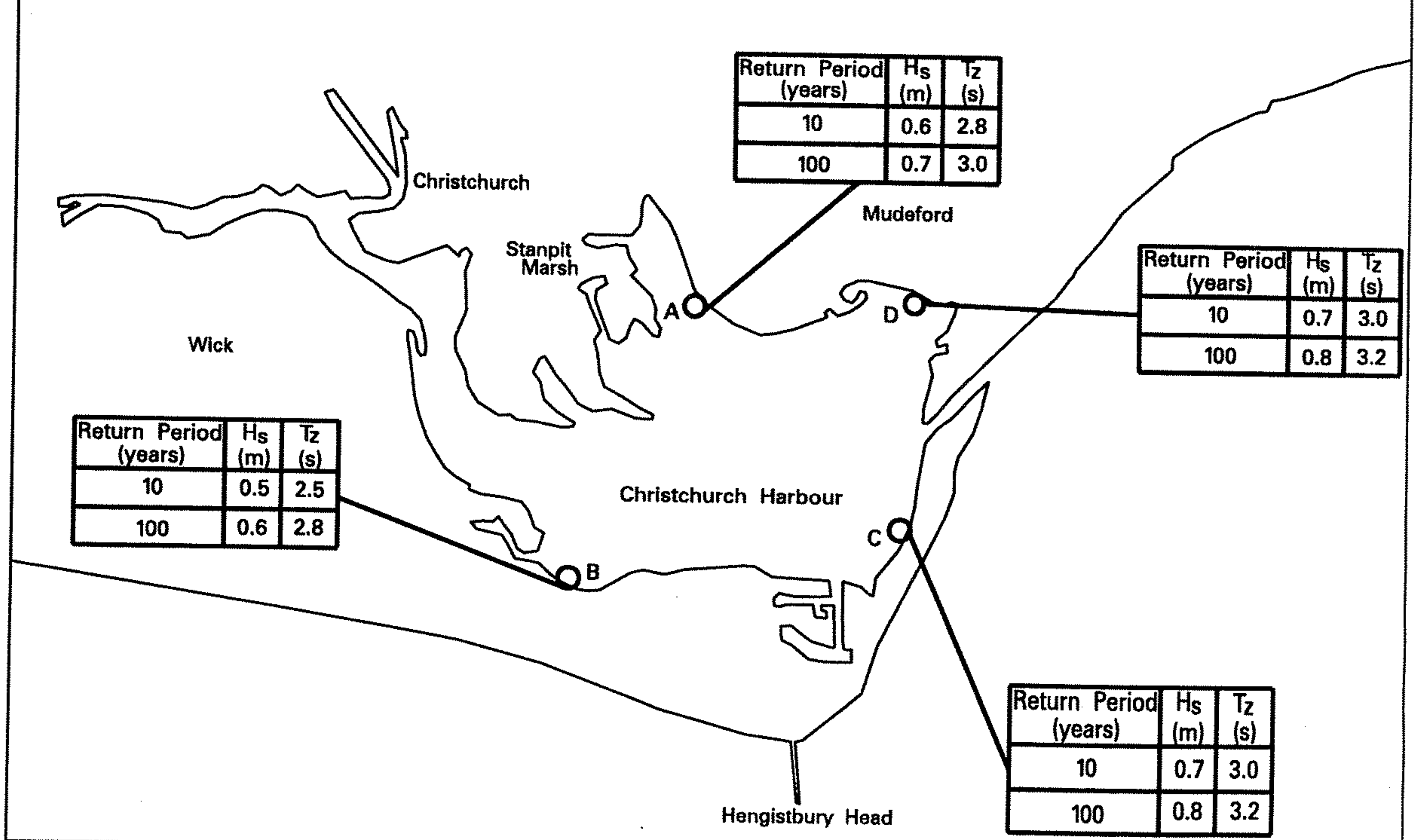

Figure 3.1 Extreme Wave Heights In Christchurch Harbour.

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3.3 Area 5F-3 Hengistbury Head Long Goyne to Sandbanks Ferry Slipway (Poole Bay)

3.3.1 Wave Climate

The inshore wave climate was previously determined at eight nearshore points along the Poole Bay frontage by HR (1995), based on 15 years of hindcast offshore wave data. HR's nearshore points were located on the 2mCD contour, as shown in Figure 3.2. These locations are similar to those analysed for the present study. However, the analysis undertaken by HR did not take into account swell waves, or allow for wave breaking in the shallow water depths of the analysis positions. Caution should therefore be applied when using the HR (1995) results, since the waves will generally be depth limited. In determination of depth limited wave conditions and overtopping discharges the wave period is likely to be of more importance than the estimated extreme nearshore wave heights

For this study, further wave climate modelling was undertaken to improve understanding of wave climate. This was based on the transformation of the five years of Met-Office offshore data to nearshore points using the regional wave modelling undertaken for this study. Tables 3.9 to 3.10 below show nearshore wave height and period scatter tables for a location in central Poole Bay and outside Poole Harbour entrance.

TABLE 3.9a Wave height scatter table for Boscombe

Position P14	Wave Direction (Degrees)			
Number of occurrences	120 - 150	150 - 180	180 – 210	Totals
Wave height (m)				
3.5 - 4.0	0	5	0	5
3.0 - 3.5	0	9	7	16
2.5 - 3.0	0	28	18	46
2.0 - 2.5	1	50	66	117
1.5 - 2.0	23	86	287	396
1.0 - 1.5	126	148	825	1099
0.5 - 1.0	263	95	2485	2843
0 - 0.5	103	18	5037	5158
% in sector	5.3	4.5	90.1	9680

Source: Wave modelling for this study
Numbers show occurrences of three hourly wave events over the five-year period

TABLE 3.9b Wave period scatter for Boscombe

Position P14	Wave Period (s)					
	0 - 2	2 - 4	4 - 6	6 - 8	8 - 10	10 - 12
Wave height (m)						
3.5 - 4.0	0	0	0	5	0	0
3.0 - 3.5	0	0	0	12	4	0
2.5 - 3.0	0	0	0	36	10	0
2.0 - 2.5	0	0	33	73	11	0
1.5 - 2.0	0	0	149	225	22	0
1.0 - 1.5	0	25	535	535	4	0
0.5 - 1.0	0	253	1917	642	21	10
0 - 0.5	0	1006	3484	574	86	8

Source: Wave modelling for this study
Numbers show occurrences of three hourly wave events over the five-year period

TABLE 3.10a Wave height scatter table off Poole Harbour Entrance

Position P6 Number of occurrences	Wave Direction (Degrees)				
Wave height (m)	90 - 120	120 - 150	150 - 180	180 – 210	Totals
3.5 - 4.0	0	0	0	0	0
3.0 - 3.5	0	3	0	0	3
2.5 - 3.0	0	17	1	0	18
2.0 - 2.5	0	43	7	0	50
1.5 - 2.0	7	127	38	0	172
1.0 - 1.5	17	186	237	0	440
0.5 - 1.0	23	323	925	0	1271
0 - 0.5	6	260	7455	5	7726
% in sector	0.6	9.9	89.5	0.1	9680

Source: Wave modelling for this study
Numbers show occurrences of three hourly wave events over the five-year period

TABLE 3.10b Wave period scatter off Poole Harbour Entrance

Position P6	Wave Period (s)					
Wave height (m)	0 - 2	2 - 4	4 - 6	6 - 8	8 - 10	10 - 12
3.5 - 4.0	0	0	0	0	0	0
3.0 - 3.5	0	0	0	3	0	0
2.5 - 3.0	0	0	0	18	0	0
2.0 - 2.5	0	0	4	44	2	0
1.5 - 2.0	0	0	110	52	10	0
1.0 - 1.5	0	10	260	142	28	0
0.5 - 1.0	0	112	516	628	14	1
0 - 0.5	0	1162	5228	1215	104	17

Source: Wave modelling for this study
Numbers show occurrences of three hourly wave events over the five-year period

The 1 in 50 year extreme nearshore wave heights estimated during this study for Poole Bay are shown in Figure 2.4 Typically, extreme nearshore waves increase towards the east of the bay, with the 1:50 year nearshore wave typically ranging from 3 to 5m.

The omni-directional extreme wave heights at HR's inshore points are given in Table 3.11. Further details, including directional extremes can be found in Tables 2.32 to 2.39 of HR (1995). However, these values should be treated with caution as wave breaking effects would limit all of these nearshore heights.

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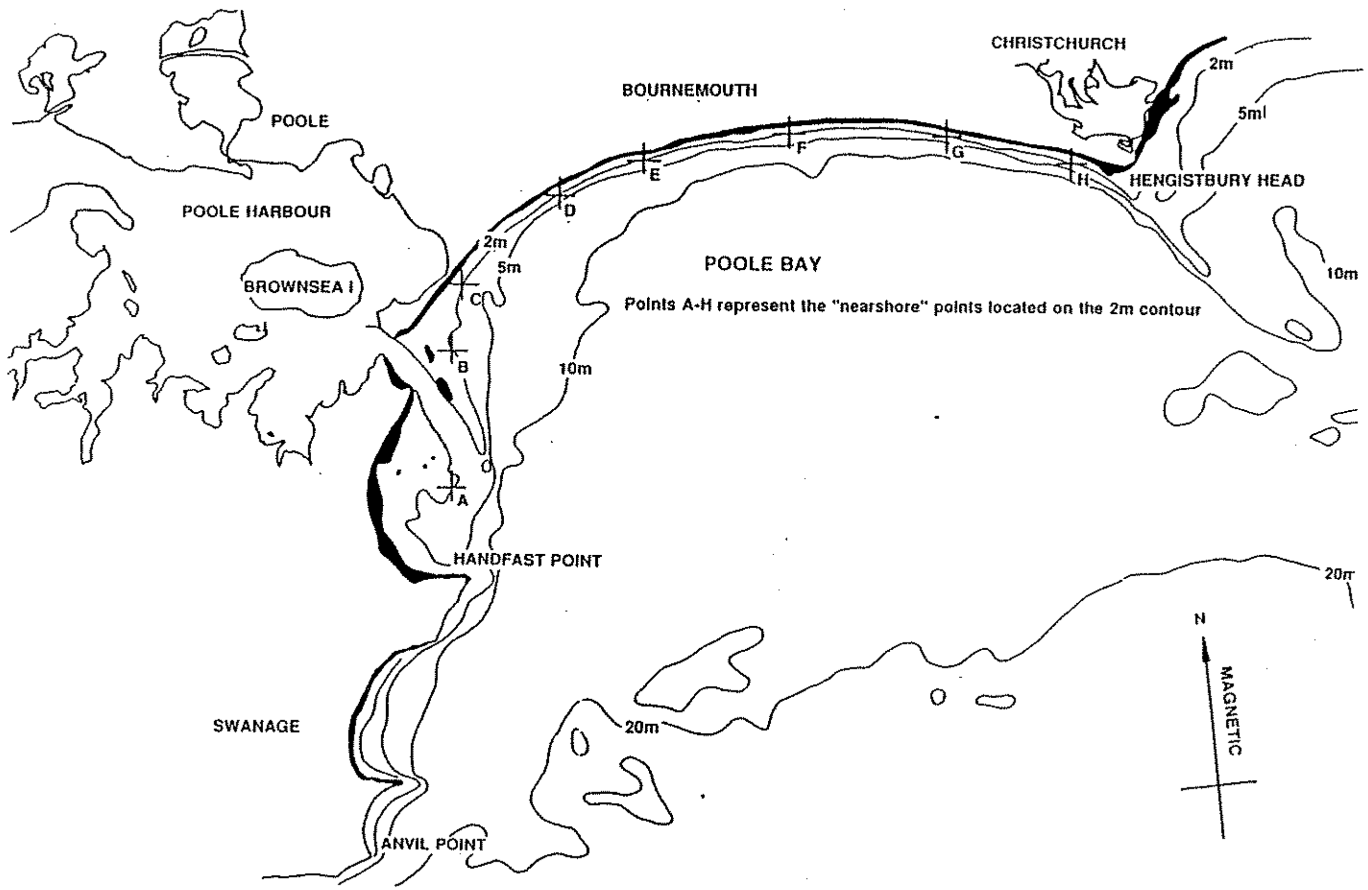

Contours in m (CD)

Figure 3.2 Poole Bay wave analysis locations from HR. (1995)

TABLE 3.11 Extreme Inshore Waves in Poole Bay (HR 1995)

Return Period (Yrs)	Wave Height (m) Inshore Location (Poole bay, see Figure 3.2)							
	A	B	C	D	E	F	G	H
1	4.2	4.4	3.3	4.3	3.9	3.7	4.7	4.4
2	4.7	4.7	3.7	4.8	4.3	4.0	5.2	4.7
5	5.3	5.2	4.1	5.3	4.9	4.4	5.7	5.2
10	5.8	5.6	4.5	5.8	5.3	4.7	6.1	5.5
20	6.3	5.9	4.8	6.2	5.7	5.0	6.6	5.8
50	7.0	6.4	5.3	6.8	6.2	5.5	7.1	6.3
100	7.6	6.7	5.6	7.3	6.6	5.8	7.6	6.6
B*	10.7	11.3	11.0	11.0	10.5	11.0	10.7	10.7

*=The corresponding wave period may be derived from $T_z=B^*\sqrt{H/g}$

The values quoted are for unbroken waves. Wave breaking effects would limit all of these nearshore wave heights

Extreme inshore waves were estimated for a position near Poole Harbour Entrance by Halcrow (1994). The extreme waves obtained are compared below to values from this study in Table 3.12.

TABLE 3.12 Extreme wave heights at Poole Harbour Entrance

Return Period (years)	Halcrow (1994) Hs (m)	This Study Hs (m) Position P4
1	2.1	2.1
5	2.3	2.5
10	2.4	2.6
20	2.5	2.6
50	2.5	2.7
100	2.6	-

The wave modelling undertaken by HR (1995) to derive the inshore wave climate included use of wind-wave hindcasting for 15 years of hourly data and a spectral wave refraction model. HR's analysis therefore differs considerably from Halcrow's analysis for this study, which is based on five years of Met Office model output.

HR's values tend to be significantly higher than those estimated by Halcrow. This is because HR did not take into account wave breaking. However, for the analysis of beach control structures and revetments the extreme values calculated in either case will be depth limited by breaking in shallow water.

It is recommended that for the analysis of beach control structures and revetments the extreme values calculated by Halcrow be adopted. However, it should be noted, as discussed in Section 2.4 that further studies would be necessary for detailed analysis of coastal schemes.

3.3.2 Water Levels

Tidal levels representative of Poole Bay may be predicted for Bournemouth based on data in the ATT. Table 3.13 gives the principal tidal levels.

TABLE 3.13 Tide Levels for Bournemouth

Tidal State	Level at Bournemouth (mOD)
MHWS	+0.6
MHWN	+0.2
MSL	-0.2
MLWN	-0.4
MLWS	-1.1

Source: Admiralty Tide Tables (1998)

Analysis of water level data that has been collected by POL at Bournemouth Pier has been undertaken for this project in order to estimate surge heights. The analysis has derived 61 tidal harmonic constituents, which may be used to derive tide predictions, see Appendix A. Based on the derived harmonic constants, surge heights were also derived from the two years of recorded data. The maximum positive surge found was 0.8m, and maximum negative –0.5m. Based on the limited (two year) data set, a 1m positive surge is estimated to have a return period of between 5 and 10 years and the 1 in 2 year extreme total water level is about 1.4mOD. Tidal ranges based on this latest analysis are slightly larger than given in Table 3.13 above.

The tidal range increases slightly from west to east across Poole Bay. HR (1995) recommended differences in extreme water levels across Poole Bay frontage based on their tidal modelling. Compared to extreme values in Poole Harbour, 7cm should be added to extreme water levels for HR points G and H, 5cm for point F and 3cm for points C, D and E. The difference for points A and B was found to be negligible. These allowances are based on modelled differences in high water levels rather than actual measured data in Poole Bay. (See Figure 3.2 for locations).

To assess the adequacy of the assumption that surge heights in Poole Bay will be the same as in Poole Harbour, the measured total water levels and surge heights for Poole Harbour, North Haven and Bournemouth have been compared. Figure 2.8 shows that this assumption is in fact borne out by the data. There is little difference in the surge heights at the three stations.

It is recommended that for the present the extreme water level estimates derived by HR (1995) should be adopted for Poole Bay. However, these extreme levels appear to be conservative when compared to the Halcrow (1996) estimates and the latest data from the Bournemouth gauge. The tide gauge data for Bournemouth collected by POL presently contains only about two years. It is recommended that this data should be analysed to derive extreme total water levels when say 5 years' data are available.

3.3.3 Tidal Currents

Tidal currents for Poole Bay have been shown to be low, see Figures 2.9 and 2.10. Typically peak tidal currents are less than 0.3m/s. Near to Poole Harbour entrance the flows are significantly influenced by discharges from the Harbour, see Figures 3.3 and 3.4. Tidal currents, when combined with waves will play a significant role in beach sediment transport for the Sandbanks frontage.

The currents along the east face of the Sandbanks peninsula increase in the East Looe channel approaching the Harbour entrance. HR (1994) found from a comparison of historical bathymetry charts that the channel was tending to migrate towards the neck of the Sandbanks peninsula. Beach control structures have been used here to prevent further erosion.

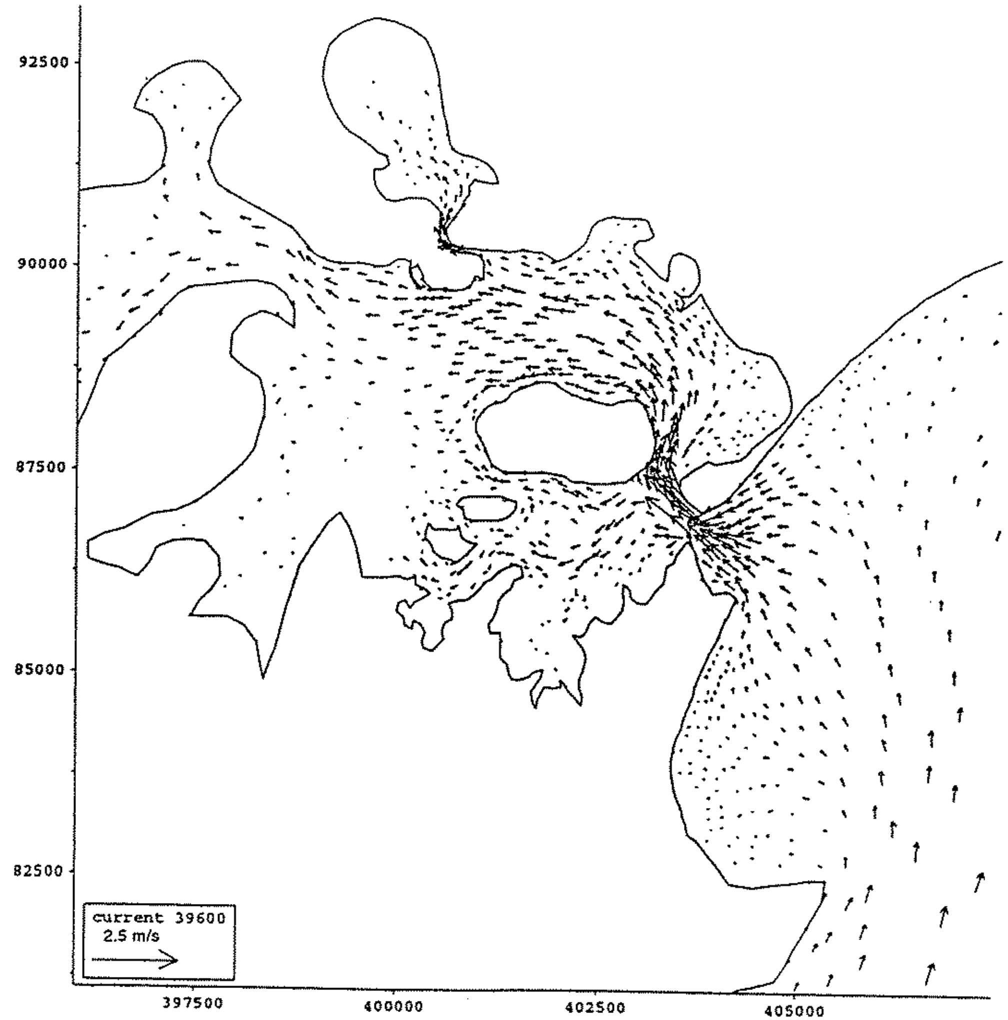

Figure 3.3 Peak flood tide currents in Poole harbour.

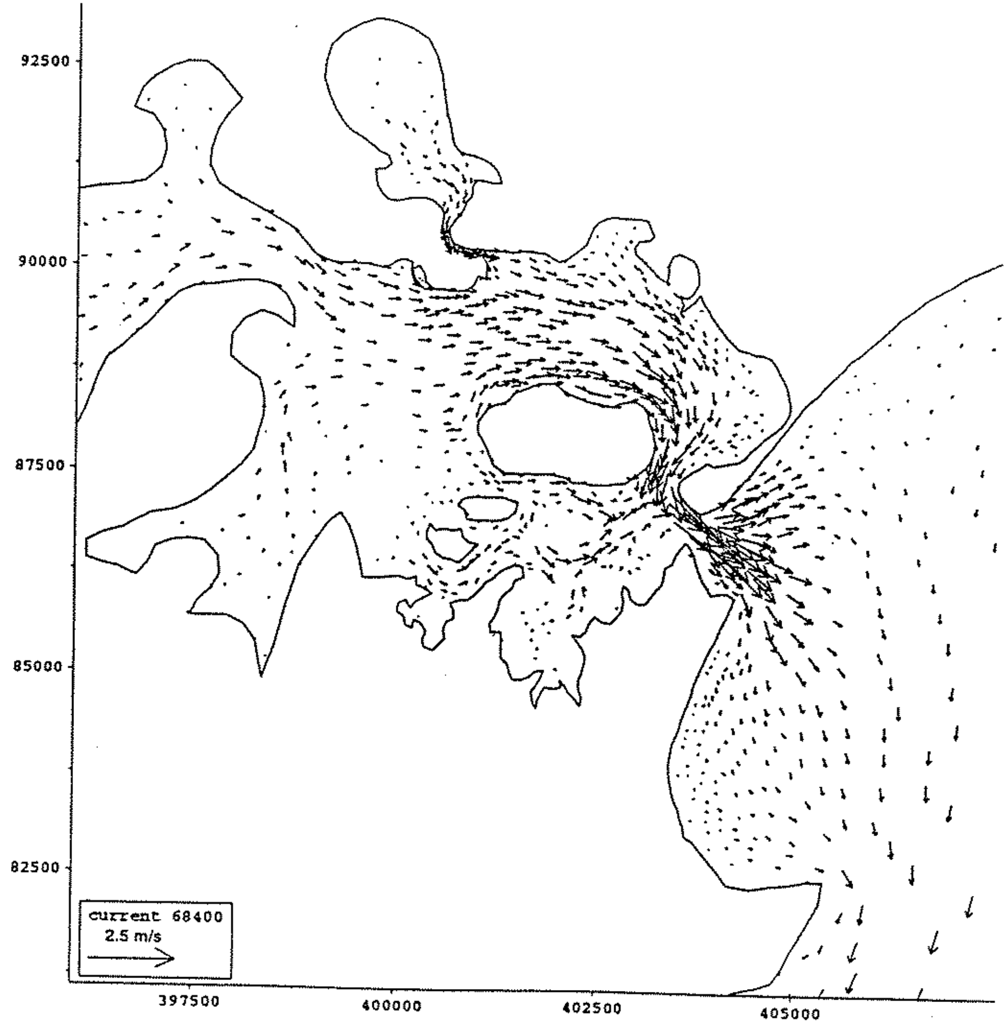

Figure 3.4 Peak ebb tide currents in Poole harbour.

3.4 Area 5F-4 Poole Harbour

3.4.1 Winds

Knowledge of representative wind conditions for Poole Harbour is important for the estimation of locally generated wave conditions. Wind data are recorded by PHC at the harbour Office. Data are also available from Hurn Airport. HR (1995) derived a set of extreme wind conditions, based primarily on data from Hurn Airport, but also taking into account other local sources. Table 3.14 gives wind conditions for estimation of wave heights in Poole Harbour.

TABLE 3.14 Representative wind conditions for Poole Harbour

Direction bound (degs N)	Av. wind speed (m/s)	10% exceedance speed (m/s)	1% exceedance speed (m/s)	1:1 return period speed (m/s)	1:100 return period speed (m/s)	Percentage data in sector
-15 to 15	4.3	8.2	11.7	15.2	20.8	0.1
15 to 45	4.7	8.3	10.8	13.6	17.7	9.1
45 to 75	4.0	7.1	9.2	11.0	14.6	8.7
75 to 105	3.9	7.3	9.3	11.4	15.5	5.0
105 to 135	5.5	9.9	13.3	15.8	21.4	4.0
135 to 165	5.4	9.7	13.8	17.6	23.9	3.9
165 to 195	6.9	12.0	18.2	23.3	31.3	8.0
195 to 225	7.9	13.2	18.4	23.5	29.9	10.3
225 to 255	7.1	11.2	17.3	22.2	28.7	16.0
255 to 285	6.0	10.6	15.8	21.0	28.3	11.6
285 to 315	4.1	9.1	13.7	17.0	22.5	9.1
315 to 345	3.9	8.3	12.0	16.1	23.3	6.2

3.4.2 Wave Climate

The wave climate inside Poole Harbour is almost entirely dominated by waves generated over the local fetches within the Harbour. This has been investigated using Halcrow's grid based wave model and a detailed bathymetry grid. Extreme offshore waves derived for a position outside Poole Harbour entrance were used as boundary conditions for the model. However, the model results showed that extreme storm waves do not penetrate significantly into the harbour entrance due to the dissipation of the wave energy by refraction onto the banks, and diffraction through the entrance.

The wind data has been used to derive extreme wave heights within Poole Harbour and the results are shown in Table 3.15. The locations referred to are shown on Figure 3.5.

TABLE 3.15 1:100 year wave conditions in Poole Harbour

	Wave Hindcast Location (inside Poole Harbour)												
	A	B	C	D	E	F	G	H	I	J	K	L	M
Hs	0.7	0.9	0.5	0.9	0.9	0.8	0.9	1.1	0.9	0.7	1.0	1.2	0.9
Tm	2.6	3.0	2.2	3.0	3.1	2.9	3.1	3.4	3.0	2.1	3.1	3.4	3.0

Source: HR(1995) Points A to I, Points J to M this study

Much of Poole Harbour is shallow with very flat bed slopes. At high tide water depths over the inter-tidal flats may be of the order of a metre, whilst at low water large areas of tidal flats are exposed. The shallow water means that even the small locally generated waves will be depth limited at many of the defences, where it is appropriate to use a design breaking significant wave height of 0.55 times the water depth. For design considerations, it is therefore of most importance that adequate allowances for tide and surge levels are made.

The wave climate is most severe for positions along the north coast that are exposed to the south and south west. Here the typical conditions at high water for 1:1, 1:10 and 1:100 year conditions are 0.6, 0.8 and 1m respectively.

3.4.3 Water Levels

As discussed in Section 2.5, tide predictions for Poole North Haven are available from the ATT. Principal tidal levels are given in Table 3.16. It should be noted that the predicted levels from Admiralty data have been found by PHC to underestimate the tidal levels, as has been found by the harmonic analysis for this study, see Figure 2.7. PHC use a level of 0.86m for MHWS.

TABLE 3.16 Tide Levels for Poole North Haven

Tidal State	Level at North Haven (mOD)
MHWS	+0.9
MHWN	+0.3
MSL	+0.2
MLWN	-0.1
MLWS	-0.8

Source: Admiralty tide tables (1998) and PHC

Recorded data from the RoRo terminal and North Haven have been analysed for this study, in order to allow a comparison of surge heights. The resulting harmonic constituents, see Appendix A, can be used to calculate predicted tidal levels. These constituents give slightly greater tidal ranges than predicted in the ATT.

The ATT (1998) comments that in Poole Harbour the tide is above mean water level from about 2 hours after Low Water to about 2 hours before the next. In addition, it is mentioned that strong and continuous winds from the East through South to South West may raise levels by as much as 0.2m, whilst winds from the West through North to North East may lower levels by up to 0.1m. Barometric pressure effects are also appreciable.

Extreme water levels were estimated by HR (1995) from less than two years of recorded data supplied by PHC. Ideally, the recording period would have been much longer to get reliable estimates for longer return period events. However, Reading University have recently undertaken an analysis of monthly and annual maxima for 18 years of data from Poole Town Quay and found very similar results to those of HR, Table 3.17 shows this comparison.

The tidal numerical modelling undertaken by HR (1995) for Poole Harbour, suggested that there is no significant difference in extreme water levels for different locations within Poole Harbour. This has been further confirmed by the analysis of recorded tidal data in Bournemouth and Poole Harbour (See Appendix A). The surge heights at the RoRo terminal are very similar to those at North Haven.

It is noted that the extreme levels given in Table 3.16 are significantly lower than the levels estimated by Dixon and Tawn (1997) for the open coast, see Table 2.7. However, the resolution of the tide and surge model operated by POL is around 30km and is only applicable to the open coast. It may be that the tidal assymetry

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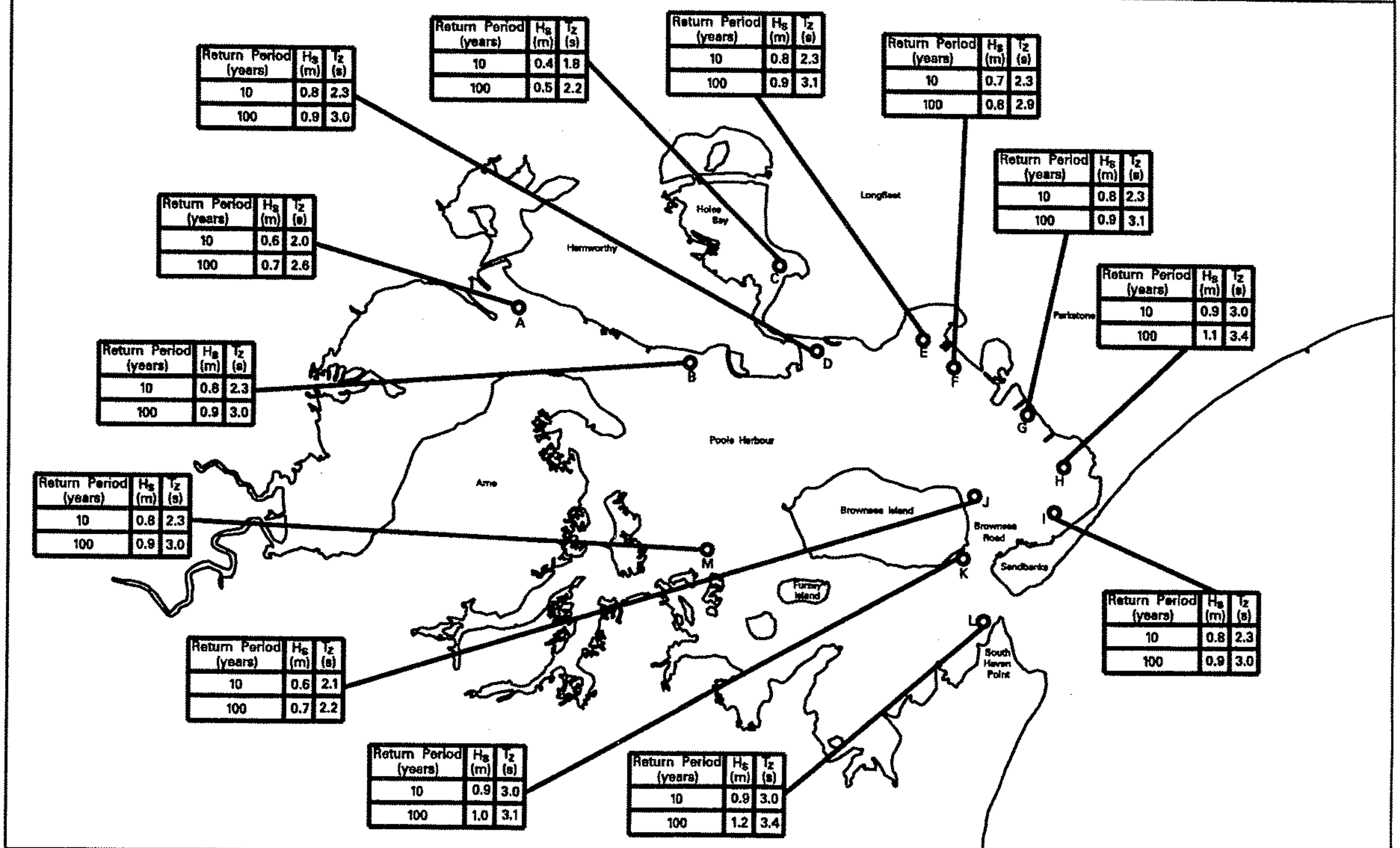

Return Period (years)	H_s (m)	T_z (s)
10	0.8	2.3
100	0.9	3.0

Return Period (years)	H_s (m)	T_z (s)
10	0.4	1.8
100	0.5	2.2

Return Period (years)	H_s (m)	T_z (s)
10	0.8	2.3
100	0.9	3.1

Return Period (years)	H_s (m)	T_z (s)
10	0.7	2.3
100	0.8	2.9

Return Period (years)	H_s (m)	T_z (s)
10	0.8	2.3
100	0.9	3.1

Return Period (years)	H_s (m)	T_z (s)
10	0.6	2.0
100	0.7	2.6

Return Period (years)	H_s (m)	T_z (s)
10	0.9	3.0
100	1.1	3.4

Return Period (years)	H_s (m)	T_z (s)
10	0.8	2.3
100	0.9	3.0

Return Period (years)	H_s (m)	T_z (s)
10	0.8	2.3
100	0.9	3.0

Return Period (years)	H_s (m)	T_z (s)
10	0.8	2.3
100	0.9	3.0

Return Period (years)	H_s (m)	T_z (s)
10	0.6	2.1
100	0.7	2.2

Return Period (years)	H_s (m)	T_z (s)
10	0.9	3.0
100	1.0	3.1

Return Period (years)	H_s (m)	T_z (s)
10	0.9	3.0
100	1.2	3.4

Figure 3.5 Extreme wave heights in Poole harbour.

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and spatial variation is too complex for the model to be representative for the study area. Both the work by HR (1995) and the comparison of surge levels at Bournemouth and Poole Harbour undertaken for this study suggest that there is little difference in surge levels at the RoRo, North Haven or Bournemouth. This implies that interpolation from the Dixon and Tawn estimates is inappropriate for Poole Bay.

TABLE 3.17 Extreme Water Levels in Poole Harbour

	Water Level (mOD)	
Return Period (Yrs)	HR (1995)	Reading Univ (1998)
1	1.4	-
2	1.5	-
5	1.5	-
10	1.6	1.6
20	1.7	1.7
50	1.8	1.8
100	1.8	1.8
150	-	-
200	-	1.9

The analysis by Reading University identified a secular trend of about 5mm/yr in extreme water levels between 1955 and 1997. This is larger than the trend found for the two closest analysis locations of Dixon and Tawn and greater than found in other studies for Southampton and for Newlyn, but similar to that found for Portsmouth (see Bray et al 1994). However, there are concerns that there was a discontinuity in the Poole data in 1979, prior to which a different water level gauge was used. It is therefore recommended that the 6mm/yr future mean sea level rise allowance is adopted for the present, as for the rest of sub-cell 5F (see Section 2.5.5).

This trend needs to be taken into account when designing coastal defences. In addition to the past secular trend it is also necessary to make allowances for predicted future changes in mean level due to Global Warming, see Section 2.5.5.

It is recommended that the extreme water levels derived by HR be adopted for management purposes.

3.4.4 Tidal Currents

There have been a number of studies of tidal currents and water levels within Poole Harbour. These have included several by Falconer (1984) and more recent studies by HR (1994, 1995). Falconer undertook studies of the dispersal of effluents and the impacts of construction of the bridge / bund across Holes Bay. HR have studied the impacts of the deepening of the shipping channel and more recently the impact of tidal flows on sediment movements with respect to shoreline management.

Peak spring ebb and flood tidal flow vectors are shown in Figures 3.3 and 3.4, taken from HR (1995). Within Poole Harbour the peak ebb flow generally occurs at or just before low water, when strong currents occur between Poole Town Quay and Sandbanks (Figure 3.4). The flood tide commences about an hour after low water with peak flood tidal currents occurring at about three hours after low water. The first high water occurs at 6 hours after low water and corresponds to virtually quiescent conditions. Tidal flows change direction at about seven hours after low water, but flow rates drop significantly at nine hours due to the second high water.

At ten hours after low water, a strong ebb flow has set in again, reaching peak current speeds at around low water

The strongest tidal currents occur in the entrance to the Harbour approximately 2.0 m/s. Tidal flows around most of the periphery of Poole Harbour, Holes Bay and Lychett Bay are generally low. Strong currents are largely limited to the main channel from the entrance to the Town Quay / boat haven area, and the constricted entrances to Holes Bay and Lychett Bay. Typical maximum tidal currents in the main channel are approximately 0.5 m/s. The strong flows from the Backwater channel at the Holes Bay entrance affect the Town Quay frontage.

3.5 Area 5F-5 South Haven Point to Handfast Point (Studland Bay)

3.5.1 Wave Climate

Studland Bay is very sheltered from the dominant south westerly wave climate by Handfast Point. The main wave exposure is to locally generated waves from within Poole Bay. For waves transformed from offshore, Studland Bay has some of the smallest extreme wave heights of the study frontage, see Figure 2.4.

Table 3.18a and b below give the nearshore wave frequency data from the wave modelling.

TABLE 3.18a Nearshore Wave height frequency table for Studland Bay

Location P4	Wave Direction (Degrees)			
Number of occurrences	90 - 120	120 - 150	150 - 180	Totals
Wave height (m)				
3.5 - 4.0	0	0	0	0
3.0 - 3.5	4	1	0	1
2.5 - 3.0	14	15	0	15
2.0 - 2.5	27	29	0	29
1.5 - 2.0	83	88	0	88
1.0 - 1.5	71	337	0	337
0.5 - 1.0	104	1008	7	1015
0 - 0.5	16	4933	2943	7876
% in sector	3.4	68.5	31.5	9361

Source: Wave modelling for this study
Numbers show occurrences of three hourly wave events over the five-year period

TABLE 3.18b Wave period scatter for Studland Bay

Position P4	Wave Period (s)					
	0 - 2	2 - 4	4 - 6	6 - 8	8 - 10	10 - 12
Wave height (m)						
3.5 - 4.0	0	0	0	0	0	0
3.0 - 3.5	0	0	0	5	0	0
2.5 - 3.0	0	0	0	28	1	0
2.0 - 2.5	0	0	8	47	1	0
1.5 - 2.0	0	0	126	35	10	0
1.0 - 1.5	0	12	262	121	13	0
0.5 - 1.0	0	124	457	508	29	1
0 - 0.5	0	1148	5265	1358	104	17

Source: Wave modelling for this study
Numbers show occurrences of three hourly wave events over the five-year period

Extreme locally generated waves have been estimated for comparison to those derived from waves transformed from offshore, see Table 3.19.

TABLE 3.19 Estimates of extreme wave heights for Studland Bay

	Locally Generated Waves		Transformed Waves	
Return Period (Years)	Hs (m)	Tp (s)	Hs (m)	Tp (s)
1	1.0	3.9	2.2	7.0
50	1.3	4.4	3.0	8.2

Source: Estimates for this study

3.5.2 Water levels and Tidal currents

There are no tidal records available for this frontage. Information on water levels for this frontage would be represented by consideration of information at Poole North Haven (see Section 3.4) and Swanage to a lesser degree (see Section 3.6). Similarly relevant information on tidal currents is limited or is covered in Section 3.4 and 3.6.

3.6 Area 5F-6 Handfast Point to Peveril Point (Swanage Bay)

3.6.1 Wave Climate

Swanage Bay is enclosed and protected by the two major headlands of Ballard Point to the north and Peveril Point to the south. The bay is deeply indented and thus the only direct major wave generating fetch is in an easterly direction. Large storm or swell waves propagating up the English Channel would have to diffract around both Durlston Head and Peveril Point to enter the bay. The bed slope in the bay is typically 1:100, which when combined with the small tidal range means that most storm waves penetrating the bay will be depth limited.

The wave climate for the Swanage Bay area has been studied previously by HR (1986, 1987), by Halcrow (1994) and in the ongoing Beach Management Study for Swanage Bay (Halcrow (1998).

HR undertook wave modelling studies for the yacht marina that was proposed for the south end of Swanage Bay. The preliminary studies (HR 1986) described wave prediction and refraction calculations leading to a representative wave climate and extremes for the marina. Subsequently HR (1987) undertook further investigations for the marina, which included derivation of the inshore wave climate for two further points in the bay. HR also undertook an investigation of the impacts of the proposed marina on the littoral drift regime in the bay.

HR used hourly wind speed and direction data from Portland between 1974 and 1983 to hindcast the offshore wave climate. The wind data was calibrated to be representative of conditions at sea by comparison to records from the Shambles Light Vessel. A wave ray back tracking model was used by HR to refract the waves to three nearshore study points. A short period of measured inshore wave data (29 January to 6 April 1987) was used for further calibration and validation of the wave model results. The inshore data were measured with a pressure sensor gauge at Swanage Pier. The inshore points studied by HR were located at the end of Swanage Pier, near the Mowlem Theatre and adjacent to Tanville Ledges. The extreme wave heights at the three inshore points are given in Table 3.20 below. Note that the extrapolation to extremes will not take into account depth limitation.

TABLE 3.20 Inshore Extreme wave heights from HR Report EX1573

Return period (years)	Significant Wave Height (m)		
	Swanage Pier (bed level~4mCD)	The Mowlem (bed level~1mCD)	Tanville Ledges (bed level~1mCD)
0.5	2.9	3.1	3.2
1	3.0	3.3	3.4
2	3.2	3.6	3.6
5	3.4	3.9	3.9
10	3.6	4.1	4.1
20	3.7	4.3	4.3
50	3.9	4.6	4.5
100	4.1	4.9	4.7

Source: HR(1987)

A scatter table showing the modelled nearshore wave climate for central Swanage Bay, position S203 from the wave modelling for this study is shown in Table 3.21 below.

TABLE 3.21a Nearshore Wave height frequency table for Swanage Bay

position s203 Number of occurrences	Wave Direction (Degrees)			
Wave height (m)	90 - 120	120 - 150	150 - 180	Totals
3.5 - 4.0	0	0	0	0
3.0 - 3.5	3	0	0	3
2.5 - 3.0	17	0	0	17
2.0 - 2.5	42	18	0	60
1.5 - 2.0	123	123	0	246
1.0 - 1.5	132	585	0	717
0.5 - 1.0	180	1462	352	1994
0 - 0.5	40	1192	5411	6643
% in sector	5.5	34.9	59.5	9680

Source: Wave modelling for this study
Numbers show occurrences of three hourly wave events over the five-year period

TABLE 3.21b Wave period scatter for Swanage Bay

Position s203	Wave Period (s)					
	0 - 2	2 - 4	4 - 6	6 - 8	8 - 10	10 - 12
Wave height (m)						
3.5 - 4.0	0	0	0	0	0	0
3.0 - 3.5	0	0	0	3	0	0
2.5 - 3.0	0	0	0	17	0	0
2.0 - 2.5	0	0	5	42	13	0
1.5 - 2.0	0	0	112	101	33	0
1.0 - 1.5	0	4	261	447	5	0
0.5 - 1.0	0	124	1027	832	10	1
0 - 0.5	0	1156	4713	660	97	17

Source: Wave modelling for this study
Numbers show occurrences of three hourly wave events over the five-year period

Nearshore extremes derived from the present wave modelling for Swanage Bay are given in Table 3.22.

TABLE 3.22 Extreme wave heights for Swanage Bay

	Northern Swanage Bay (S204)	Peveril Point (S202)
Return period (years)	Significant Wave Height (m)	Significant Wave Height (m)
1	2.3	3.7
5	2.7	4.6
10	3.0	5.0
20	3.2	5.3
50	3.5	5.6

Source: Halcrow modelling for this study

The mathematical modelling for the ongoing Beach management study for Swanage Bay (Halcrow 1998) has also included more detailed wave modelling with a 20m resolution grid in order to undertake beach evolution modelling. More detailed information on the variation in the nearshore wave climate around the bay is available from this study.

3.6.2 Water Levels

There are no long term tide gauge records available from this part of the study frontage. Swanage is a Secondary Port to Portsmouth in the and tide predictions are possible based on the ATT data. Principal tidal levels for Swanage are given in Table 3.23 below.

TABLE 3.23 Tide Levels for Swanage Bay

Tidal State	Level at Swanage (mOD)
MHWS	+0.6
MHWN	+0.2
MSL	-0.15
MLWN	-0.3
MLWS	-1.1

Source: Admiralty tide tables

Extreme water levels may be derived from Dixon and Tawn's (1997) study of the UK coast and the interpolated results for Swanage are shown in Table 3.24.

TABLE 3.24 Extreme Water Levels for Swanage Bay

Return Period (years)	Water Level (mOD) at Swanage
1	1.7
10	2.0
25	2.2
50	2.3
100	2.5

3.6.3 Tidal Currents

There appears to be little information available on tidal currents in Swanage Bay. Admiralty Chart 2172 shows that there are strong currents offshore from Peveril Point on the ebb tide, but gives no information on the magnitude.

During their investigations for the proposed Swanage Yacht Haven adjacent to Swanage Pier, HR undertook a mathematical modelling study of the tidal flows (HR, 1987). The model simulated flow patterns for spring and neap tides. The flow patterns were found to be complex with a large tidal eddy forming in Swanage Bay during much of the flood tide. Maximum tidal flows within the bay occur at about 4 hours before LW mid ebb with currents typically less than 0.5 m/sec. The south going current speeds reduce during the ebb, starting to reverse just after LW. As the flood tide commences (LW+1hr), flow is northwards within the bay (<0.2m/s) and an eddy starts to the north of Peveril Point. This eddy expands as the flow accelerates, until at LW+3hrs the eddy occupies virtually all of the bay, with the flow directed southwards adjacent to the shore. Current speeds reduce in the eddy, until it breaks up around high water. The neap tide simulation showed similar results with smaller velocities. The results therefore show a slight southerly tidal residual.

Tidal flow pattern figures supplied by the local sailing club tend to confirm the above model results. The figures appear to be based on observations, although there is a reference to a Dorset Underwater Survey 1978.

3.7 Area 5F-7 Peveril Point to Durlston Head (Durlston Bay)

Tidal information for Durlston Bay will be well represented by the data for Peveril Point and Swanage presented in Section 3.6. Durlston Bay is separated from Swanage Bay by Peveril Point and the Peveril Ledge which effectively separates the two bays in terms of sediment movement. Durlston Bay comprises coarse sediments whilst Swanage Bay has a self enclosed beach of predominantly sand with some shingle towards the northern end.

There is one nearshore wave model position in Durlston Bay from the present study. The nearshore wave frequency data from the wave modelling study are shown in Table 3.25 and the extreme wave heights are given in Table 3.26.

TABLE 3.25a Nearshore Wave height frequency table for Durlston Bay

Position s201	Wave Direction (Degrees)			
Number of occurences	90 - 120	120 - 150	150 - 180	Totals
Wave height (m)				
3.5 - 4.0	0	0	0	0
3.0 - 3.5	2	1	0	3
2.5 - 3.0	8	23	9	40
2.0 - 2.5	26	65	46	137
1.5 - 2.0	76	152	249	477
1.0 - 1.5	80	187	1059	1326
0.5 - 1.0	96	219	2506	2821
0 – 0.5	14	90	4716	4876
% in sector	3.1	7.6	88.7	9680

Source: Wave modelling for this study
Numbers show occurrences of three hourly wave events over the five-year period

TABLE 3.25b Nearshore Wave period frequency table for Durlston Bay

Position s201	Wave Period (s)					
	0 - 2	2 - 4	4 - 6	6 - 8	8 - 10	10 - 12
Wave height (m)						
3.5 - 4.0	0	0	0	0	0	0
3.0 - 3.5	0	0	0	3	0	0
2.5 - 3.0	0	0	0	25	15	0
2.0 - 2.5	0	0	2	113	22	0
1.5 - 2.0	0	0	176	294	7	0
1.0 - 1.5	0	18	665	640	3	0
0.5 - 1.0	0	292	2061	441	21	6
0 - 0.5	0	974	3214	586	90	12

Source: Wave modelling for this study
Numbers show occurrences of three hourly wave events over the five-year period

TABLE 3.26 Extreme wave heights for Durlston Bay

	Durlston Bay (S201)
Return period (years)	Significant Wave Height (m)
1	2.9
5	3.1
10	3.1
20	3.1
50	3.2

Source: Wave modelling for this study

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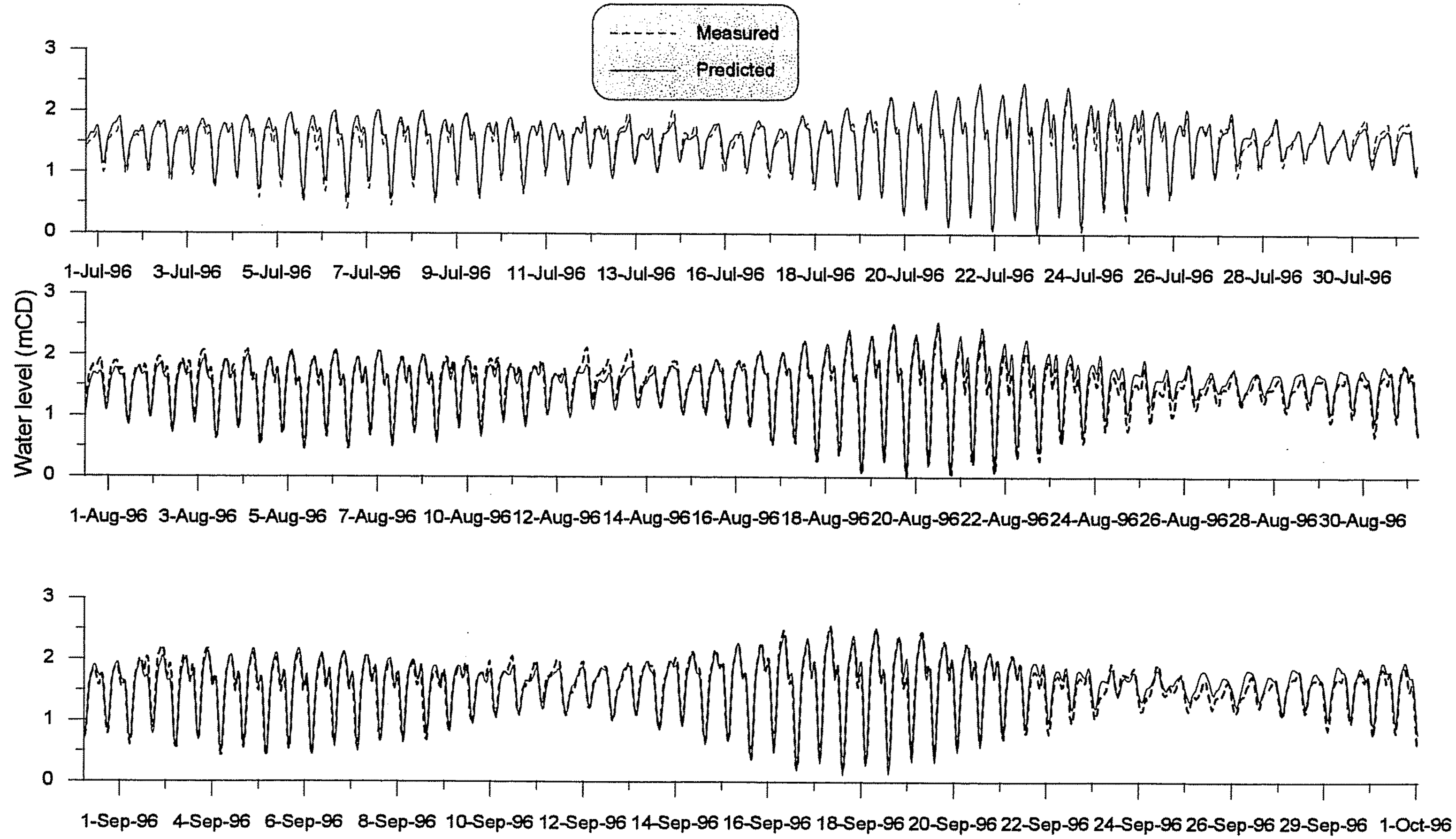
Appendix A

Appendix A: Tidal Harmonic Constituents for Poole Harbour, North Haven & Bournemouth

	Bournemouth		North Haven		Poole Harbour (Ro-Ro)	
HARMONIC NAME	AMPLITUDE (m)	PHASE (Deg)	AMPLITUDE (m)	PHASE (Deg)	AMPLITUDE (m)	PHASE (Deg)
SA	0.0548	302.59	0.0415	321.57	0.0701	321.91
SSA	0.0485	124.82	0.0261	112.14	0.0332	139.57
MM	0.0272	58.20	0.0033	268.95	0.0134	224.12
MSF	0.0068	107.65	0.0135	65.49	0.0108	191.75
MF	0.0089	121.04	0.0082	76.29	0.0029	75.62
2Q1	0.0064	289.60	0.0075	257.74	0.0067	247.26
SIG1	0.0066	305.60	0.0075	302.44	0.0067	299.02
Q1	0.0064	307.10	0.0084	328.97	0.0085	333.67
RHO1	0.0022	331.31	0.0045	271.54	0.0060	267.54
O1	0.0436	339.47	0.0404	350.94	0.0408	352.88
MP1	0.0022	330.15	0.0106	195.27	0.0083	195.15
M1	0.0081	114.65	0.0118	81.85	0.0099	85.01
CHI1	0.0023	238.59	0.0079	3.10	0.0075	0.89
PI1	0.0052	317.79	0.0059	302.75	0.0058	304.91
P1	0.0328	108.20	0.0356	114.14	0.0334	110.62
S1	0.0088	59.01	0.0147	66.61	0.0121	58.24
K1	0.0887	117.48	0.0938	122.37	0.0900	118.21
PSI1	0.0022	139.30	0.0043	129.36	0.0036	129.16
PHI1	0.0010	66.35	0.0038	150.54	0.0041	140.45
THE1	0.0063	55.26	0.0073	31.16	0.0080	32.61
J1	0.0104	209.31	0.0073	215.40	0.0071	211.92
SO1	0.0102	279.20	0.0133	287.84	0.0123	289.87
OO1	0.0131	266.74	0.0127	285.05	0.0115	280.93
OQ2	0.0070	344.32	0.0027	319.68	0.0031	320.96
MNS2	0.0208	158.55	0.0151	172.80	0.0162	158.87
2N2	0.0198	200.69	0.0093	229.26	0.0090	215.17
MU2	0.0689	192.00	0.0605	211.39	0.0638	205.26
N2	0.1076	249.03	0.1123	267.15	0.1146	259.14
NU2	0.0132	278.81	0.0153	298.35	0.0134	295.57
OP2	0.0069	63.46	0.0060	92.49	0.0061	68.48
M2	0.4185	273.36	0.4127	289.11	0.4319	282.38
MKS2	0.0084	234.95	0.0053	243.12	0.0061	237.97
LAM2	0.0127	57.99	0.0098	90.86	0.0099	76.61
L2	0.0186	75.42	0.0118	101.44	0.0131	93.72
T2	0.0092	284.05	0.0099	288.19	0.0120	283.38
S2	0.1882	291.87	0.1770	308.03	0.1891	303.44
R2	0.0040	327.34	0.0025	358.38	0.0010	41.45
K2	0.0511	297.62	0.0525	307.27	0.0554	304.23
MSN2	0.0088	298.41	0.0085	315.93	0.0080	303.98
KJ2	0.0041	142.52	0.0050	157.33	0.0059	148.97
2SM2	0.0110	323.83	0.0108	1.94	0.0088	350.47
MO3	0.0069	286.61	0.0075	327.66	0.0054	325.26
M3	0.0092	14.97	0.0087	61.74	0.0089	43.78
SO3	0.0014	71.39	0.0022	43.76	0.0021	99.23
MK3	0.0092	135.38	0.0096	174.85	0.0097	151.06
SK3	0.0047	218.40	0.0050	251.73	0.0051	232.75
MN4	0.0659	357.23	0.0674	39.84	0.0629	21.54
M4	0.1850	22.99	0.2091	63.57	0.1929	47.37
SN4	0.0096	100.52	0.0170	161.37	0.0141	135.65
MS4	0.1170	77.90	0.1362	123.97	0.1228	106.04
MK4	0.0346	83.56	0.0354	128.74	0.0332	110.41
S4	0.0068	147.93	0.0126	239.82	0.0105	215.74
SK4	0.0043	166.19	0.0033	250.29	0.0034	207.54
2MN6	0.0395	56.50	0.0402	116.43	0.0355	79.49
M6	0.0707	81.71	0.0745	142.06	0.0637	105.40
MSN6	0.0199	104.96	0.0168	165.82	0.0180	124.12
2MS6	0.0723	124.81	0.0723	183.82	0.0641	147.71
2MK6	0.0211	132.32	0.0211	189.13	0.0203	152.01
2SM6	0.0196	176.28	0.0166	244.28	0.0154	199.17
MSK6	0.0119	181.93	0.0086	233.48	0.0092	192.10
M8	0.0060	359.38	0.0033	11.38	0.0105	79.05

Source: Analysis for this study

Example results for July, August and September 1996



Note: Harmonic constants derived are based on analysis of the full data set from July 1996 to June 1998

Figure A.1 Harmonic analysis of water level data from Bournemouth.

Surge Heights: July 1996 to June 1998

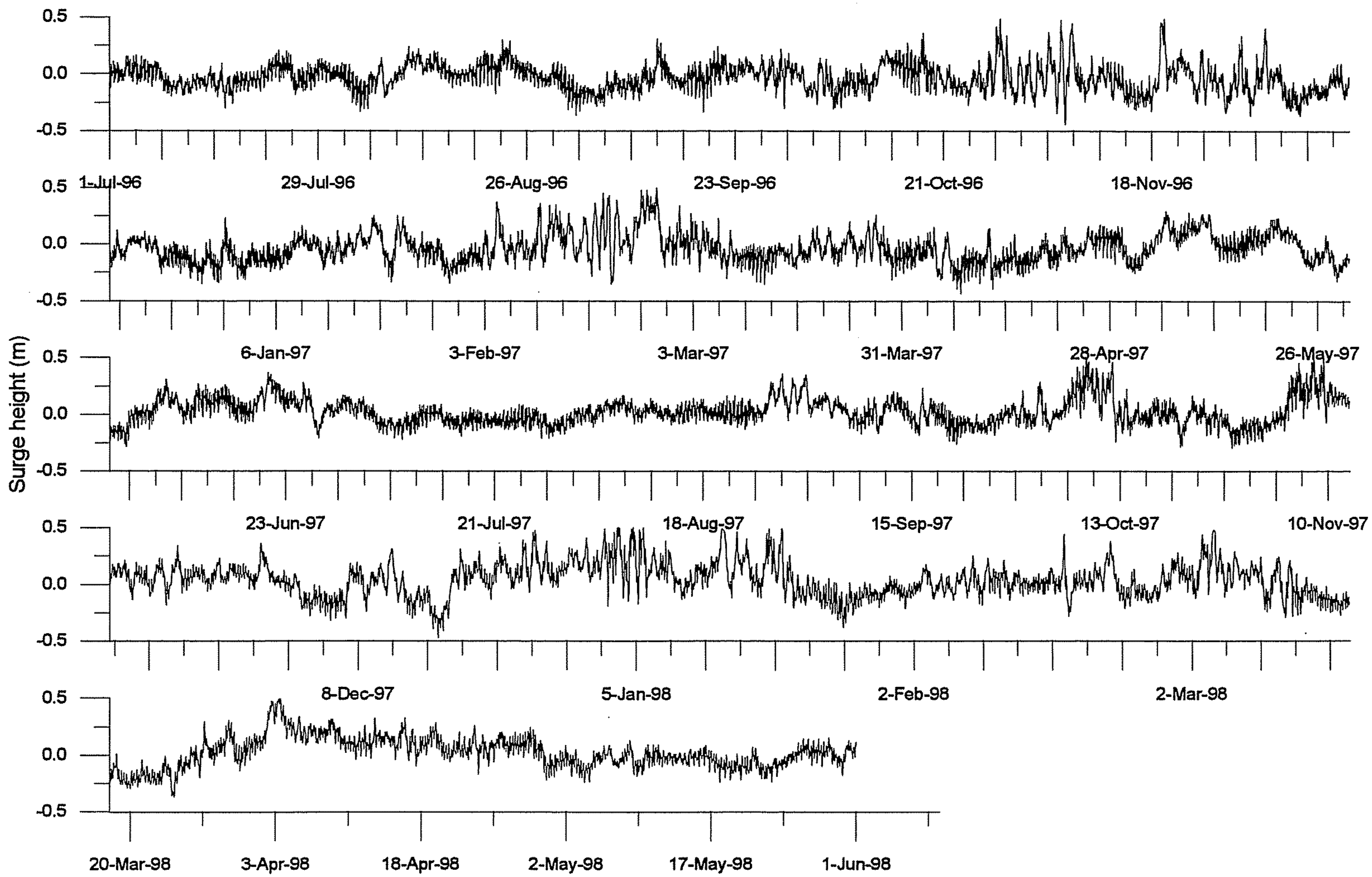


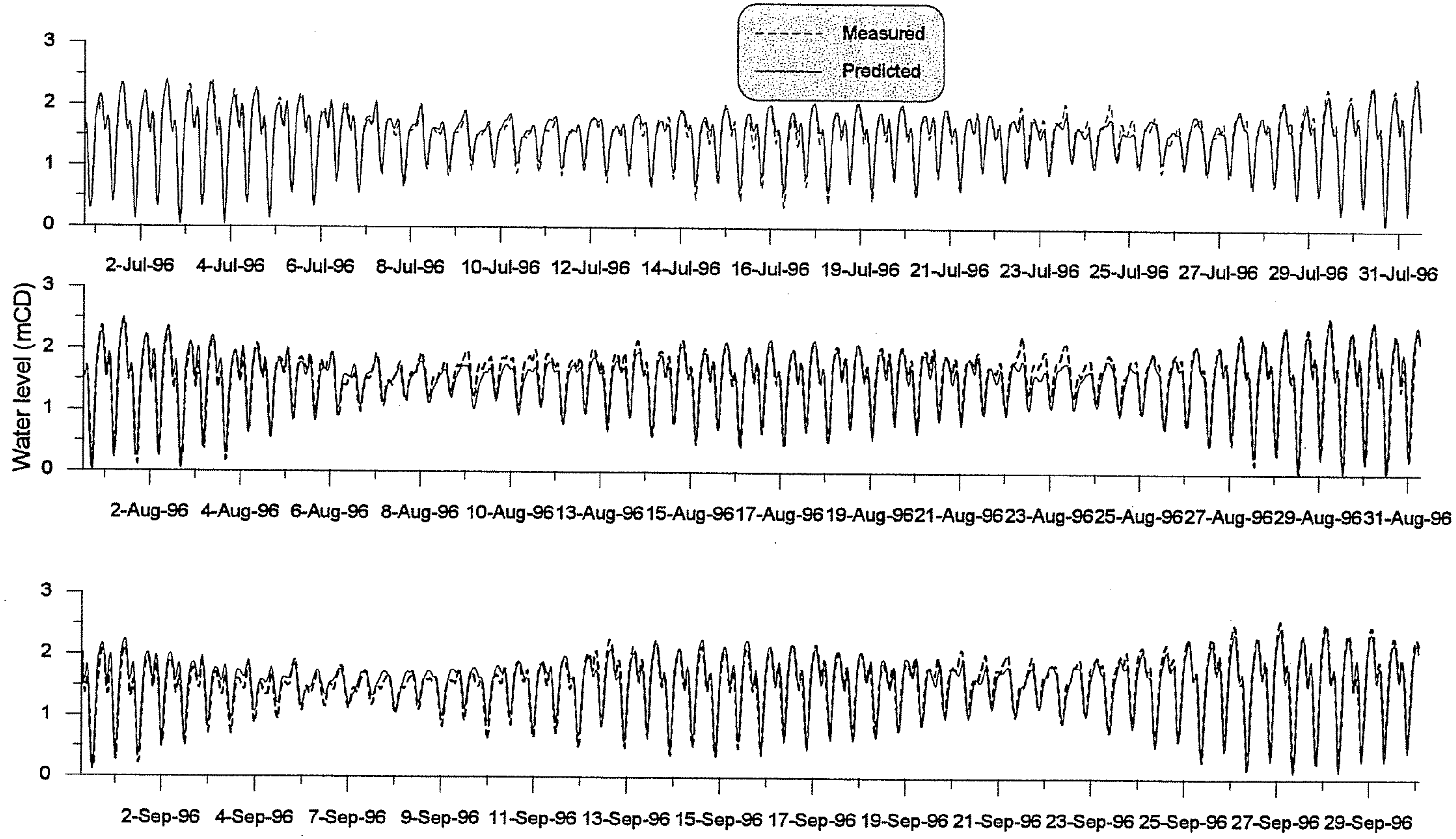
Figure A.2 Analysis of Bournemouth water level data.

Poole and Christchurch Bays Coastal Group

POOLE AND CHRISTCHURCH BAYS
Durlston Head to Hurst Spit (Subcell 5F)
SHORELINE MANAGEMENT PLAN - STAGE 2

Halcrow 1999

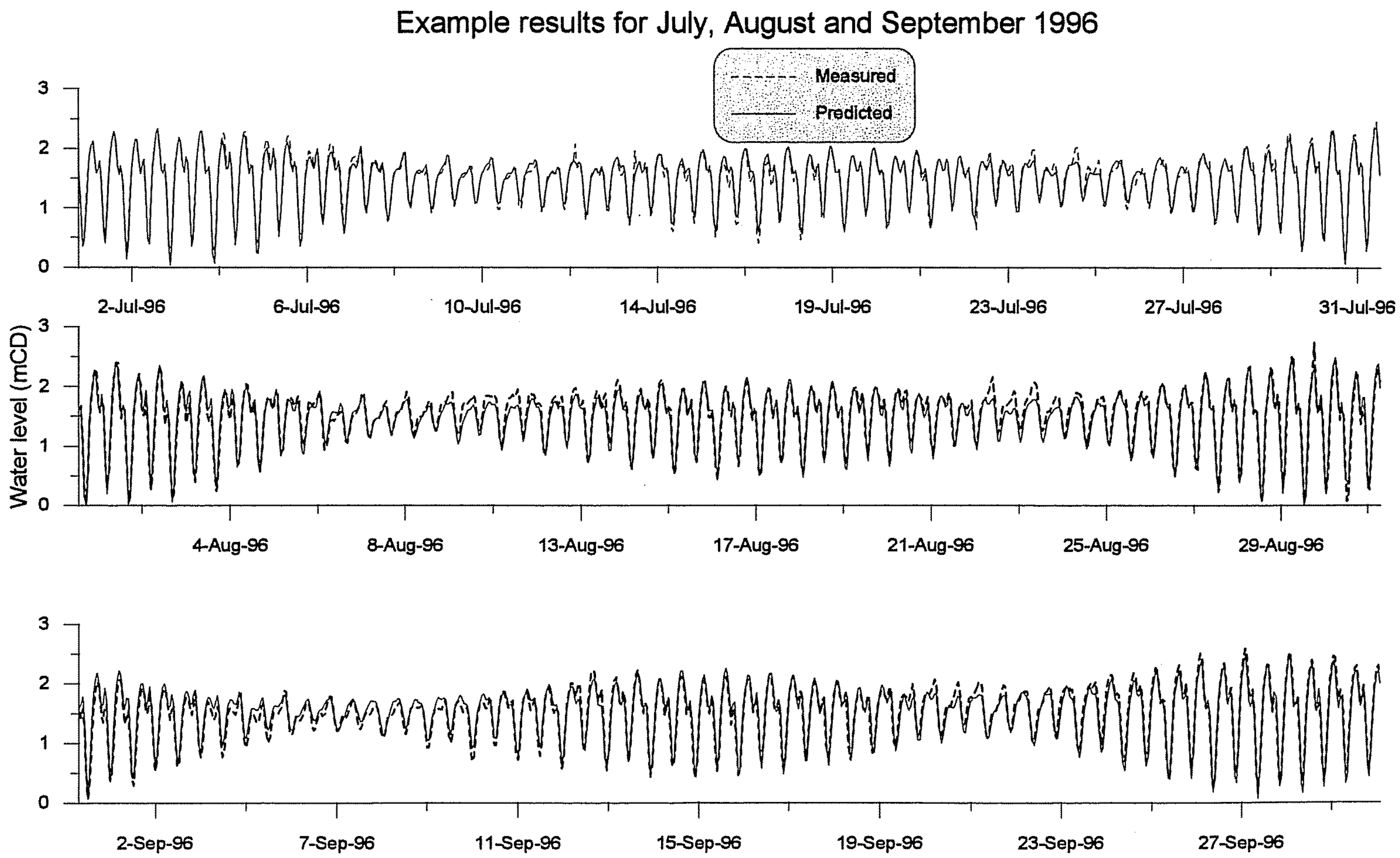
Example results for July, August and September 1996



Note: Harmonic constants derived are based on analysis of the data from 1 January 1996 to 31 December 1996

Figure A.3 Harmonic analysis of water level data from North Haven.

...\mgeprj\bmth\dgn\fig\fig_a3.dgn Mar. 19, 1999 13:29:40



Note: Harmonic constants derived are based on analysis of the data from 1 January 1996 to 31 December 1996

Figure A.4 Harmonic analysis of water level from Poole RoRo.