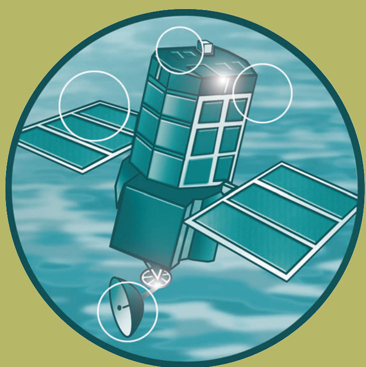
Joint Defra/EA Flood and Coastal Erosion
Risk Management R&D Programme

Understanding the lowering of beaches in front of coastal defence structures, Stage 2
Technical Note 4

R&D Project Record FD1927/PR4



Environment Agency

defra
Department for Environment Food and Rural Affairs

Understanding the lowering of beaches in front of coastal defence structures, Phase 2

Scour monitor deployment at Blackpool

Technical Note CBS0726/04 Release 3.0

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1. Introduction

Toe scour has been blamed for the failure of many coastal structures in the UK (CIRIA, 1986) and design practice has not changed substantially in the intervening period. The results from previous studies of toe scour have been highly varied, so no consensus has emerged about the magnitude and importance of toe scour. For example, toe scour holes are infrequently observed in the field (Griggs, et al., 1994) although scour troughs and undermined seawalls have recently been observed in Florida after Hurricane Jeanne in 2004 (Clark, 2005, Florida Department of Environmental Protection, 2004). This leads some such as Wiegel (2002a, 2002b, 2002c) to believe that a beach profile will go through the same cycle of erosion and accretion during a storm, whether it has beach control structures or not. However, there are indications that toe scour may be a short-lived phenomenon, with scour holes generated during storms filling in within a few hours as the storm subsides (Sutherland and Pearce, 2005). This would explain why few scour holes are observed or measured at low tide.

Toe scour is being measured within the present project, Understanding the Lowering of Beaches in Front of Coastal Defence Structures, Phase 2, (HR Wallingford, 2005, Defra project FD1927) by performing medium scale laboratory flume tests and field measurements of toe scour. A short deployment of scour monitors at a 1:2 (V:H) seawall at Southbourne, near Bournemouth, (Sutherland and Pearce, 2005) revealed that as the wave height and water level rose during the morning of the 24th May 2005, the beach level dropped by at least 0.60m when the incident significant wave height was 1.5m. The bottom scour monitor became exposed, so nobody knows exactly how far the beach level lowered. However, as water levels fell during the afternoon, the beach recovered to its previous low-tide level. This short deployment revealed valuable information about the volatility of the beach, but there was insufficient data to generalise into a relationship between waves, water levels and beach levels.

This highlighted the need for a deployment of scour monitors for as long as possible to allow the relationship between hydrodynamic conditions and beach response to be investigated more thoroughly. An additional constraint was the requirement that the scour monitor data be collected and analysed by the end of February 2006 to allow the results to be integrated into the development of an improved scour predictor and for the rest of the research programme to be completed. This effectively limited the length of any potential new deployment of scour monitors to four months (about 230 high tides).

The records of previous deployments of scour monitors in front of coastal seawalls were then examined to see whether there were any existing datasets longer than about four months. One such dataset exists. Blackpool Borough Council commissioned HR Wallingford to carry out monitoring of beach level changes and as part of this project HR Wallingford installed three “Tell-Tail” scour monitors at the toe of a seawall just to the south of Blackpool Tower in 1995. While the results obtained during the course of the commission were rather disappointing, staff from Blackpool Borough Council continued to collect data from these gauges and sent copies of it to HR Wallingford. Some basic analysis of this data has previously been carried out, using HR Wallingford’s resources as and when time and resources allowed, but we have never been able to properly analyse the bulk of the data or present the findings of this work.

The present Defra research project now gives us the opportunity to re-examine/ analyse the data that Blackpool Borough Council collected, to present the results as a “case history” and to incorporate this work into the overall project reporting. Scour monitor data collected in 1996, 1997, 1998 and 1999 have been combined with water levels from Liverpool (using the Lennon correction to convert to Blackpool levels) and UKMO wave model data to provide a long-term dataset of beach lowering and recovery.

This Technical Note describes the scour monitor deployment at Blackpool and presents a summary of the results obtained in Appendices 1 to 4. Release 1.0 of this Technical Note was sent to Defra's client representative, Dr Jonathan Rogers (of MouchelParkman) who gave permission for this dataset to be the second field site used in this research project (FD1927). The way this work fits into the present project is shown in Figure 1, highlighted in blue. Further analysis of the data is being carried out by Andrew Pearce (University of Southampton) in conjunction with HR Wallingford Ltd staff.

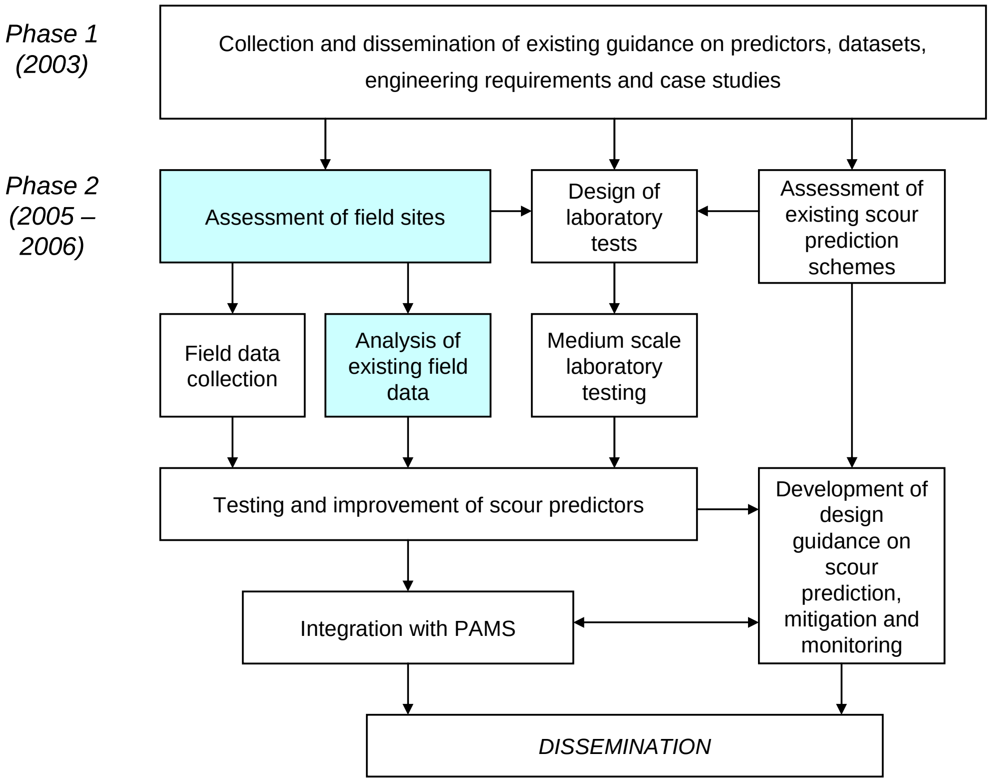

Figure 1 Flow chart of R&D processes for improved scour prediction methodology and translation into engineering framework

1.1 HR WALLINGFORD TELL-TAIL SCOUR MONITORS

In response to increasing concern about the threat of scour, engineers at HR Wallingford have developed a system which is able to detect and monitor scour. The "Tell Tail" scour monitoring system can be installed at new or existing structures and gives a clear indication of the depth of scour within the range of the system. The system records the onset of scour, the depth of scour reached, and in-filling of scour holes following storm events.

The system is based on omni-directional motion sensors, buried in the sea bed adjacent to the structure. The sensors are mounted on flexible "tails" and are connected via cable through protective conduit to a solid state data recorder. Under normal conditions, the sensors remain buried and do not move. When a scour hole begins to develop, the sensors are progressively exposed and each begins to oscillate in the flow. Each oscillation is logged on a solid state data recorder. Use of an eight level array of sensors provides a more accurate measurement of the depth of scour and also indicates whether scour hole re-fill has occurred.

2. Deployment of scour monitors at Blackpool

Three sets of scour monitors were deployed at Blackpool in 1995 on and in front of the near-vertical seawall between Central Pier and the North Pier, just south of Blackpool Tower at approximately 435950mN, 330525mE. The installation of the scour monitors is shown in Plate 1 and Plate 2. Each scour monitor had eight omni-directional tails spaced at an average of 0.24m apart vertically. Scour monitors A and B were mounted on frames designed so that they bolted directly onto the near-vertical seawall at Blackpool. They were set approximately 10m apart horizontally with the levels of corresponding tell-tails offset by approximately 0.24m, with scour monitor B being higher than scour monitor A so that the level of sensor two on scour monitor B is approximately the same as the level of sensor one on scour monitor A. The elevations of the scour monitor Tell-Tail sensors are shown in Table 1.

Table 1 Elevations of scour monitor Tell-Tail sensors

Sensor	Level at A (mODN)	Level at B (mODN)	Level at C (mODN)
1	3.131	3.324	2.343
2	2.860	3.082	2.093
3	2.598	2.828	1.843
4	2.320	2.543	1.593
5	2.124	2.458	1.343
6	1.941	2.184	1.093
7	1.691	1.911	0.834
8	1.441	1.661	0.593

The locations where scour monitors A and B were deployed can be seen on the right and left of Plates 1 and 2. Scour monitor C was mounted on a thin pole and deployed approximately 10m offshore from the seawall. This enabled the variation in beach level at the toe of the seawall to be compared to the beach level 10m offshore. Scour monitor C was installed offshore from a point between scour monitors A and B.

Plate 1 Installation of three scour monitors at Blackpool

Plate 2 Installation of three scour monitors at Blackpool

The signal cables were attached to the seawall and routed up to battery powered solid state memory devices in a box mounted on the promenade, shown in Plate 3. The offshore monitor, C, is shown shortly after deployment in Plate 4. A shallow scour hole, estimated to be about 0.1m deep and 0.4m across has formed around the base of the scour monitor. The elongated shape of the scour hole suggests that it was caused mainly by longshore currents.

Plate 3 Scour monitor data collection box on Blackpool promenade

Plate 4 Offshore scour monitor installed at Blackpool

Plates 5 and 6 show the wall-mounted scour monitors, A and B, shortly after installation. The data cable to scour monitor C can be seen going down into the sand bed between the two other scour monitors. Plate 5 shows that there is a small scour trough extending one or two metres in front of the seawall. Plate 6 shows the position of the scour monitors relative to the nearest set of steps.

Plate 7 shows all three scour monitors in a view looking north towards the North Pier. Water-filled depressions can be seen on the north side of both sets of steps that are clearly visible in Plate 7. These depressions extend perhaps 30m in the alongshore direction and about 12m offshore from the seawall. Plate 8 shows the scour monitors in a view looking south towards the slip, lifeboat station and the Central Pier.

Plate 5 Scour monitors B, on left, and A, on right, with cable to offshore monitor C in the centre

Plate 6 Scour monitors B and A on seawall showing position relative to steps

Plate 7 Three scour monitors in front of seawall, looking north

Plate 8 Three scour monitors in front of seawall, looking south

3. Analysis of Blackpool Beach Profile Data

Cross-shore beach profiles have been collected periodically along the Blackpool frontage to assist with beach management. Two datasets were analysed – one with 11 profile lines and a time-series surveyed between 1956-1998 and one with 17 profile lines (including the 11 above) with a time-series surveyed between 1996-1999. Where there is a time overlap, the data are identical. These were both input into HR Wallingford's Beach Data Analysis System (BDAS) as separate data files, although BDAS stores them within the same database, allowing analysis of the whole period at once.

3.1 BEACH DATA ANALYSIS SYSTEM (BDAS)

The Beach Data Analysis System (BDAS) has been developed at HR Wallingford to store, recall, present and analyse large volumes of cross-section beach survey data. It can rapidly retrieve the data for any given profile and can analyse large amounts of data quickly. The main functions of the system are as follows:

- To store beach profile data, from different sites and dates, in a standard format, within a computer database.
- To add extra profile information to the database as it becomes available, with in-built data quality checking procedures.
- To recall profile data and present it "on-screen" or graphically.
- To carry out statistical analyses of beach levels, cross-sectional areas and other parameters usually as a function of time.

3.2 PROFILE LOCATIONS

The National Grid coordinates of the landward end of each of the beach profiles are listed in Table 2. The profile names were provided by the council. These were converted into Station Numbers for inclusion in BDAS. The starting points of the profiles are shown in Figure 2, with the location of the UKMO wave model point also included. The scour monitors are approximately positioned at 435950mN and 330525mE, so are between profile BBCSEC 9, which is approximately 280m north, and profile BBCSEC 9A, which is approximately 170m south of the scour monitors.

Table 2 Beach profile name, BDAS station number and coordinates of starting point

Profile name	BDAS Station number	Easting (m)	Northing (m)
BBCSEC 1	1	331221	442673
BBCSEC 2	2	331164	441891
BBCSEC 3	3	331047	441147
BBCSEC 4	4	330886	440363
BBCSEC 5	5	330706	439463
BBCSEC 6	6	330629	438631
BBCSEC 7	7	330618	437919
BBCSEC 8	8	330568	437075
BBCSEC 9	9	330537	436234
BBCSEC 9A	10	330551	435780
BBCSEC 10	11	330561	435426
BBCSC 10A	12	330567	434994
BBCSEC 11	13	330563	434630
BBCSC 11A	14	330534	434237
BBCSEC 12	15	330501	433825
BBCSC 12A	16	330391	433403
BBCSEC 13	17	330348	433001
BBCSC 13A	18	330336	432624
BBCSEC 14	19	330354	432228
BBCSEC 15	20	330506	431665
BBCSEC 16	21	330625	431144
BBCSEC 17	22	330789	430658

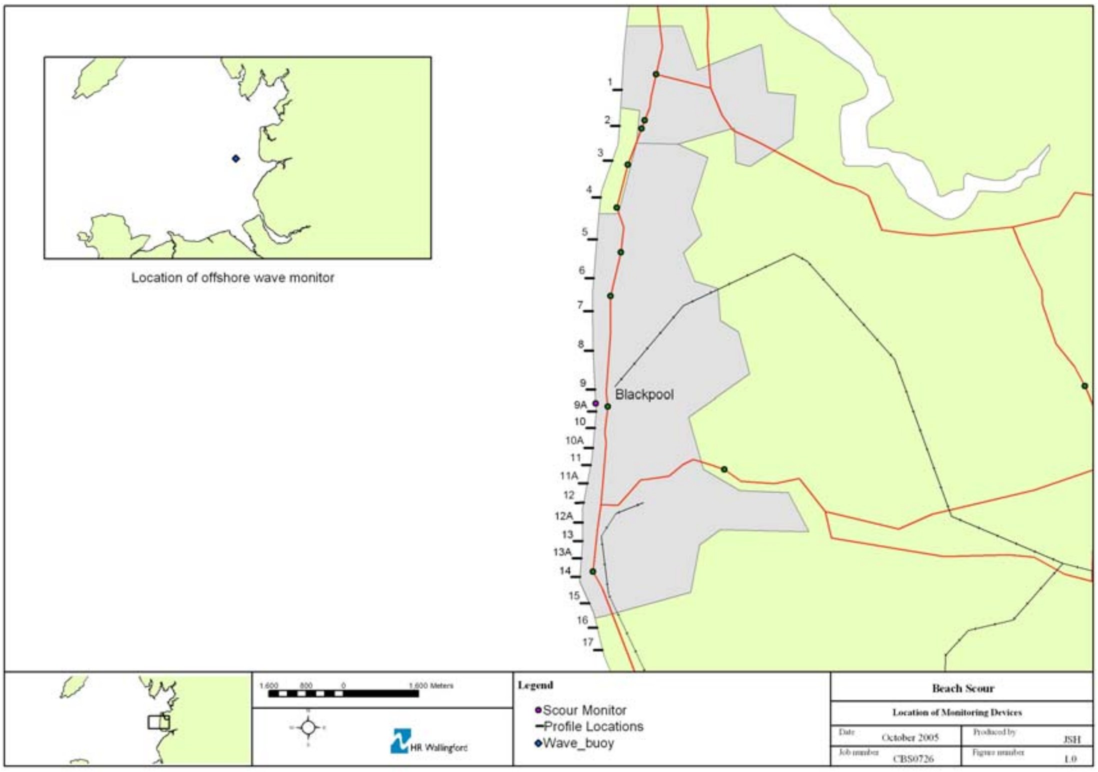

Figure 2 Location of beach profiles and UKMO wave modelling point

3.3 ANALYSIS OF BEACH PROFILES

Mean beach profiles can be plotted using BDAS by analysing levels at specified "chainages" i.e. distances down the profile from its starting point. – in this case every 20m from the 10m chainage to 300m for Profile 9 and every 20m from 10m to 380m for Profile 9A. Analysis began at 10m to remove the measurements taken at the top of the seawall. As measurements were not taken at these exact chainages, BDAS interpolates the beach level at the specified points. For Profile 9 this was carried out for both the 1996-1999 data and the full dataset.

Figure 3 shows the average profile, the data range at each 20m interval, significant trends over the period involved and the 95% confidence limits at profile BBCSEC 9 over the entire length of the dataset. Figure 3 shows a dip in the profile at the seawall, due to the reflections from the seawall. Figure 4 shows the variation of beach level at 10m chainage along profile BBCSEC 9 for all the surveys analysed (with the survey date being in years from 1900). The beach level at 10m chainage has been increasing by an average of about 0.01m per year. This may be a natural phenomenon or may have been influenced by beach management activity, such as beach recharge.

Mean profiles are plotted in Figures 5 and 6 for profiles 9A and 9 respectively, based on the 1996 – 1999 data. These graphs show the mean trend line, the data range at each 20 m interval, significant trends over the time involved and the 95% confidence limits. Large ranges of the beach elevation about the mean are shown at each chainage, although the trends identified (i.e. the rate of change in the mean elevation) are smaller.

The beach levels at 10m chainage are plotted against the northings of the landward point of each profile for the 1996 – 1999 surveys in Figure 7, to provide an approximate longitudinal beach level survey along the base of the seawalls at Blackpool. Figure 7 also shows the abbreviated profile names (minus BBCSEC) of selected profiles. The vertical line shows the location of the scour monitors. This shows that there are differences in elevation of about 2m to 3m between profiles 9 and 9A, even though they are only 450m apart. The highest levels are at profile BBCSEC 7, north of the North Pier.

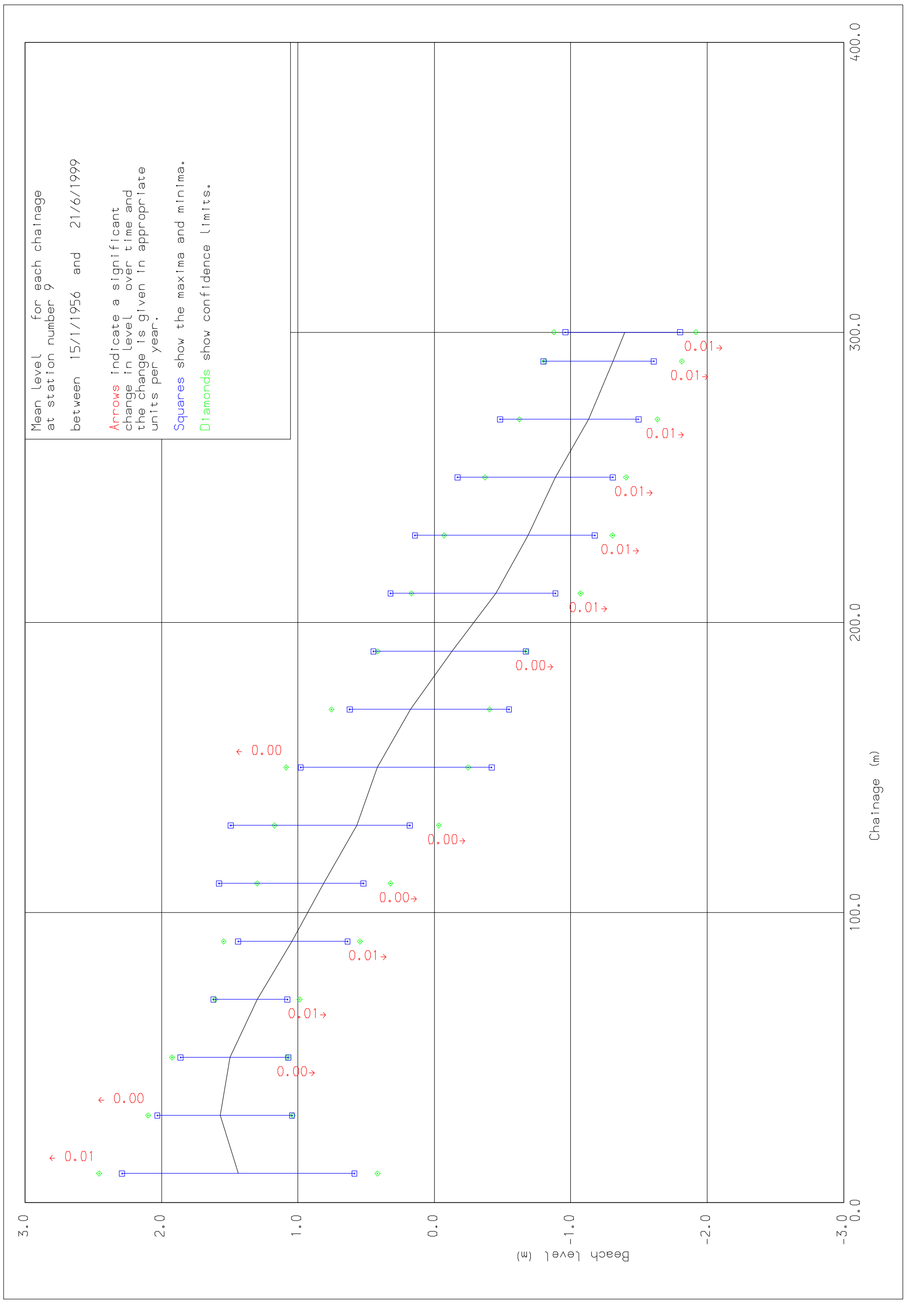

Figure 3 Average beach profile with trends at beach profile BBCSEC 9 between 1956 and 1999

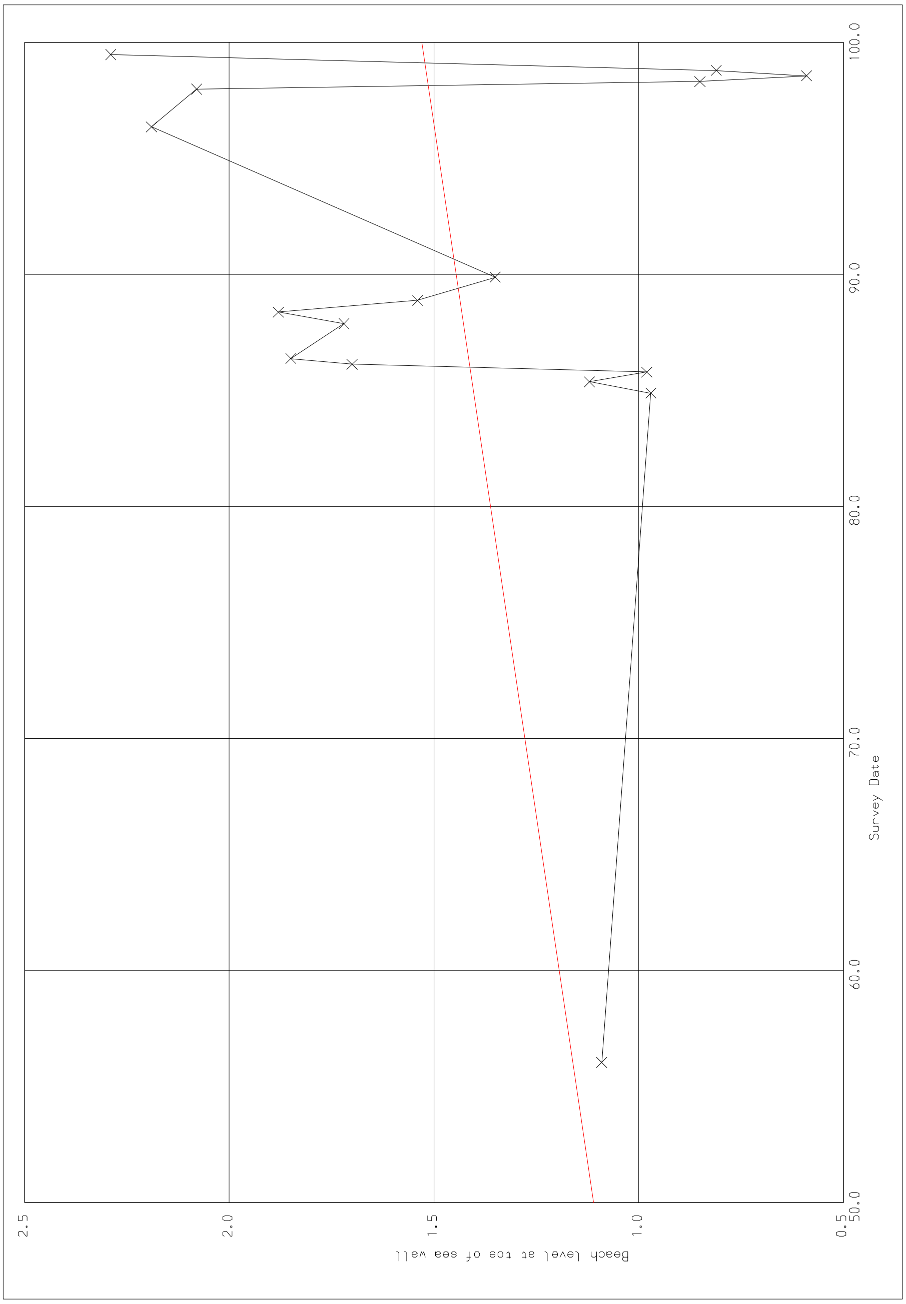

Figure 4   Time series of beach levels at 10m chainage along profile BBCSEC 9

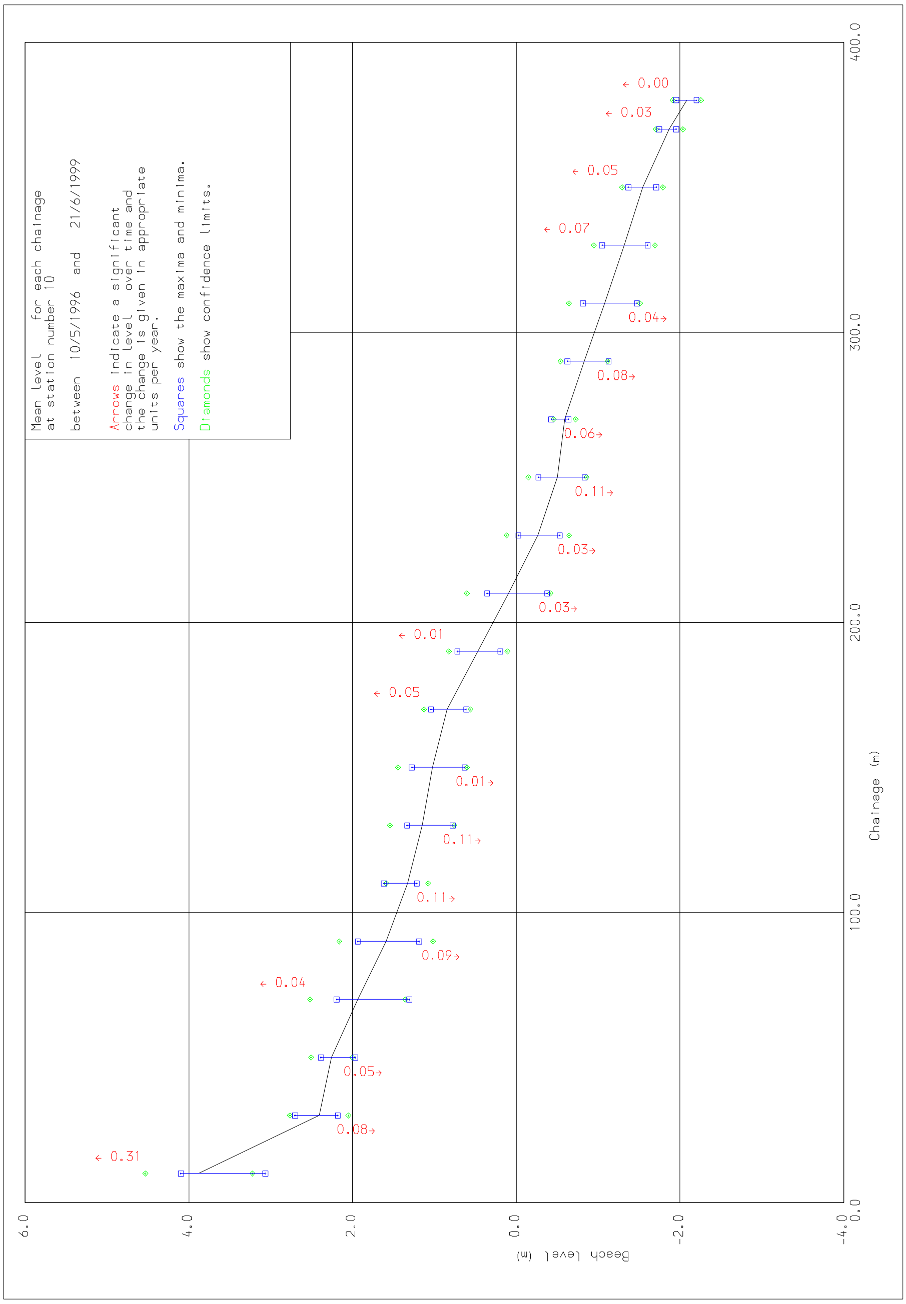

Figure 5   Average beach profile and trends at profile BBCSEC 9A between 1996 and 1999

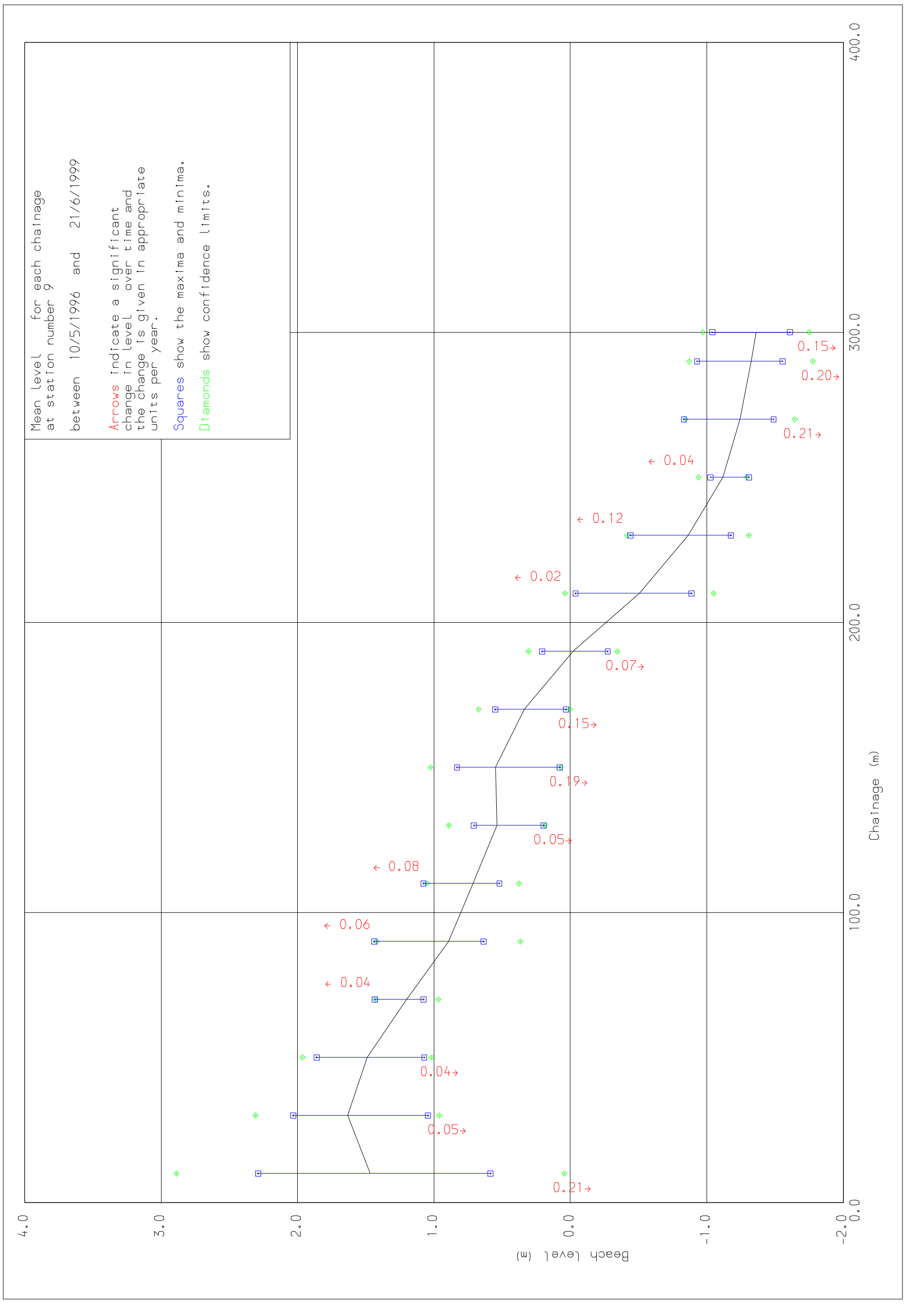

Figure 6 Average beach profile with trends at beach profile BBCSEC 9 between 1996 and 1999

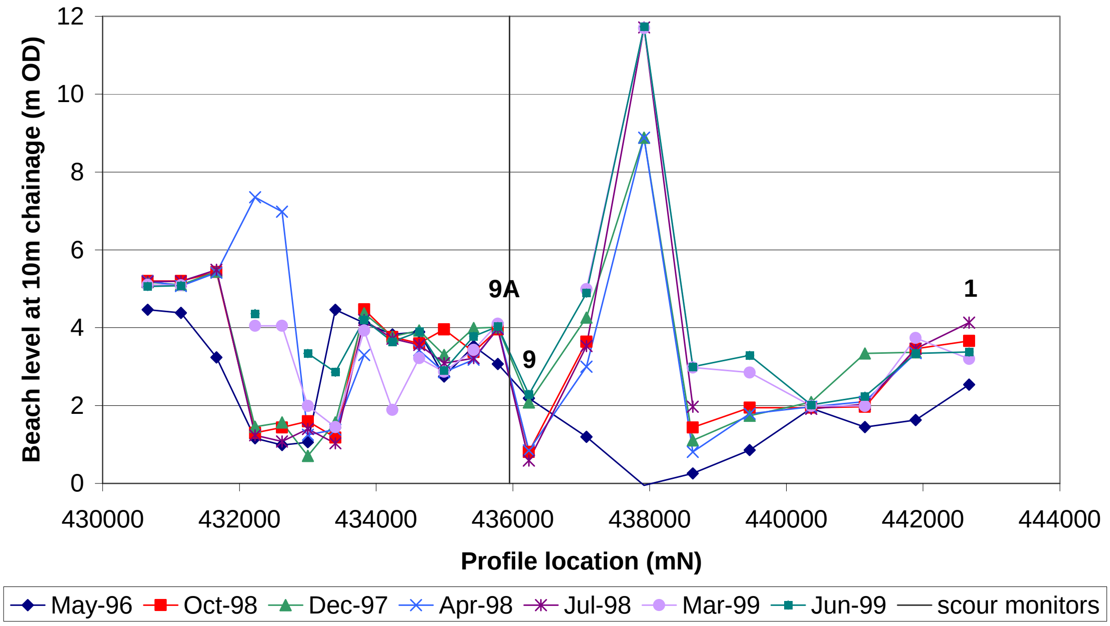

Figure 7 Time series of beach level at 10m chainage along different profiles between 1996 and 1999. Selected beach profile numbers are shown.

4. Data collected

4.1 UKMO WAVE MODEL

Data from the UKMO wave model was purchased for 1996, 1997 and 1998 at the model point at 53.75ºN -3.27ºE. This model provides predictions of the following wave parameters every three hours, except for occasional gaps:

- Year, month day and hour (GMT);
- Wind speed and direction;
- Total significant wave height, average wave period and direction;
- Wind sea significant wave height and average wave period;
- Swell sea significant wave height, average wave period and direction.

4.2 WATER LEVEL

Quality-checked water level time series were downloaded from the British Oceanographic Data Centre web site http://www.bodc.ac.uk/data/online_delivery/ntslf/processed/ for the UK National Tide Gauge Network tide gauge at Liverpool (Gladstone Dock) at latitude 53.4500ºand longitude -3.0167ºE. Time series for 1996, 1997 and 1998 were downloaded at 15 minute intervals with levels recorded with respect to Admiralty Chart Datum (ACD).

This data was used to calculate water levels at Blackpool using two methods. Firstly the correction method specified in Admiralty Tide Tables Volume 1, 1996 (crown copyright, 1995) was used to convert from the primary port of Liverpool to the secondary port of Blackpool. This was done for a trial period during October 1996 as each day had to be processed separately.

The second method used was the Lennon correction. This involved subtracting the Mean Sea Level (MSL) at Liverpool then multiplying the data by the ratio of the tidal semi-ranges (where the semi-range is defined as the difference between Mean High Water Springs and MSL) and adding in the MSL at Blackpool. In order to do this the MSL at Blackpool was estimated as 5.10mCD as MSL at Formby = 5.15mCD while at Fleetwood it is 5.03mCD. The Lennon method allowed the whole time series to be corrected at once, rather doing one day at a time. Although there is no time correction in the Lennon method, the time differences between high water at Liverpool and Blackpool are between 5 minutes and 15 minutes so can be ignored. The Liverpool data with the Lennon correction was used for all the data analysis, converted to elevation with respect to Ordnance Datum Newlyn (ODN).

4.3 SCOUR MONITOR DATA

The scour monitor data logger produced separate files for each sensor for each deployment. These files recorded the pulse rate (number of oscillations per minute) of each sensor head every 15 minutes. The data was downloaded approximately every 2 to 3 weeks between February 1996 and November 1998. A separate set of data files from November 1999 to March 2000 were also supplied to HR Wallingford, although there was no usable data in 2000. The number of days with scour monitor readings in each month is shown in Table 3 which shows that data was recovered on 78% of the days in 1996, 90% in 1997, 59% in 1998. 1999 figures will be added in Release 2.0 Data was recovered from a total of 830 days (2.27 years) between February 1996 and November 1998 inclusive, which corresponds to 80% of the time. Gaps appear at different times such as August and September 1996, January and December 1997, January, March, May, June and July 1998.

Table 3 Number of days of scour monitor data recovered in each month at Blackpool

Year	1996	1997	1998	1999
	Number of days			
Jan	0	20	12	0
Feb	18	26	28	0
Mar	29	31	14	0
Apr	30	30	30	0
May	31	31	20	0
Jun	30	30	0	0
Jul	31	31	4	0
Aug	18	31	31	0
Sep	18	30	30	0
Oct	30	31	26	0
Nov	21	30	20	
Dec	29	9	0	
Total	285	330	215	

The eight data files from a scour monitor were read into an array and the lowest scour monitor that gave a reading was identified. The assumption is made that the scour monitor head can only oscillate when the beach level has dropped below the head. Therefore identifying the lowest mobile scour monitor identifies the level that the beach must be below. When the bottom sensor is mobile it is not possible to determine how much lower the scour goes. Similarly when no sensors are mobile during a period of high water and wave activity all the sensor heads must be buried, but it is not known by how much.

5. Examples of combined data

The data on water levels, wave heights and active scour monitor sensors can be plotted together to illustrate the changes in beach level. In this case the level of the lowest active sensor was plotted at each time step. The beach level is between the level of the lowest active sensor and the level of the sensor below it, unless it is the lowest sensor in an array that is active, in which case the lower limit of the beach level is not defined. This section presents two short examples of the data collected. The following section then reproduces all the data collected but showing less detail.

Figure 8 shows combined water level, offshore significant wave height and the elevation of the lowest active scour monitor from 14th to 16th October 1996. The elevation of the lowest active scour monitor is used as an indicator of beach level. In this example the offshore significant wave height starts off at about 1m. During the 14th (the first three partial high tides shown) the indicative beach level rises as the water level rises and falls as the water level falls. In these cases no scour has been detected, illustrating the fact that computing the elevation difference between the highest and lowest active monitors is not a measure of scour.

The offshore significant wave height increases during the 15th and scour can be seen in the high tide around noon on the 15th. The distinctive sign is the elevation of the indicative beach level falling as water level rises and rising as the water level falls.

The scour monitor sensors are generally only active when the water level is greater than the level of the scour monitor sensors. There are some instances where sensors are active when the predicted water level is slightly lower than the sensor level, but these instances can generally be explained by small errors in the elevation and timing of the water levels and the possibility of wave setup due to wave and / or different surge levels at Liverpool and Blackpool. There are a few isolated instances when scour monitor sensors were activated when the water level was well below the sensor level, such as occurred between the midday and midnight high water periods during the 14th. These points should be discounted from the analysis as they may have been caused by the wind or by a person.

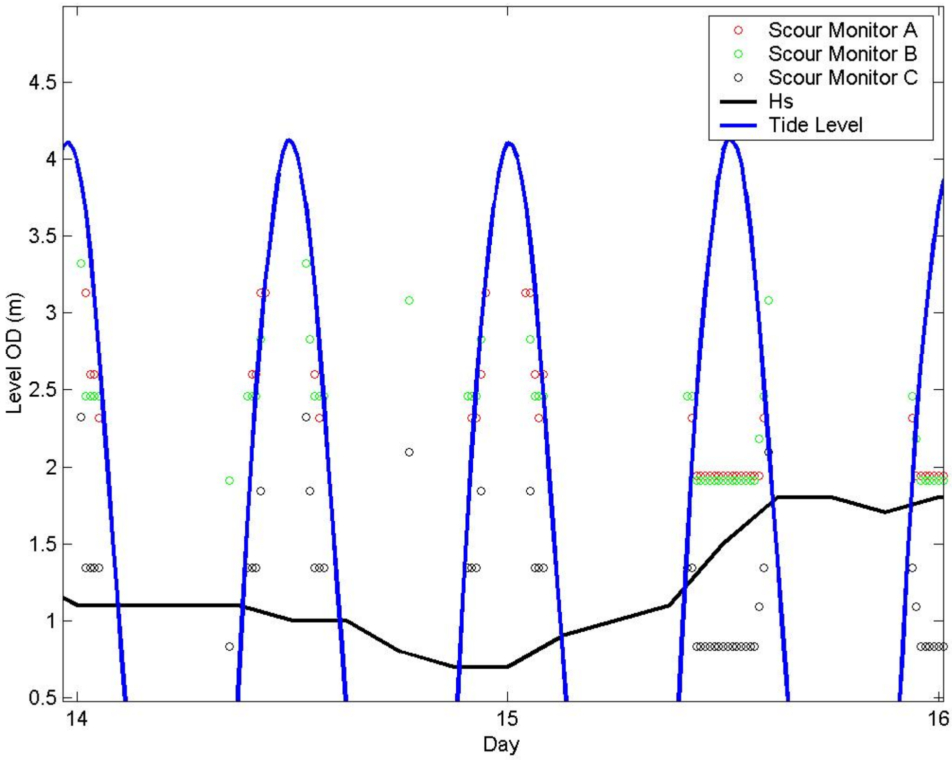

Figure 8 Combined water level, wave height and lowest active scour monitor levels from 14th to 16th October 1996

Figure 9 shows the combined water level, offshore significant wave height and lowest active scour monitor levels from 24th to 26th February 1997. The offshore significant wave height was greater than 1.5m for all of this period and was greater than 2.5m for most of it. Scour was observed during all five high tides during this period. In all cases the level of the lowest active scour monitor decreased, once the sensors were submerged by the rising tide. The beach level tended to lower and fall quite quickly by one or two sensor levels (roughly 0.25 to 0.50m) at the start and end of each high tide, but often remained at a similar level around high tide.

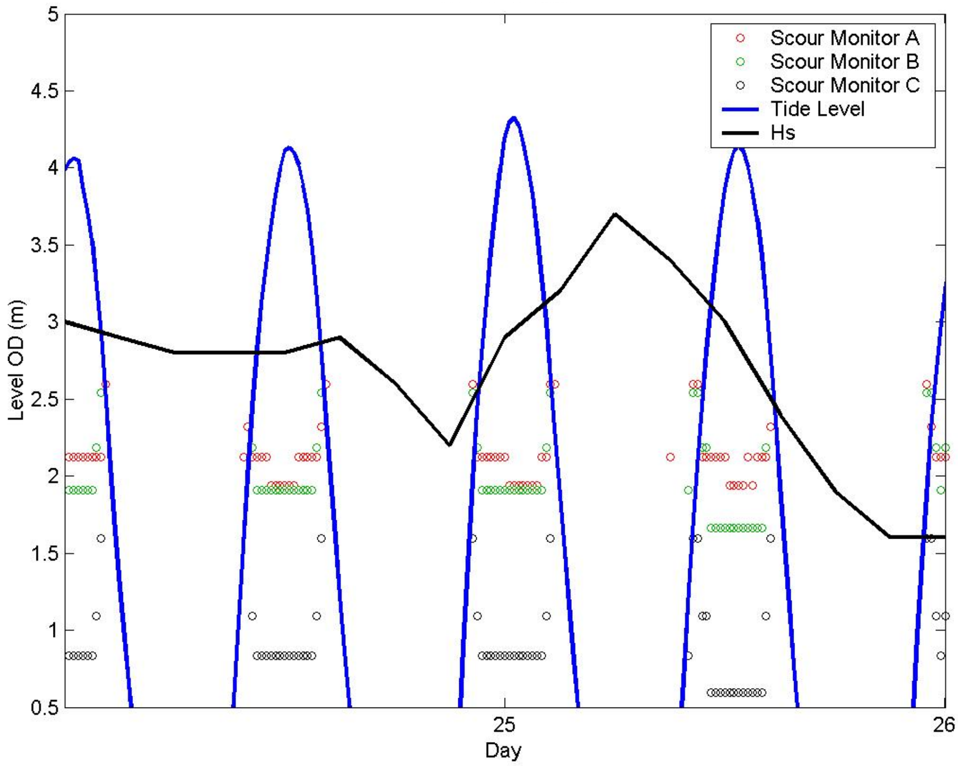

Figure 9 Combined water level, wave height and lowest active scour monitor levels from 24th to 26th February 1997

6. Summary

Three HR Wallingford Tell-Tail scour monitors were deployed on the seawall just south of Blackpool Tower during 1995 and were never removed by HR Wallingford. Data was collected from a total of 830 days during this period. Each scour monitor has eight omni-directional motion sensors mounted on flexible "tails" in a vertical array and buried in the sea bed adjacent to the structure. The sensors do not move when buried deep in the bed, but start to oscillate when exposed to wave and current motion. The oscillation rate was logged every 15 minutes for each of the eight sensors.

Two scour monitors were attached to the seawall while one was mounted on a vertical pole approximately 10m offshore from the seawall. Photographs show the deployment and the scour monitors *in situ*. The approximate location of the scour monitors has been established and measurements of cross-shore beach profiles have been analysed to put the lowering and recovery of the beach at the scour monitors in the context of the overall behaviour of the beach during the deployment period.

Water levels at Blackpool have been estimated by applying the Lennon correction to tidal measurements made by UK National Tide Gauge Network tide gauge at Liverpool (Gladstone Dock). Wave conditions from the UK Met Office wave model were purchased for 1996, 1997 and 1998 at the model point at 53.75ºN -3.27ºE.

The scour monitor sensor oscillation rates were used to determine the elevation of the lowest active sensor. This provided an upper limit on the beach level. Data on waves, water levels and the elevation of the lowest active sensor have been combined into example plots that show significant levels of beach lowering and recovery around high tide during some water level and wave height combinations.

Closer inspection of the data revealed that not all of the eight tell tail sensors on the monitors A, B, and C were working throughout the whole deployment. All sensors on each of the scour monitors appear to have functioned well throughout 1996. However during January 1997 all of the sensors (except number 3) on scour monitor C stopped working and did not work again. All the sensors of scour monitor A continued to work until October 1998 when sensor number seven stopped working. During March 1997 sensors 2, 3, & 5 on scour monitor B stopped working. After December 1999 all three scour monitors stopped working. Annual summaries of the data are provided in Appendices 1, 2, 3 and 4 for 1996, 1997, 1998 and 1999 respectively.

7. References

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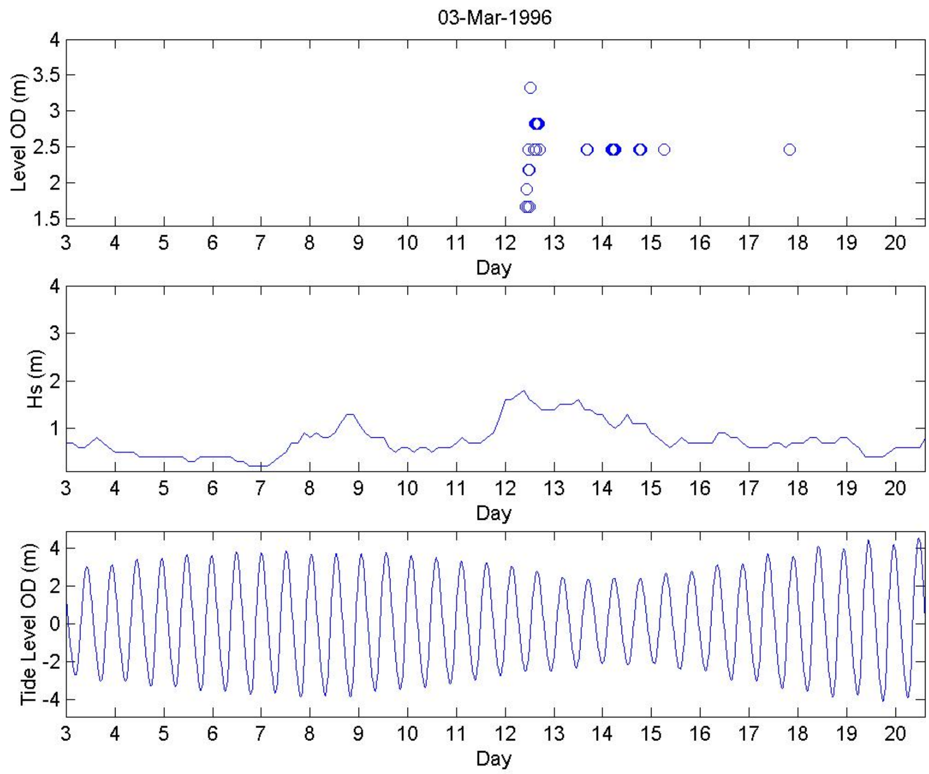
8. Acknowledgements

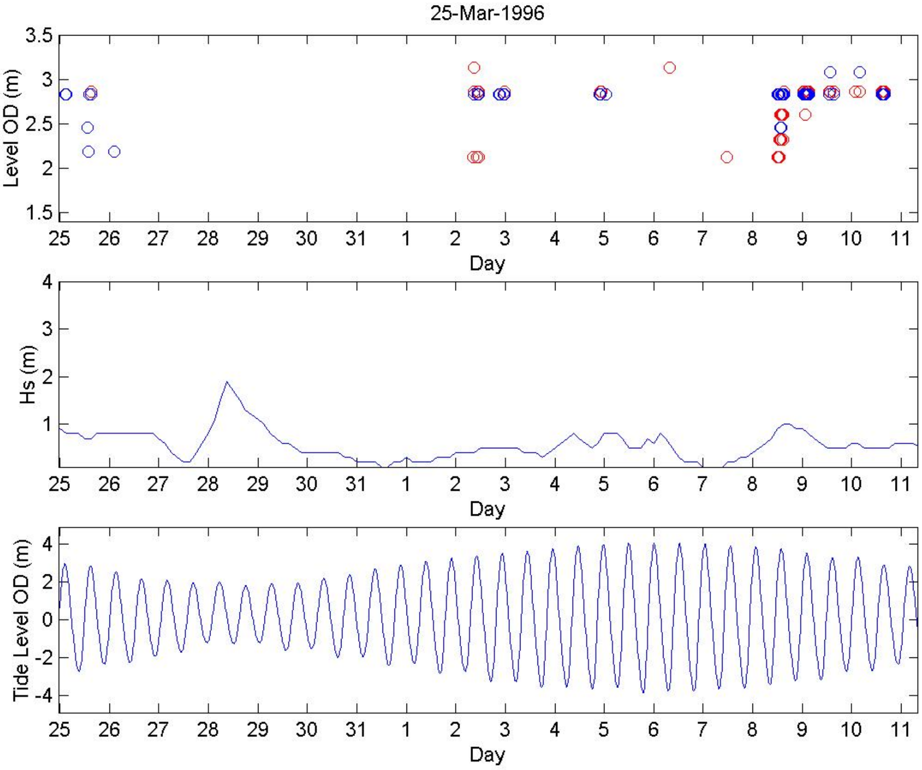
This research was funded by Defra under the Joint Defra / EA Flood and Coastal Erosion Risk Management R&D Programme as Project FD1927. The assistance of Blackpool Borough Council is also acknowledged, for permitting the deployment of the scour monitors and for collecting and sending the scour monitor data to HR Wallingford.

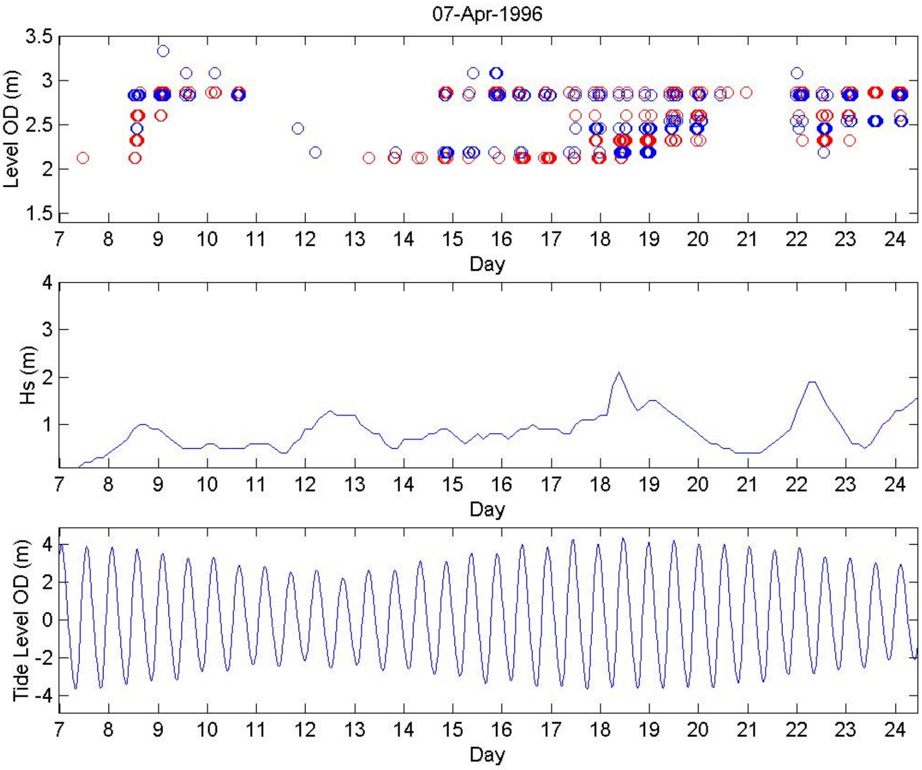
Appendix 1 Combined data from 1996

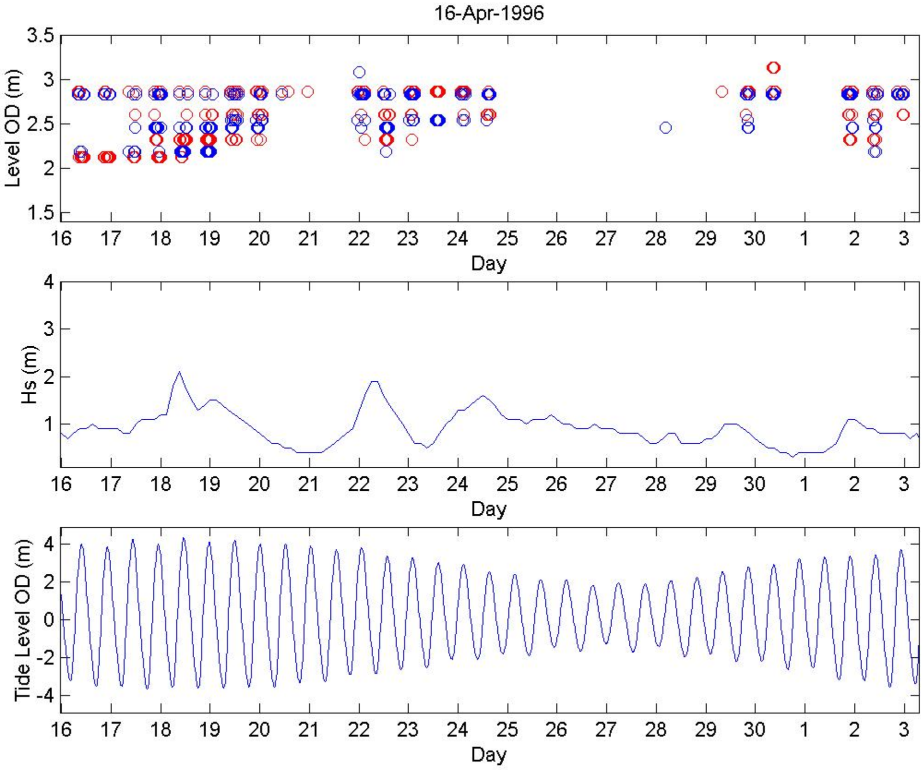
The combined data of lowest active scour monitor sensor level (mOD), with red circles for scour monitor A and blue circles for scour monitor B, are plotted with the offshore significant wave height, Hs, (m) and the Lennon-corrected water levels at Blackpool in the following plots. Each plot presents the data downloaded at one visit to the site. The scour monitors have solid state data recorders with a rolling memory, which continuously saves data to the next point in the memory. The old data is not wiped on downloading, but is overwritten in turn. This explains why some of the data series overlap.

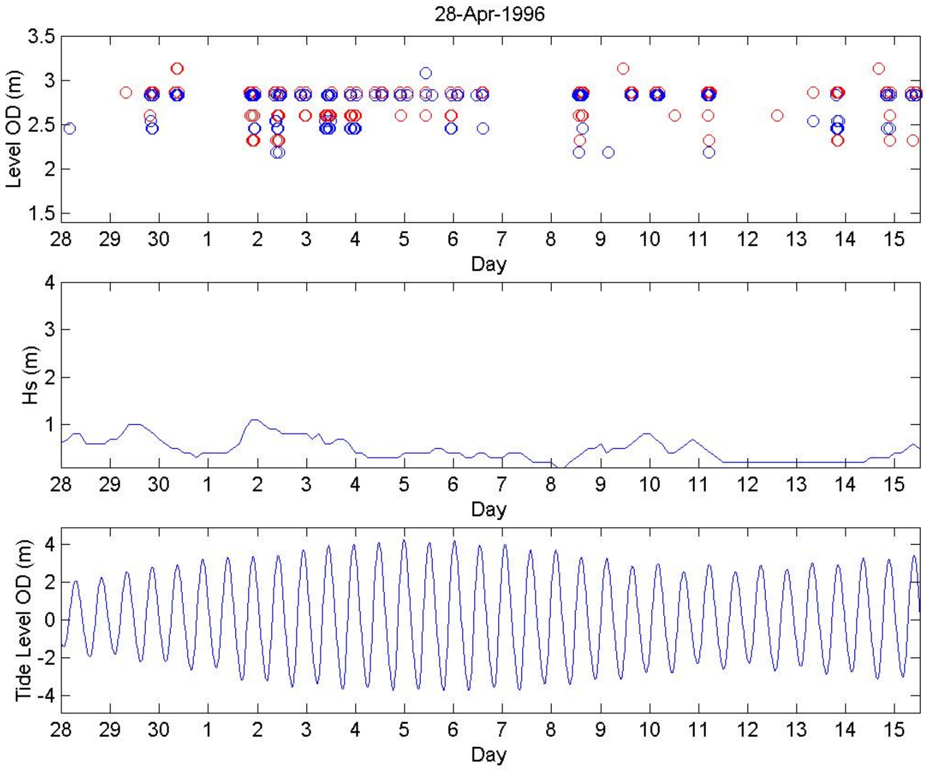
The scour monitors were deployed in 1995, but no significant scour was recorded during 1995 as the beach level accreted. Only data from 1996 to 1998 has been retained. The first significant activity occurred during the storm on 12 March 1996. No activity was recorded during the storm of 18 March, which occurred during a neap tide with water levels no greater than about 2m OD. April saw a lot more activity and subsequent months also show significant changes in beach level during single tides. Changes in beach level depend on water level and wave height and possibly other parameters as well. Subsequent analysis will attempt to produce quantitative relationships between the key parameters.

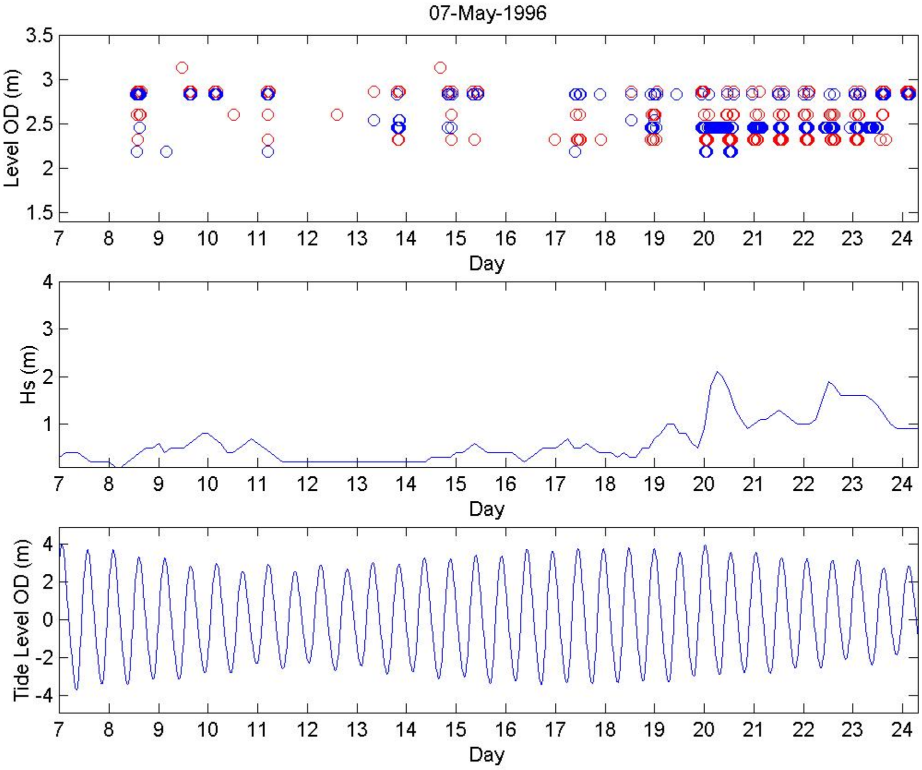


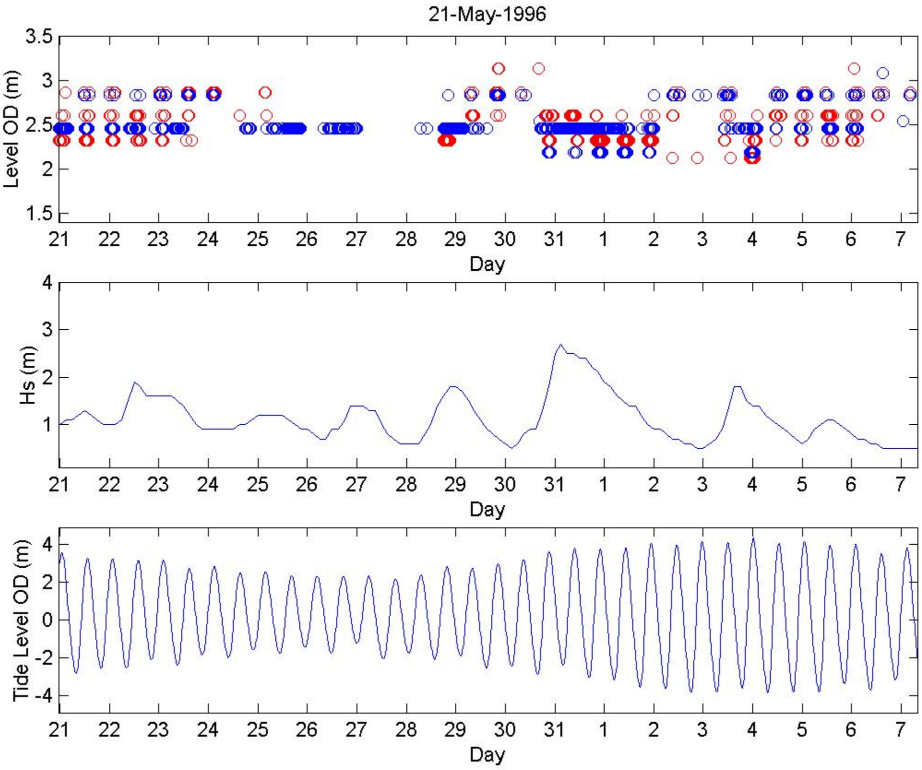

25-Mar-1996
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

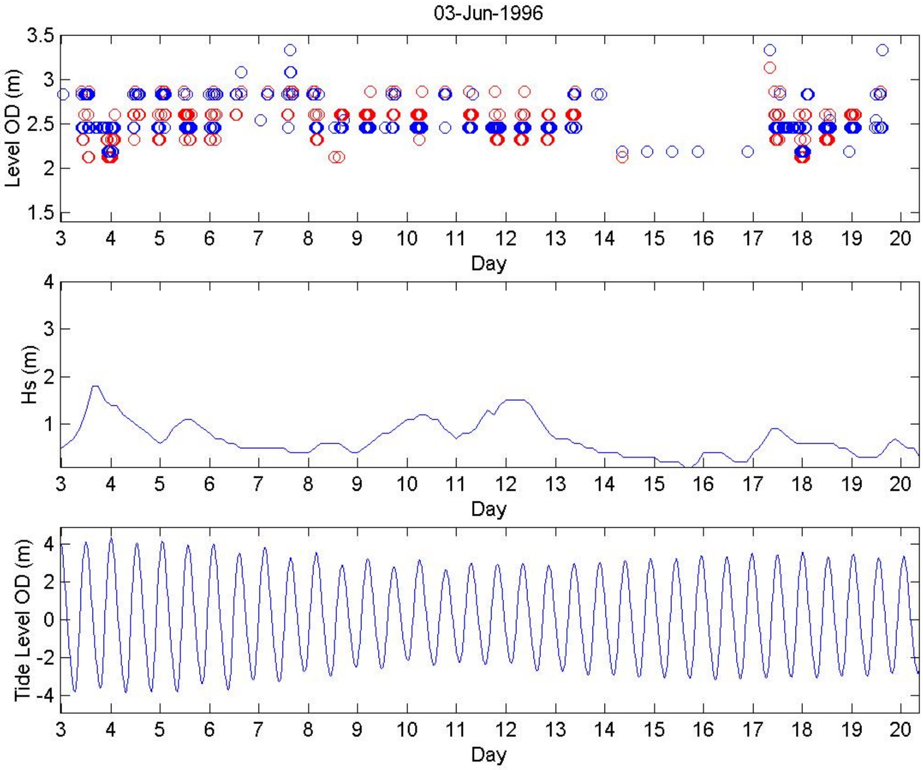

07-Apr-1996
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

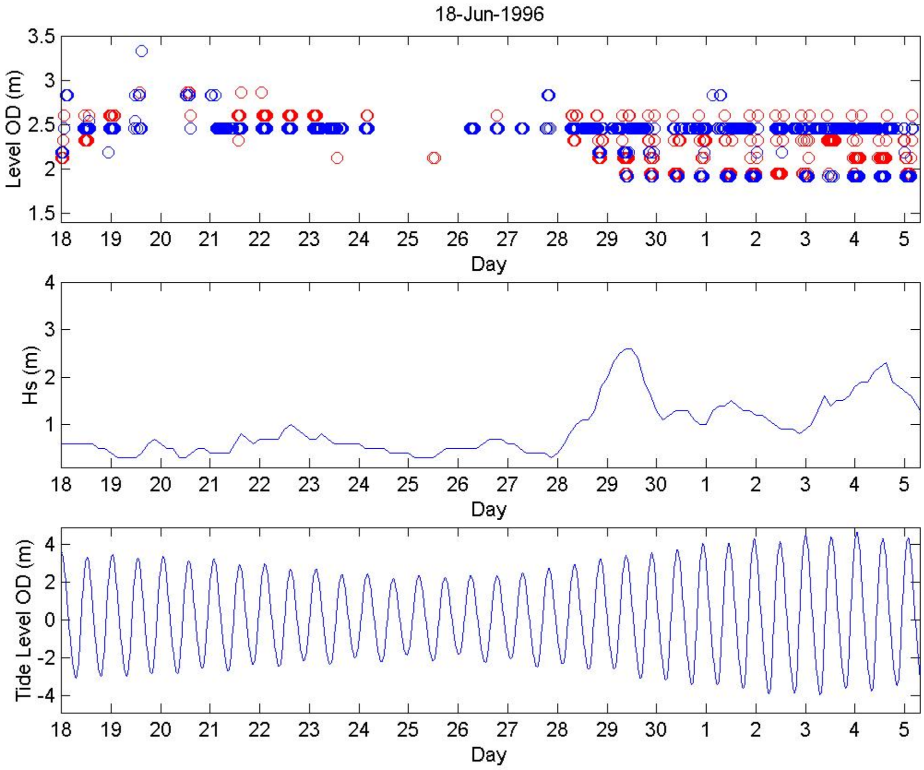

16-Apr-1996
Level OD (m)
Hs (m)
Tide Level OD (m)
Day

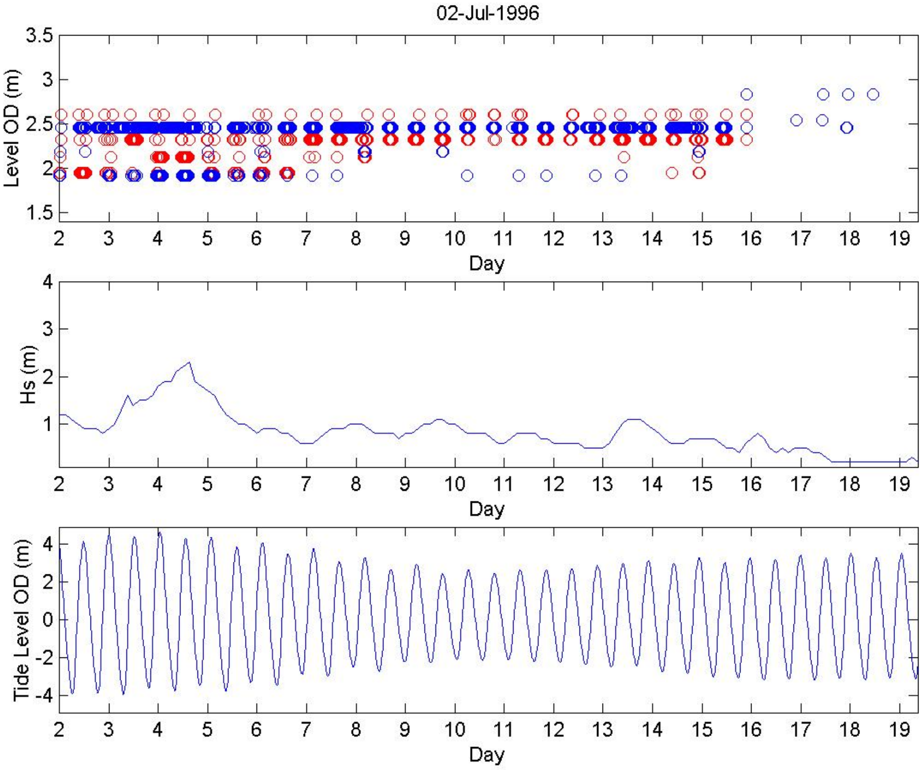

28-Apr-1996
Level OD (m)
Hs (m)
Tide Level OD (m)
Day

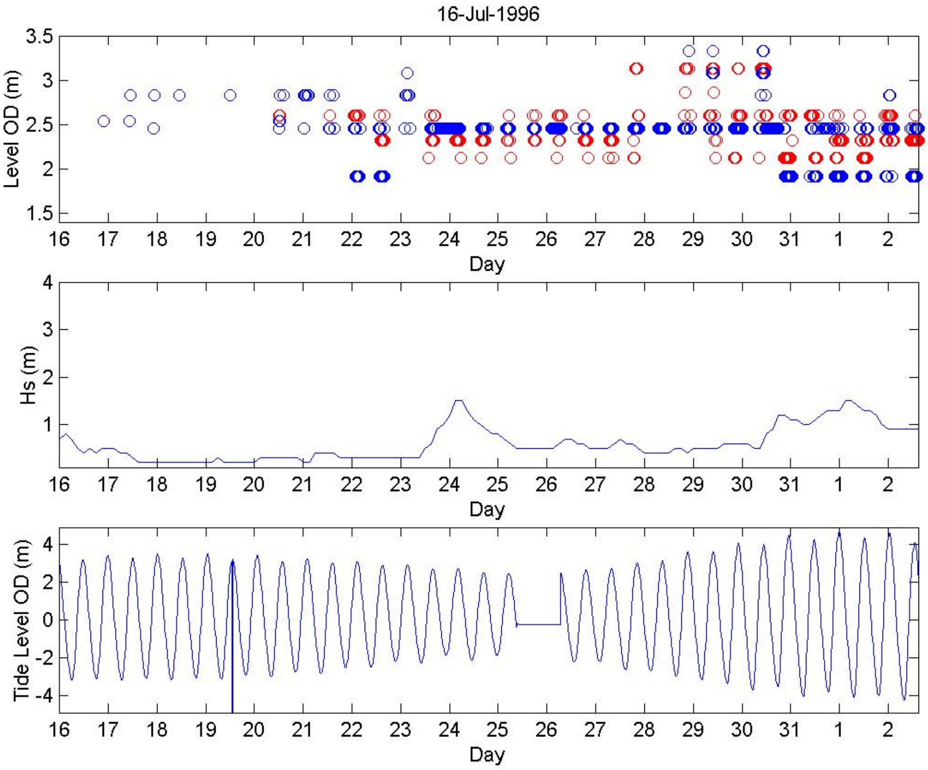

07-May-1996
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

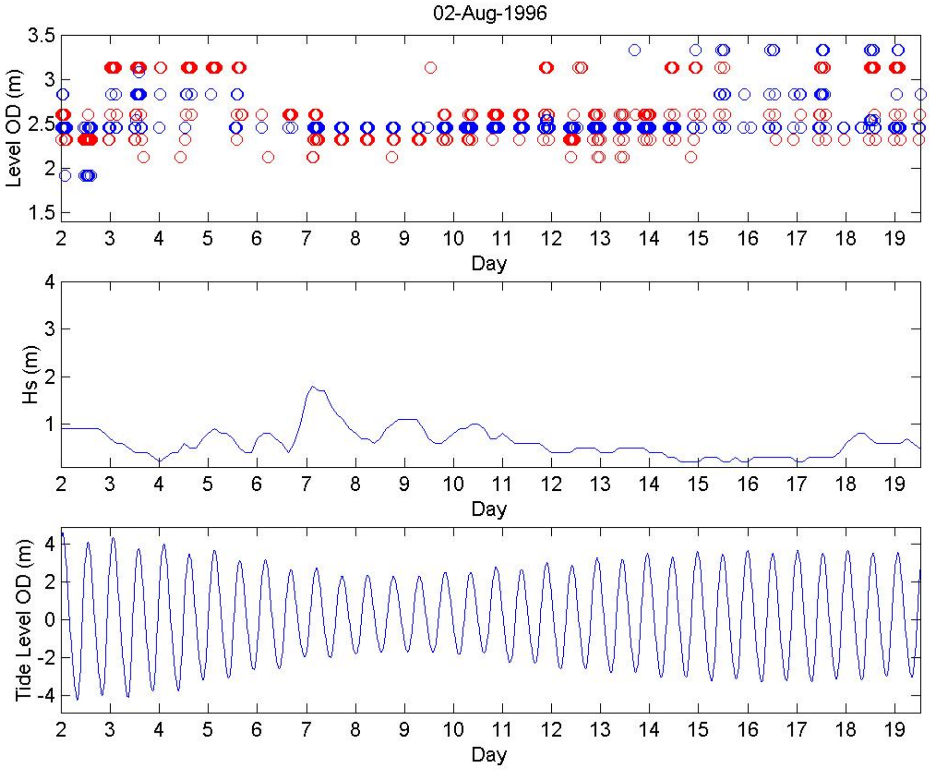

21-May-1996
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

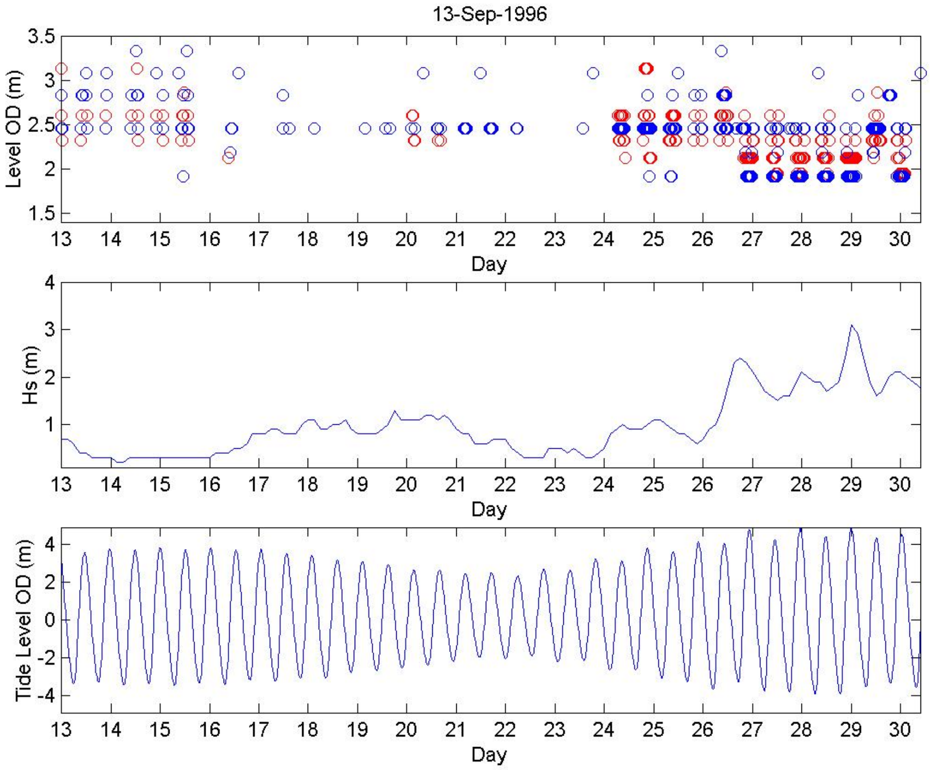

03-Jun-1996
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

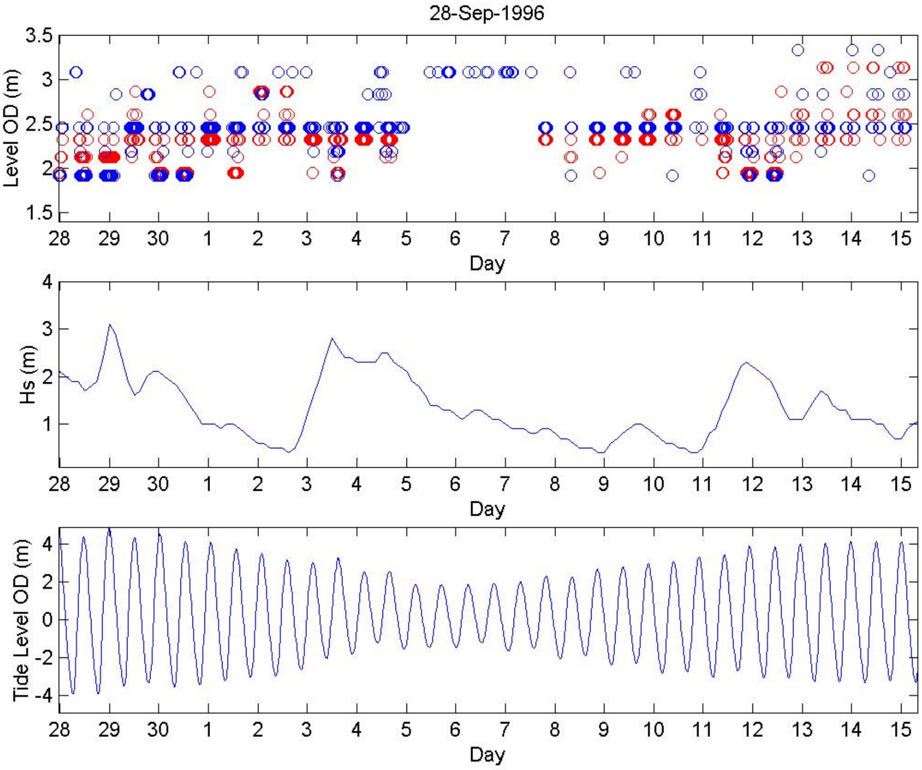

18-Jun-1996
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

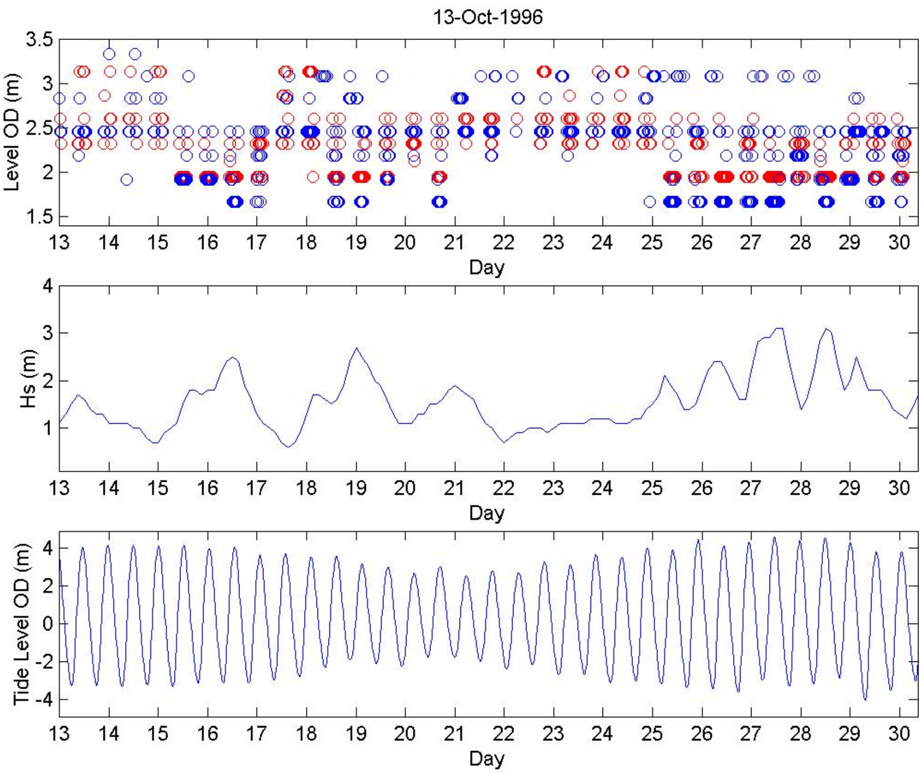

02-Jul-1996
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

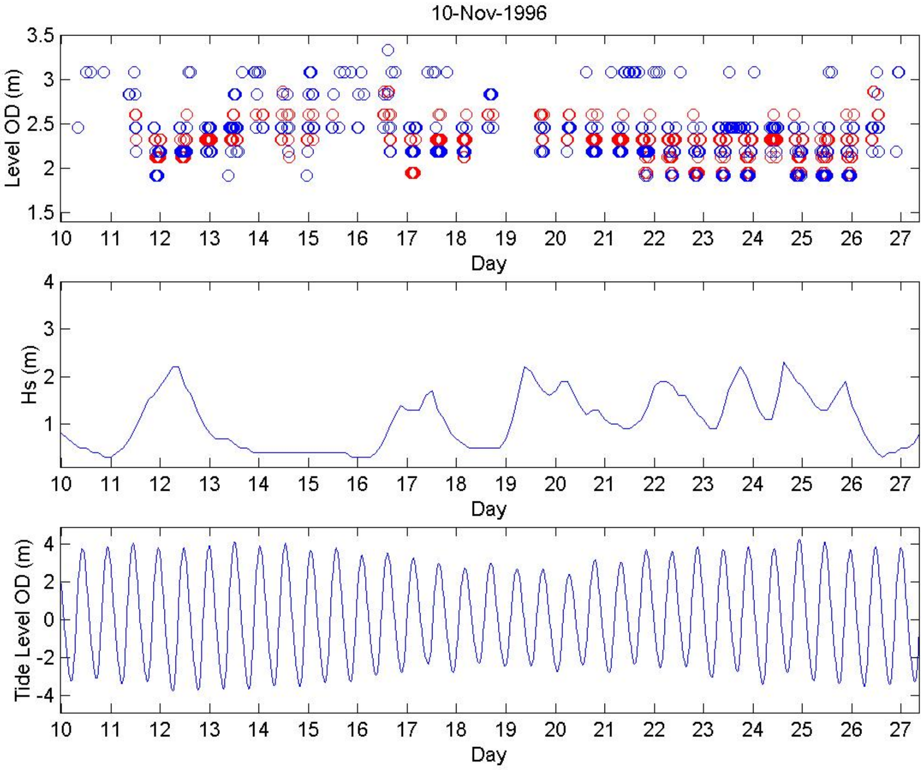

16-Jul-1996
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

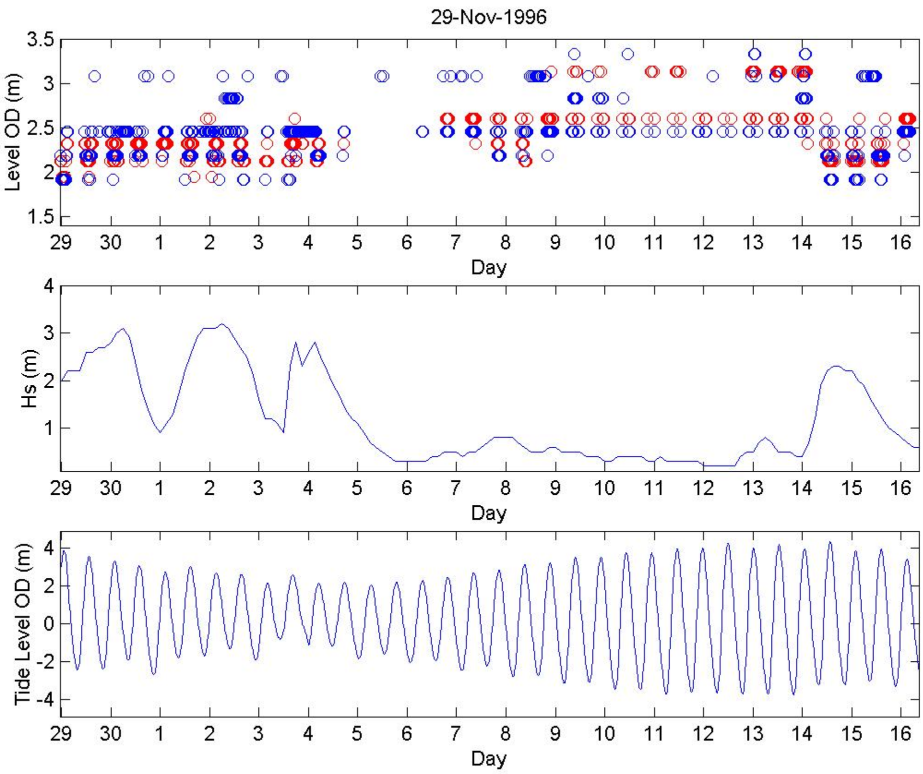

02-Aug-1996
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day


13-Sep-1996
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

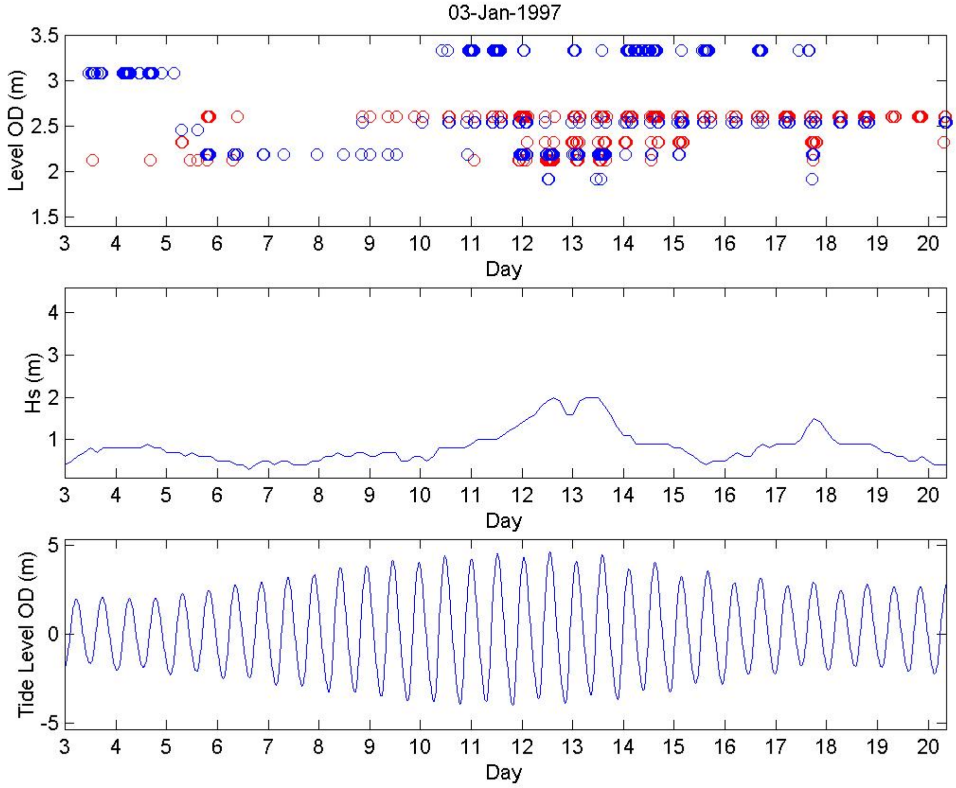

28-Sep-1996
Level OD (m)
Hs (m)
Tide Level OD (m)
Day

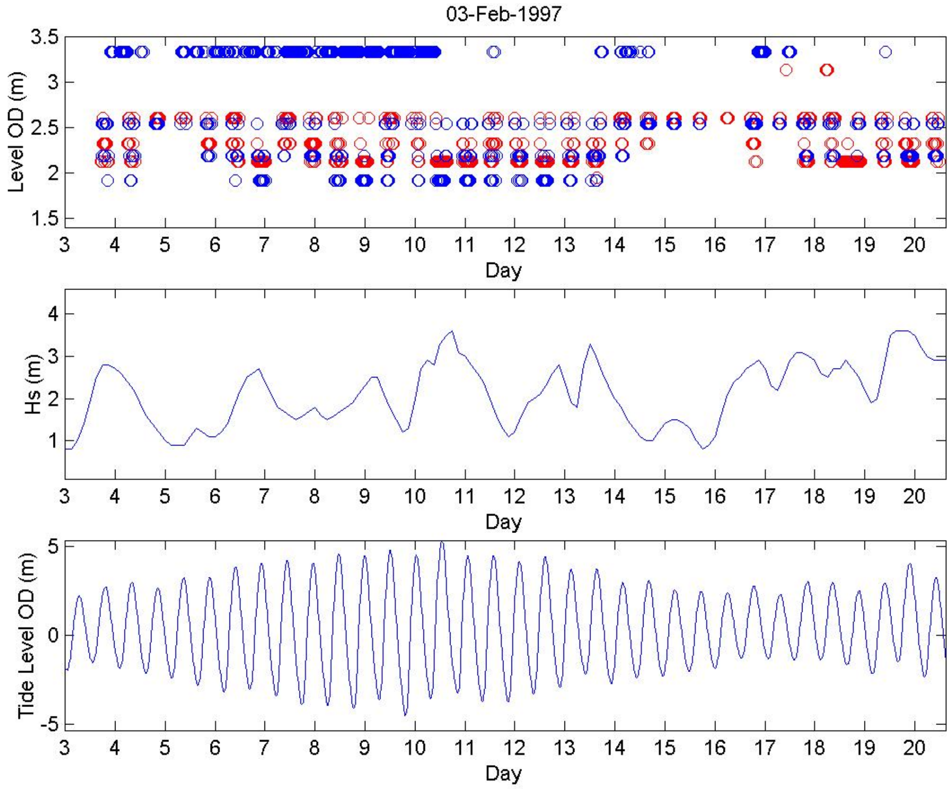

13-Oct-1996
Level OD (m)
Hs (m)
Tide Level OD (m)
Day

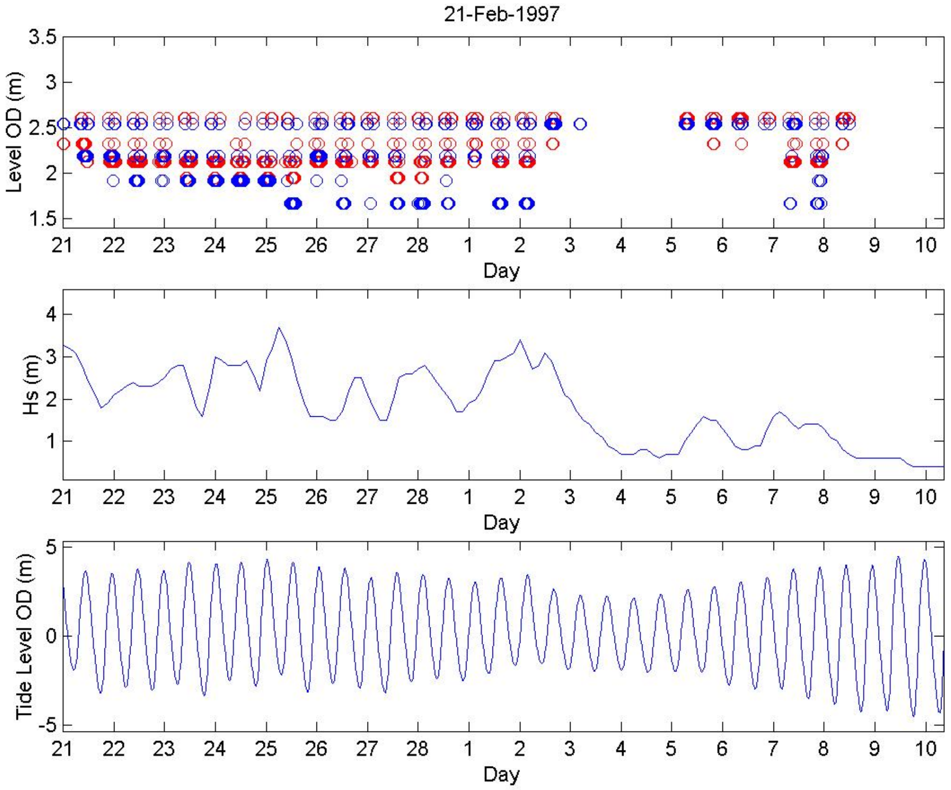

10-Nov-1996
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

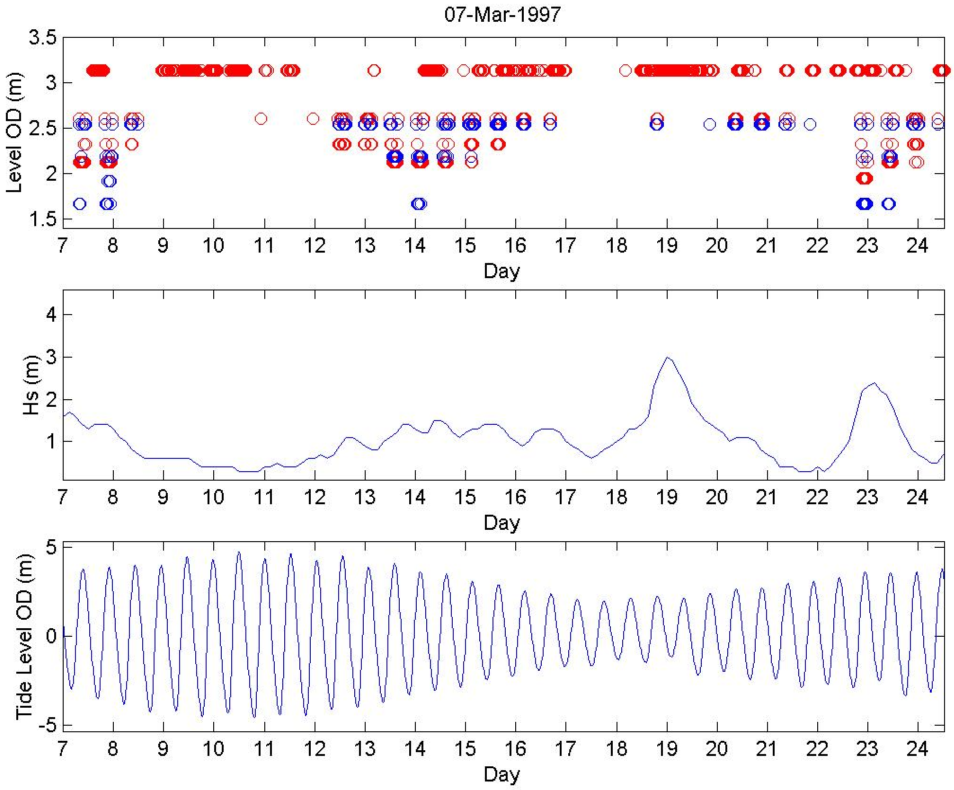

29-Nov-1996
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

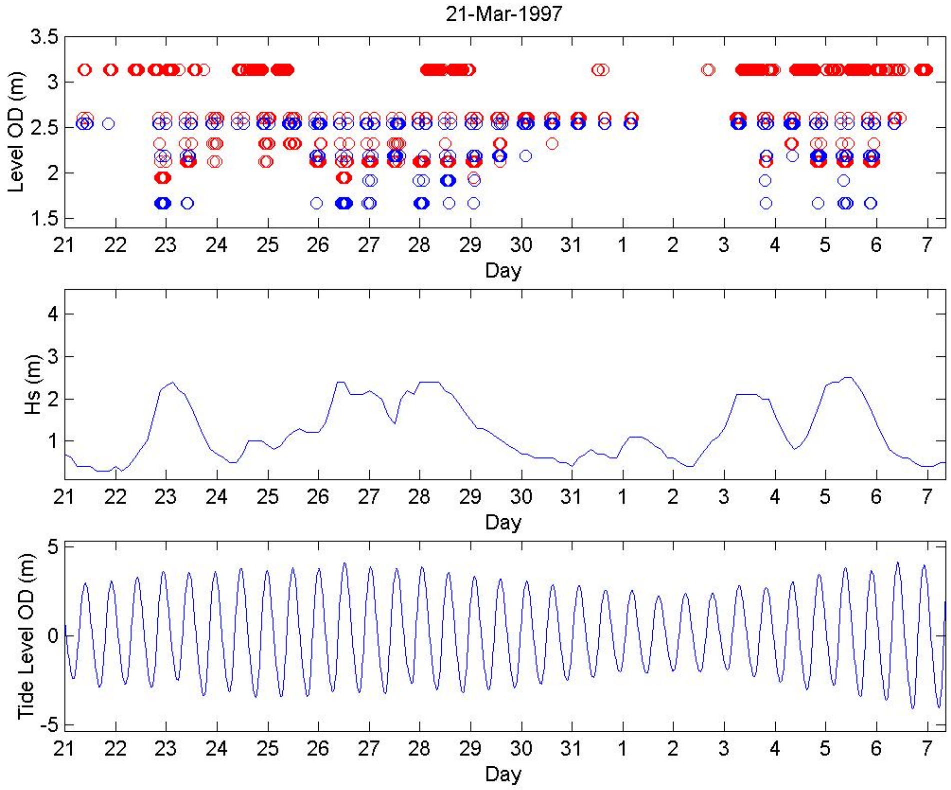
Appendix 2 Combined data from 1997

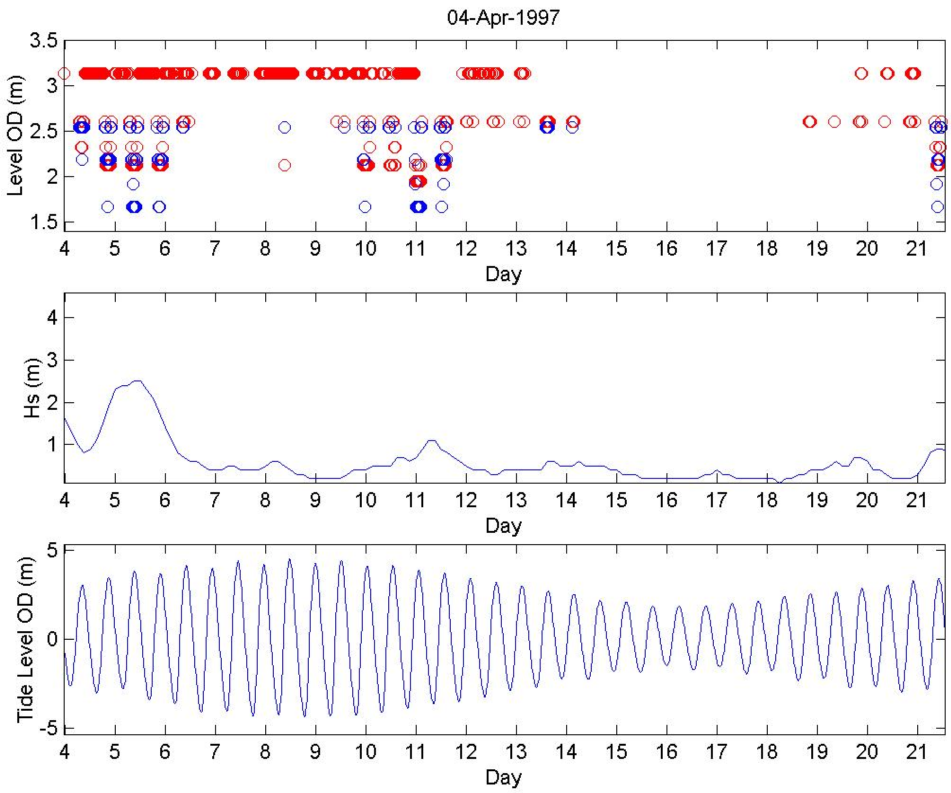


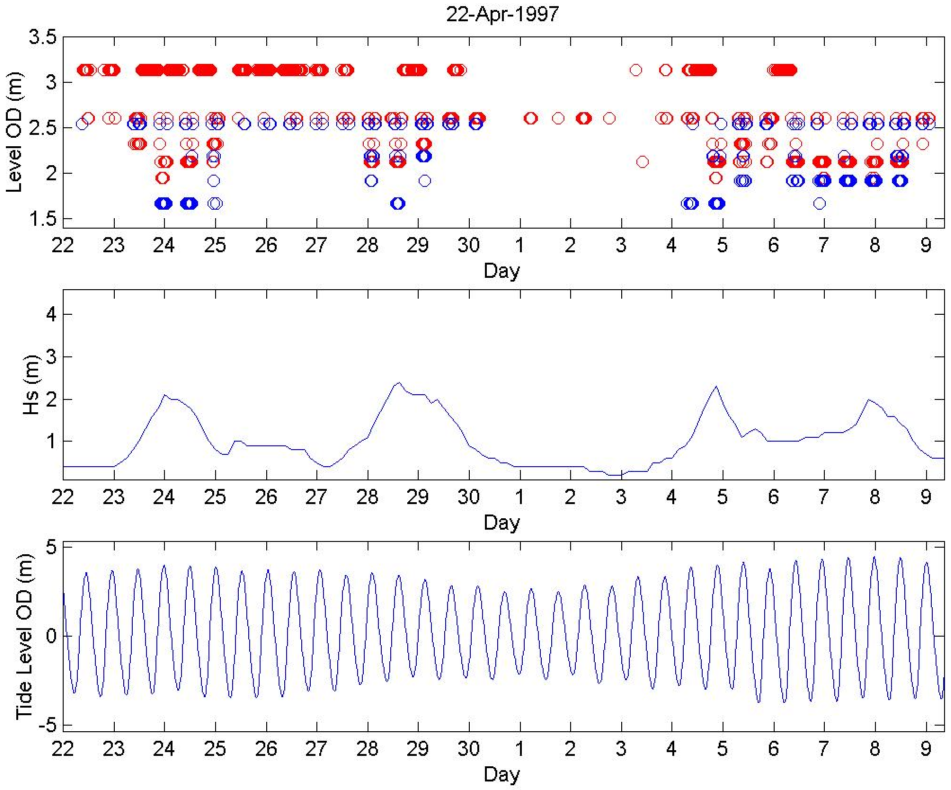


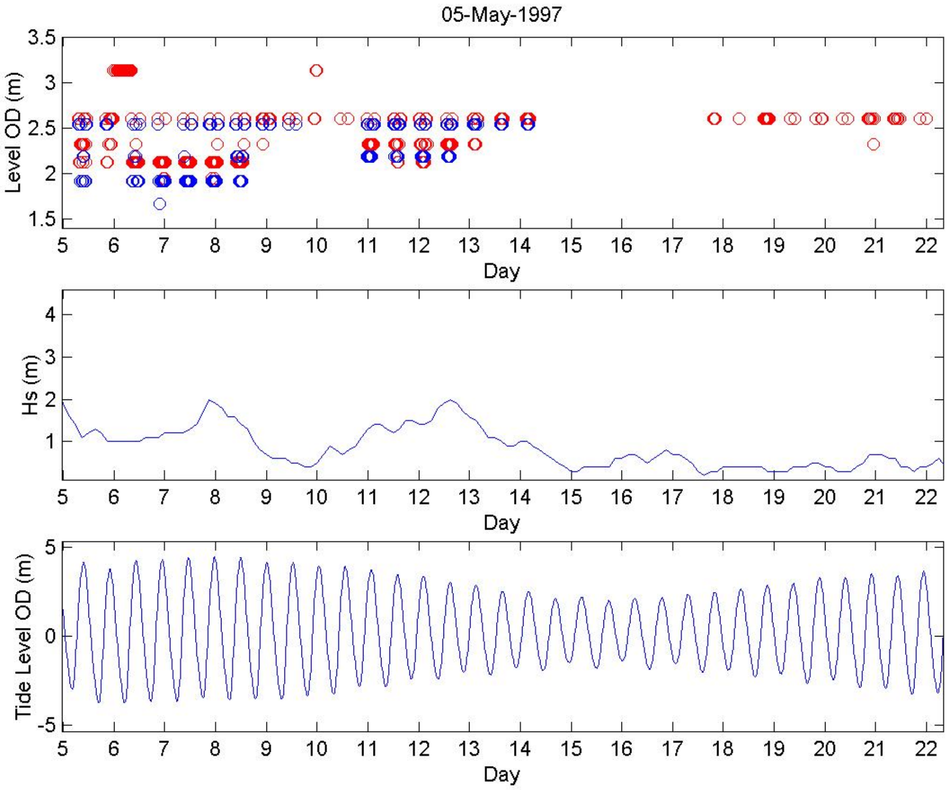

21-Feb-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

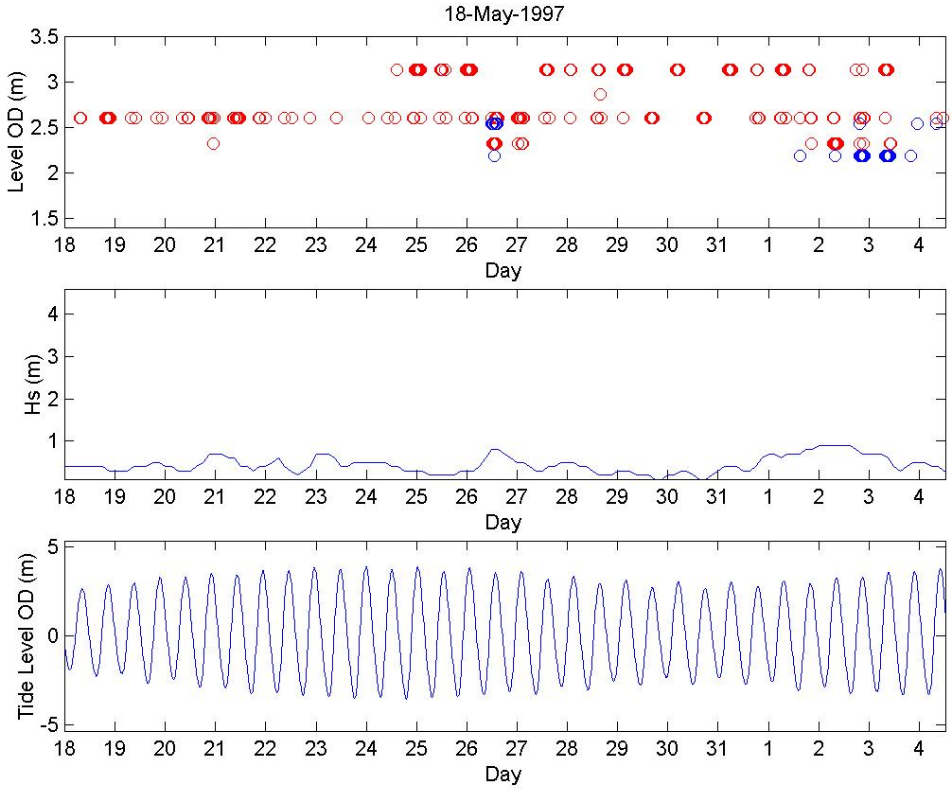

07-Mar-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

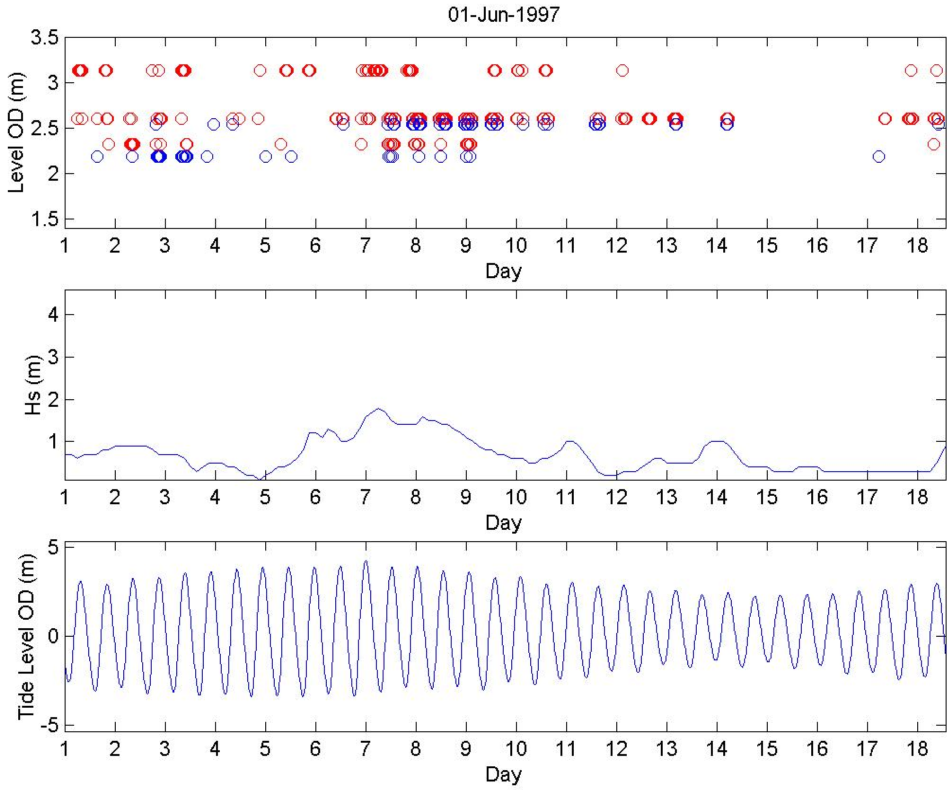

21-Mar-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

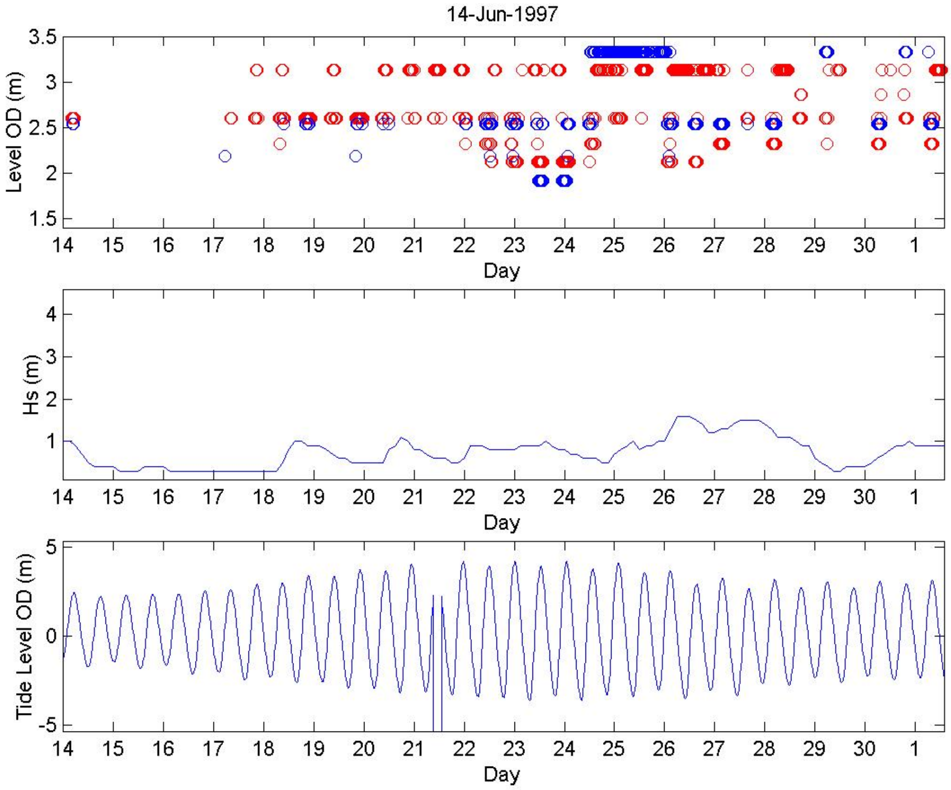

04-Apr-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

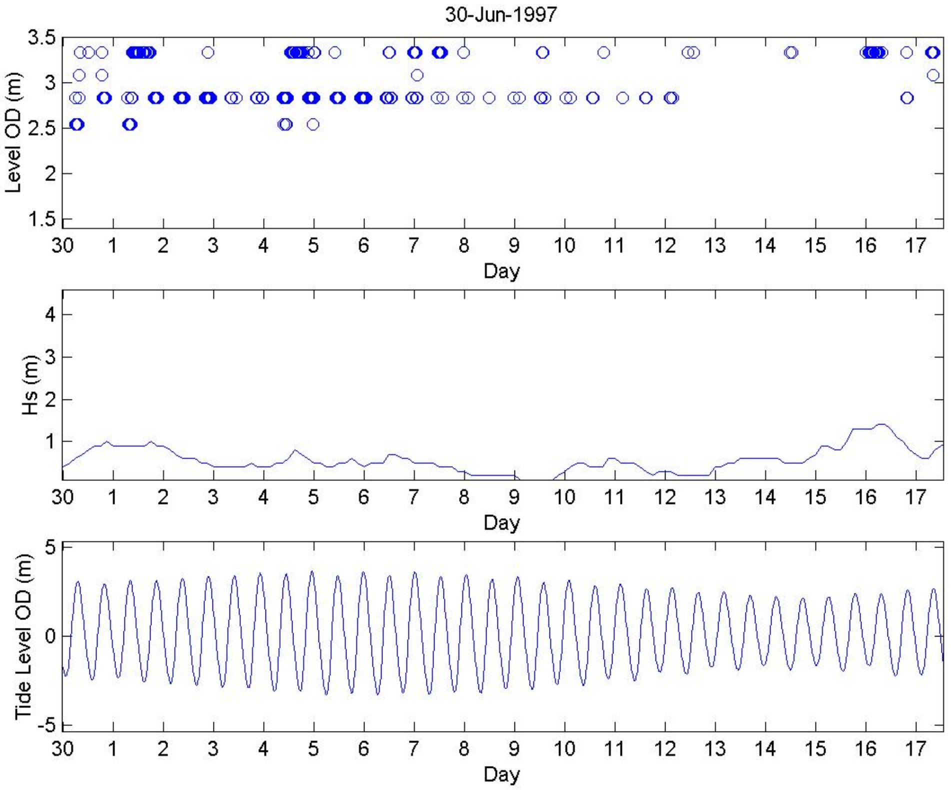

22-Apr-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

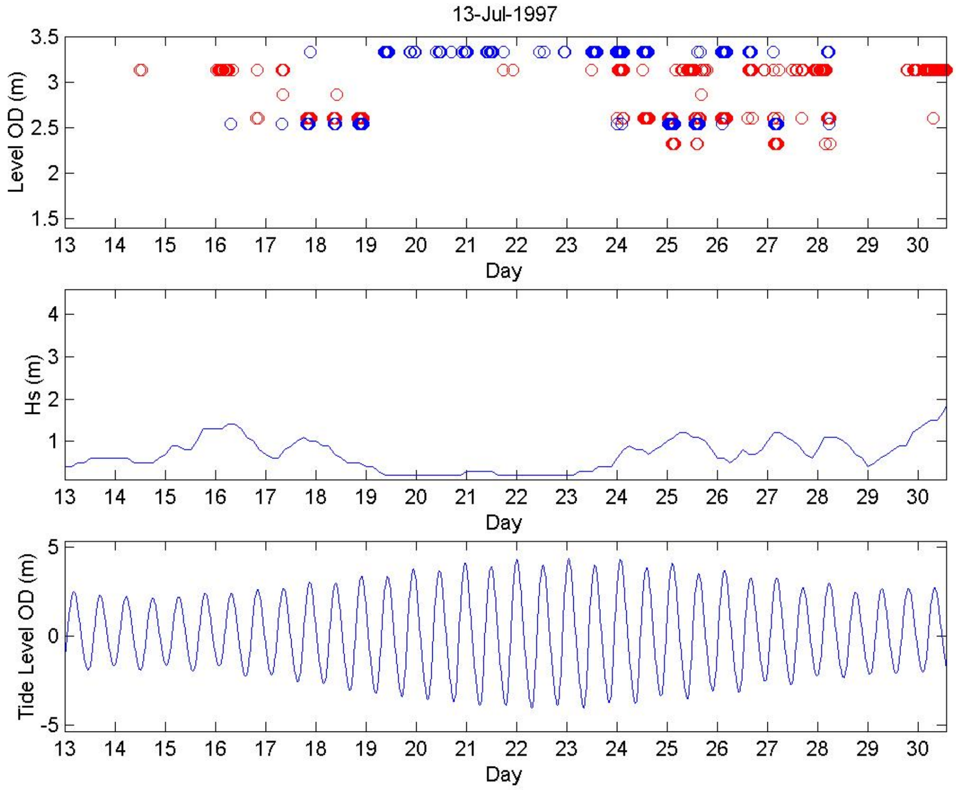

05-May-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

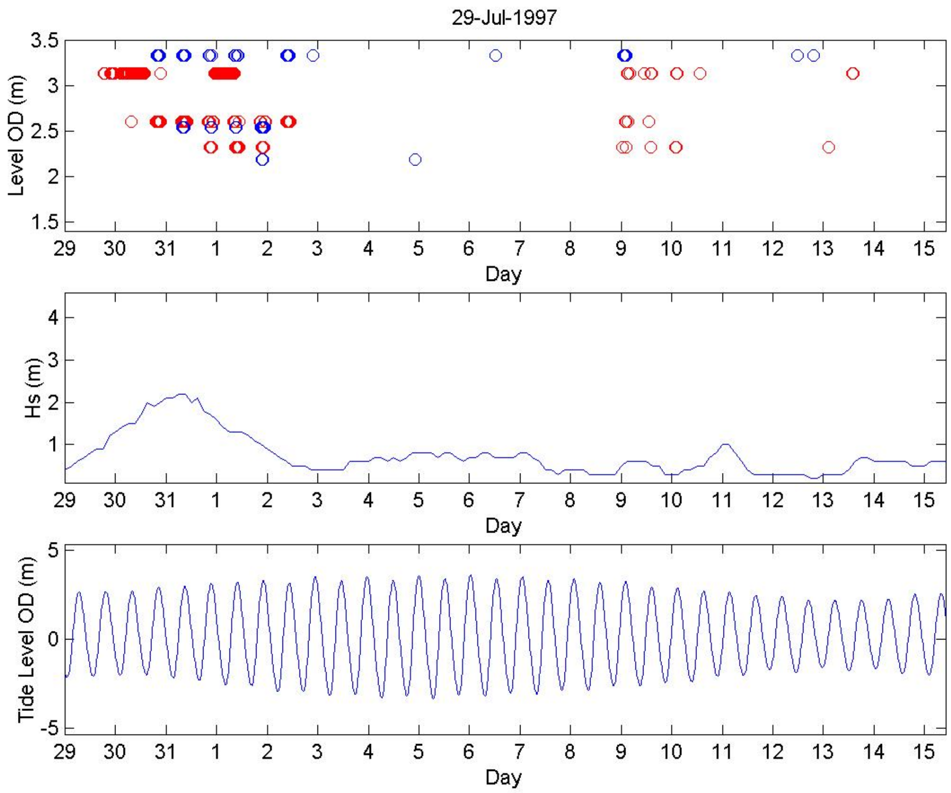

18-May-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

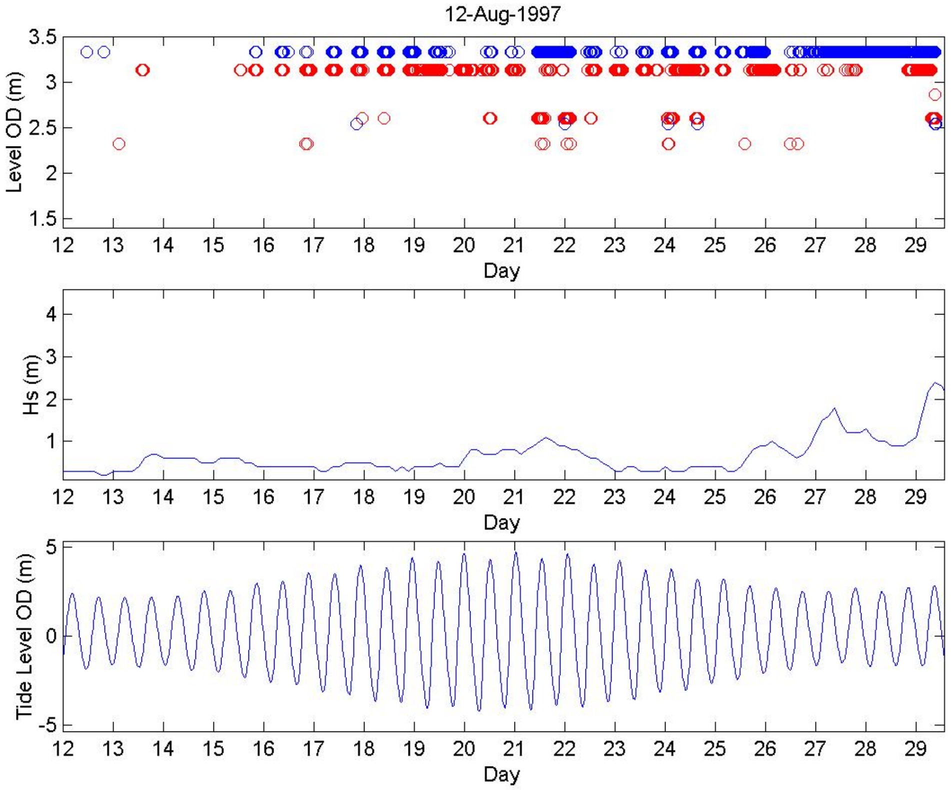

01-Jun-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

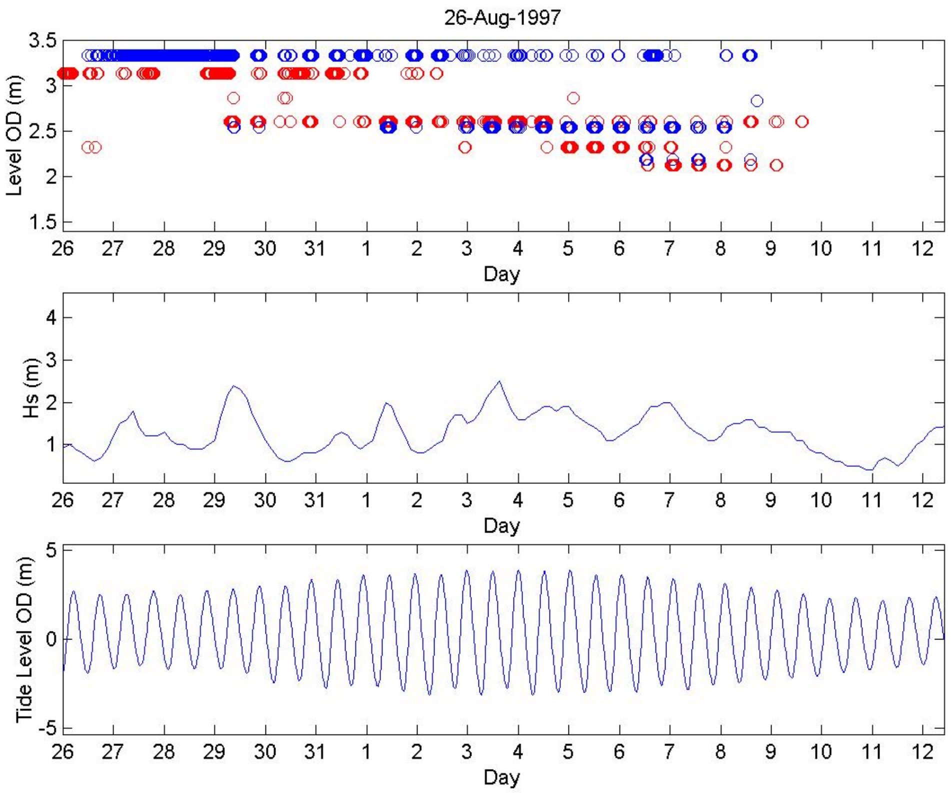

14-Jun-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

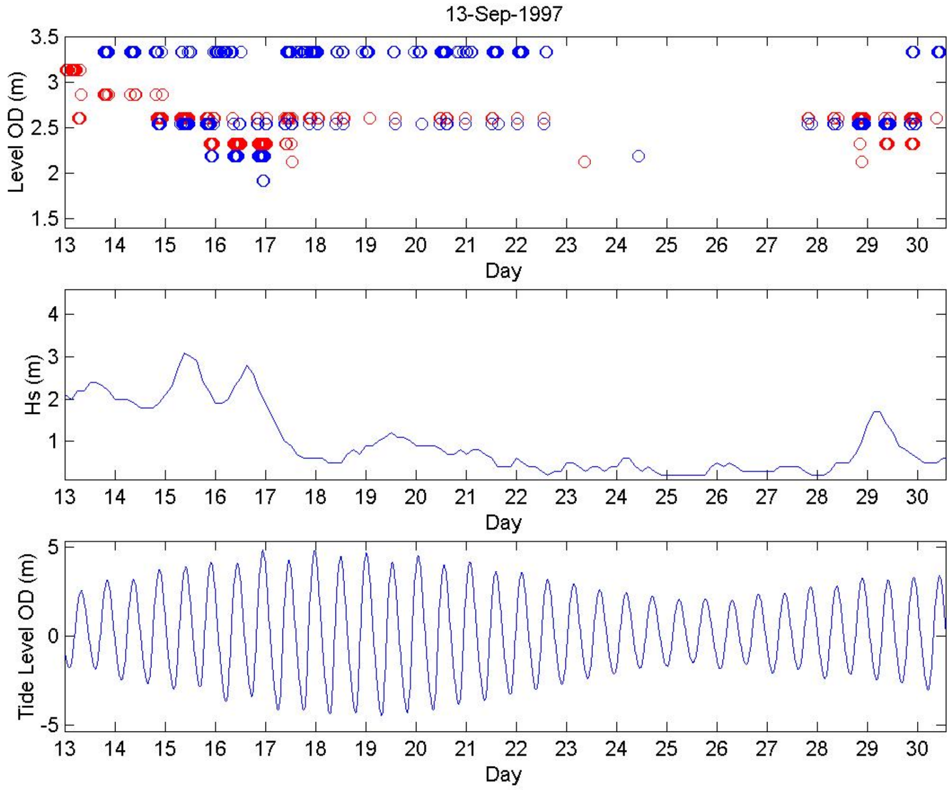

30-Jun-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

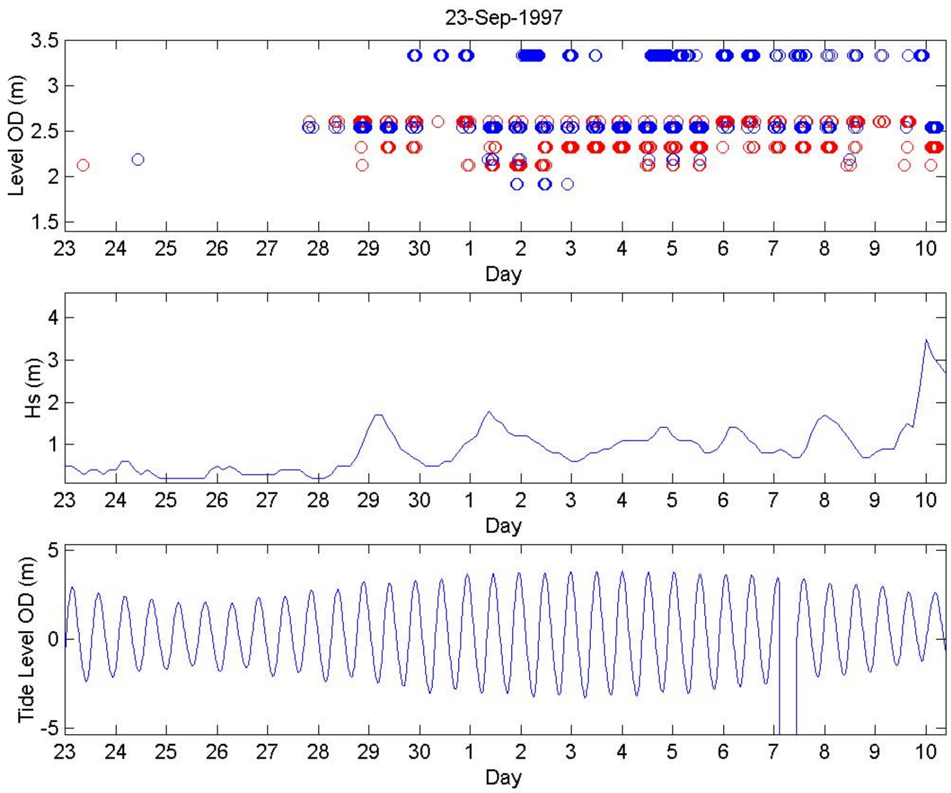

13-Jul-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

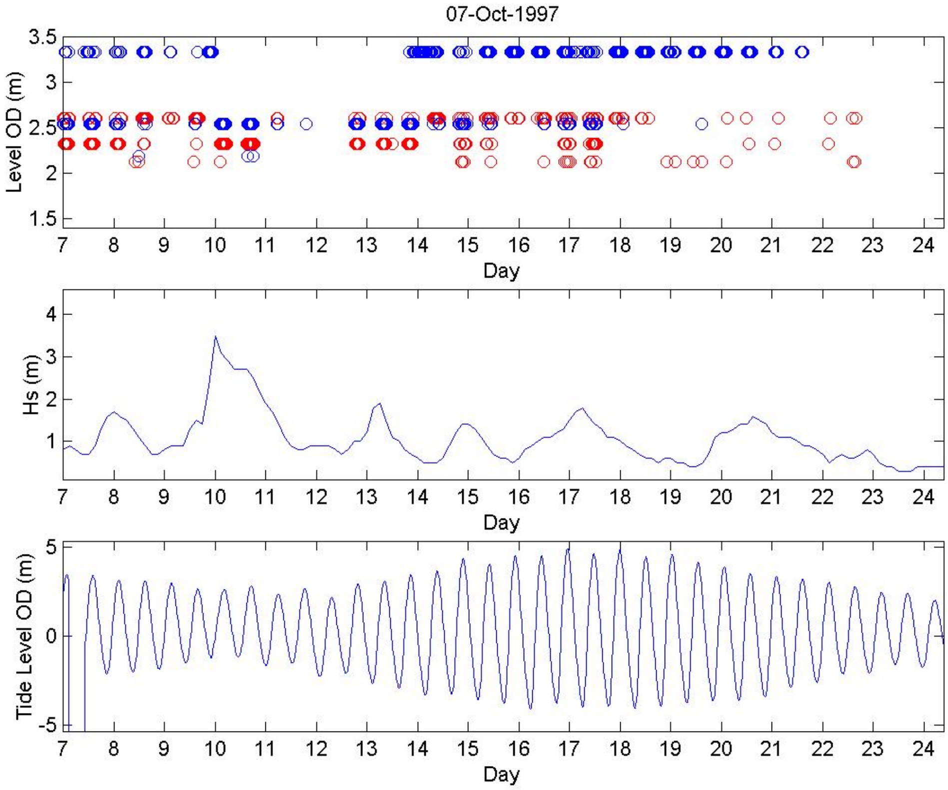

29-Jul-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

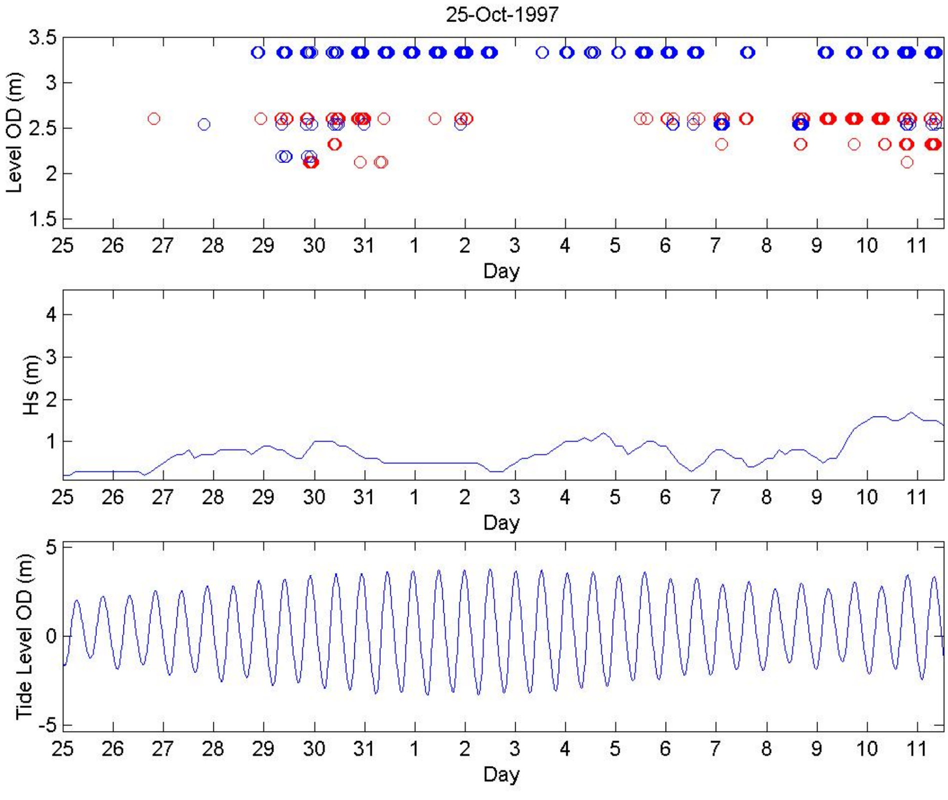

12-Aug-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

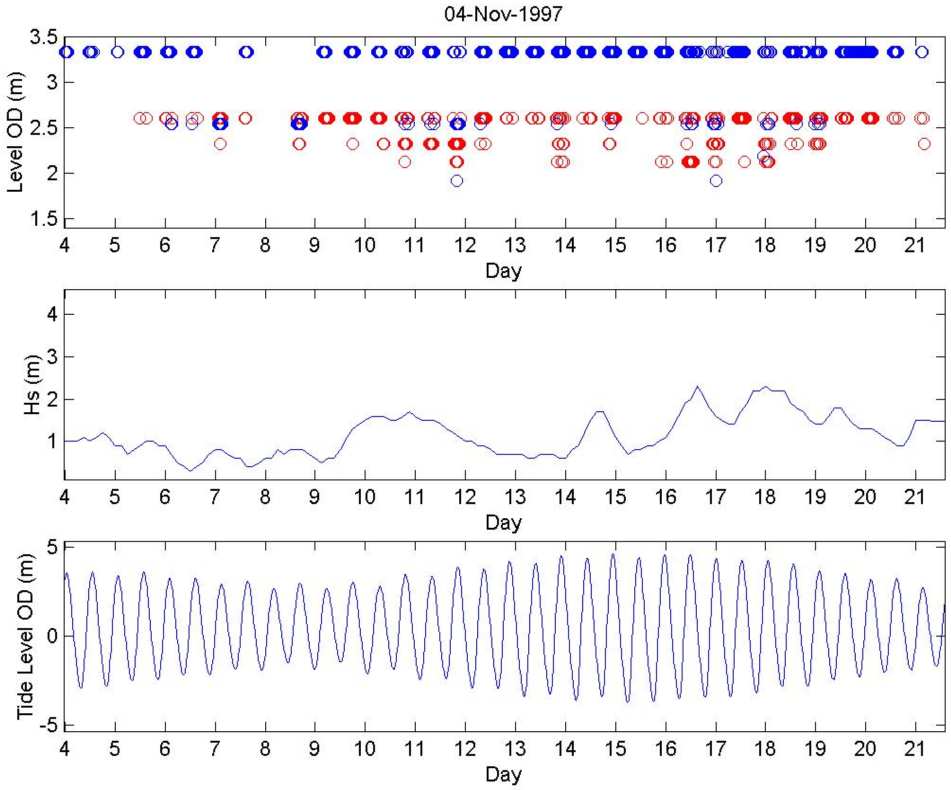

26-Aug-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

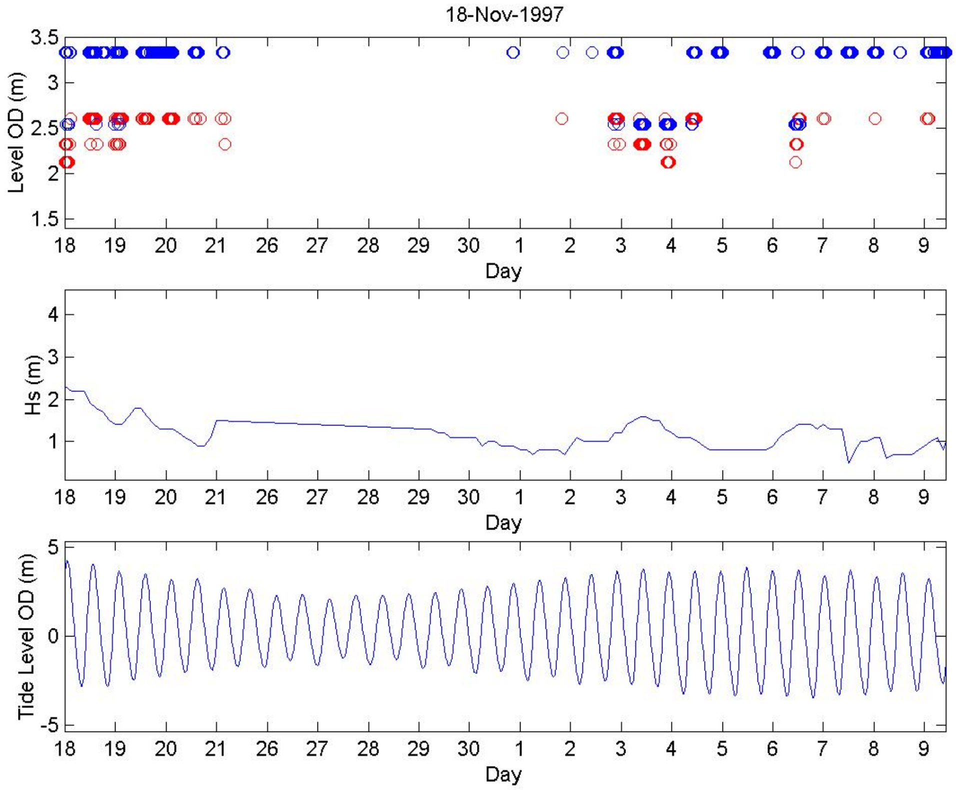

13-Sep-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day


23-Sep-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

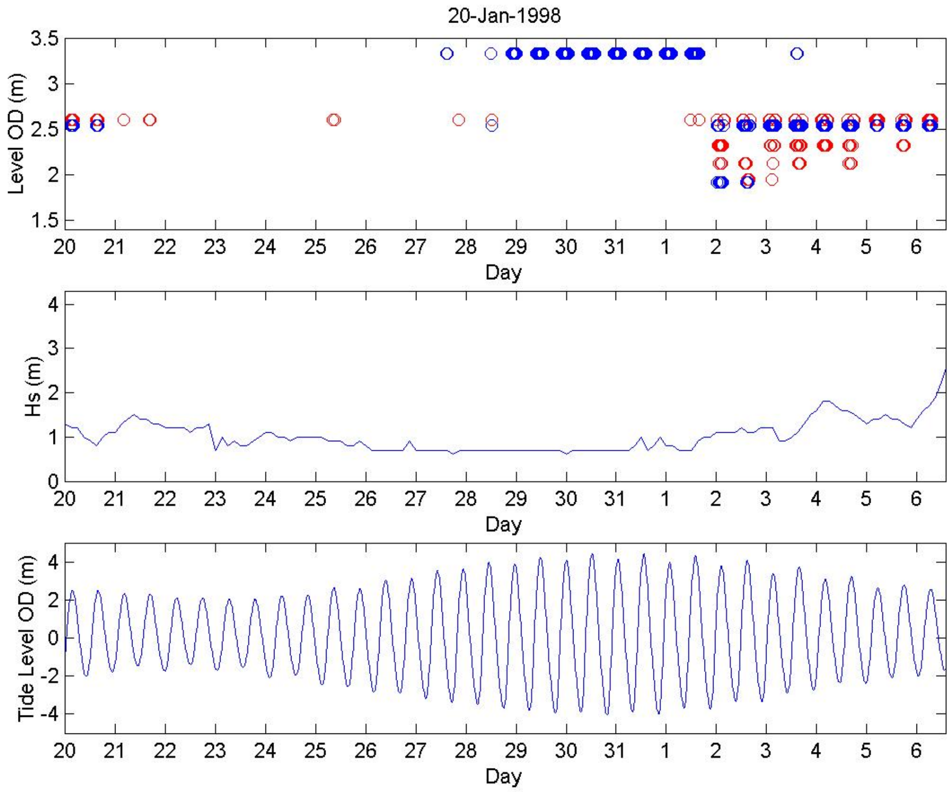

07-Oct-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

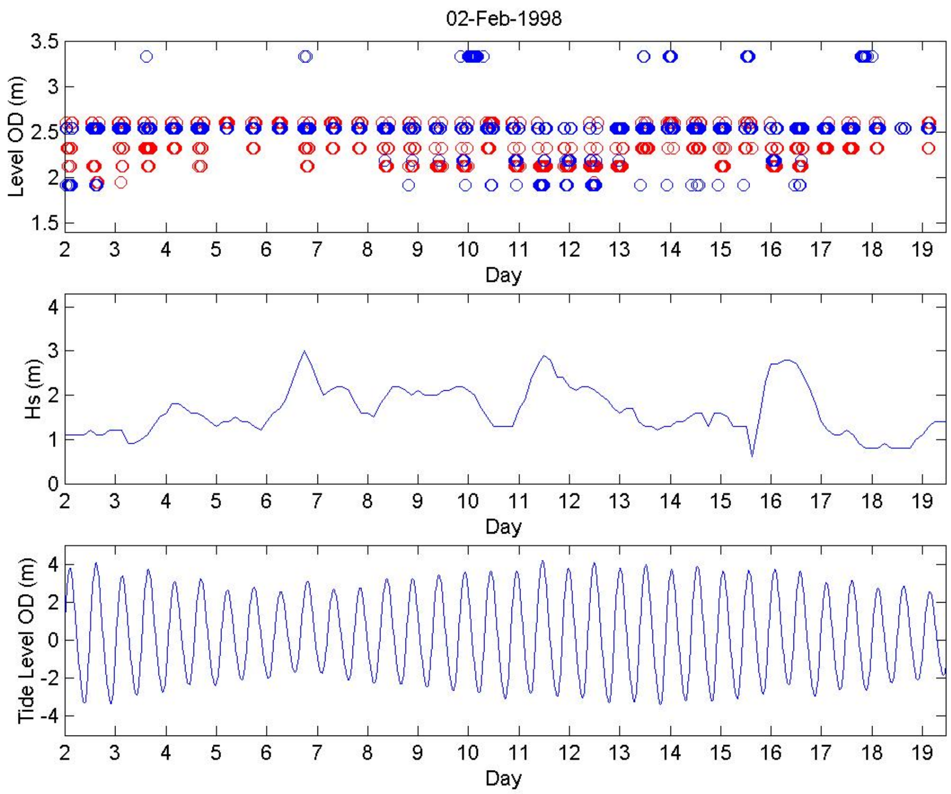

25-Oct-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

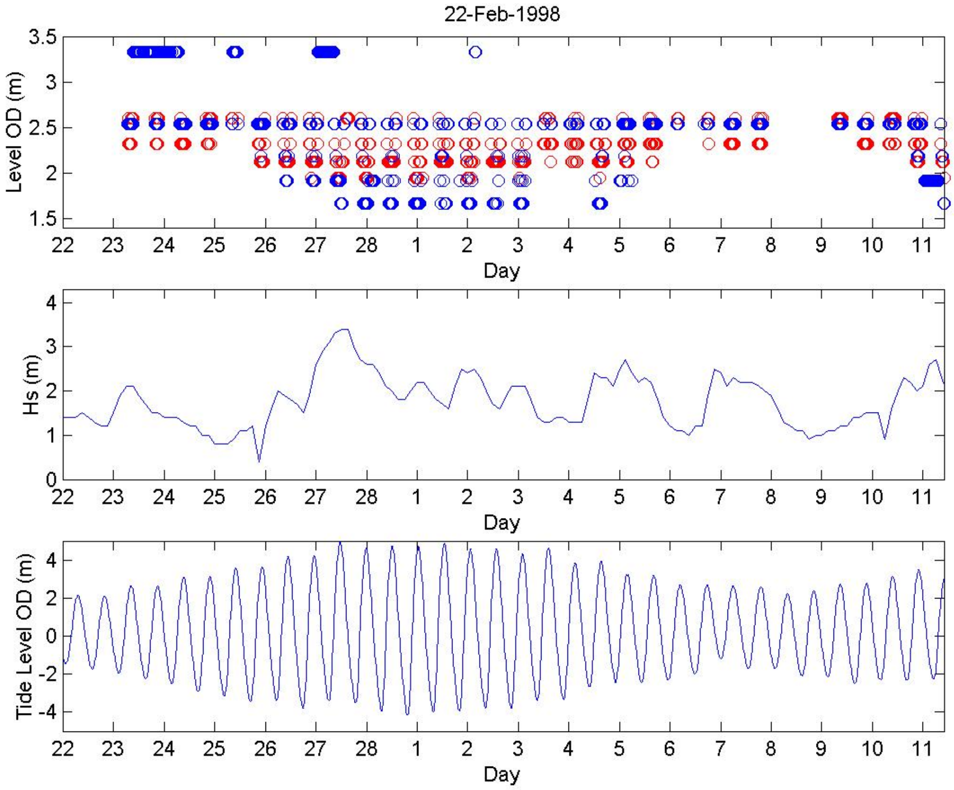

04-Nov-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

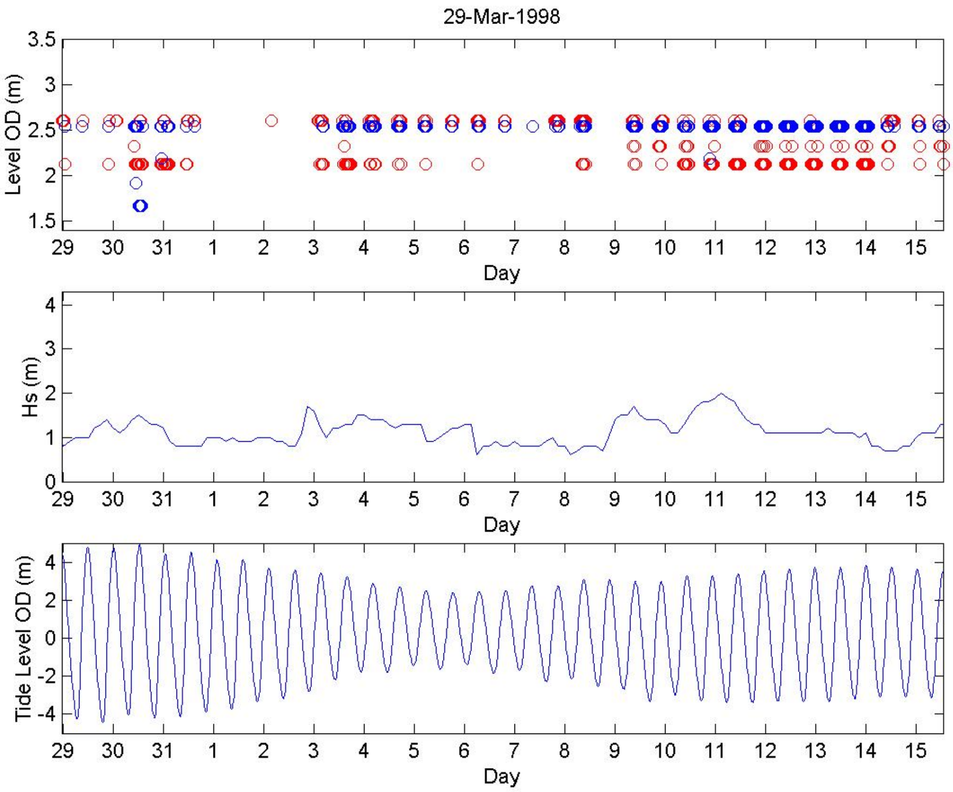

18-Nov-1997
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

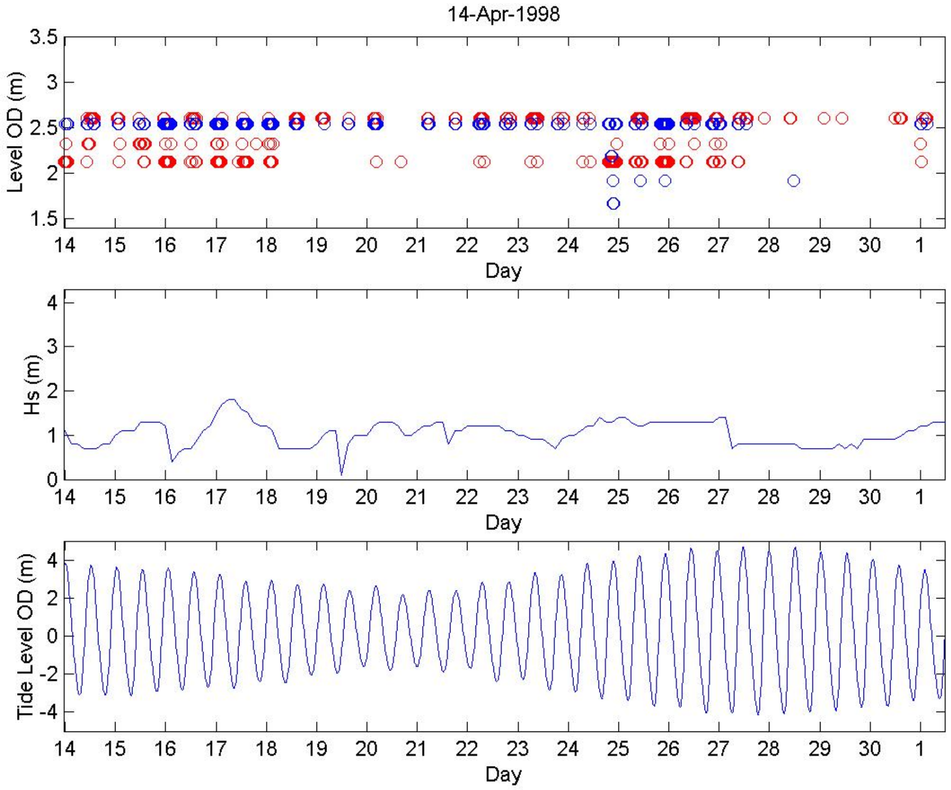
Appendix 3 Combined data from 1998

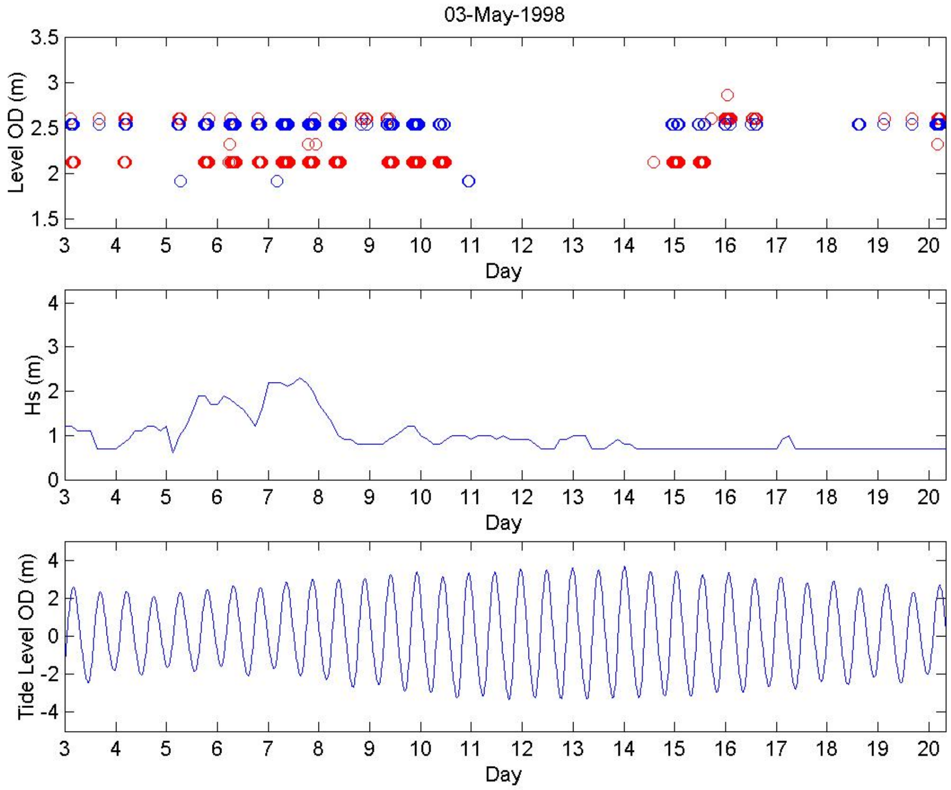


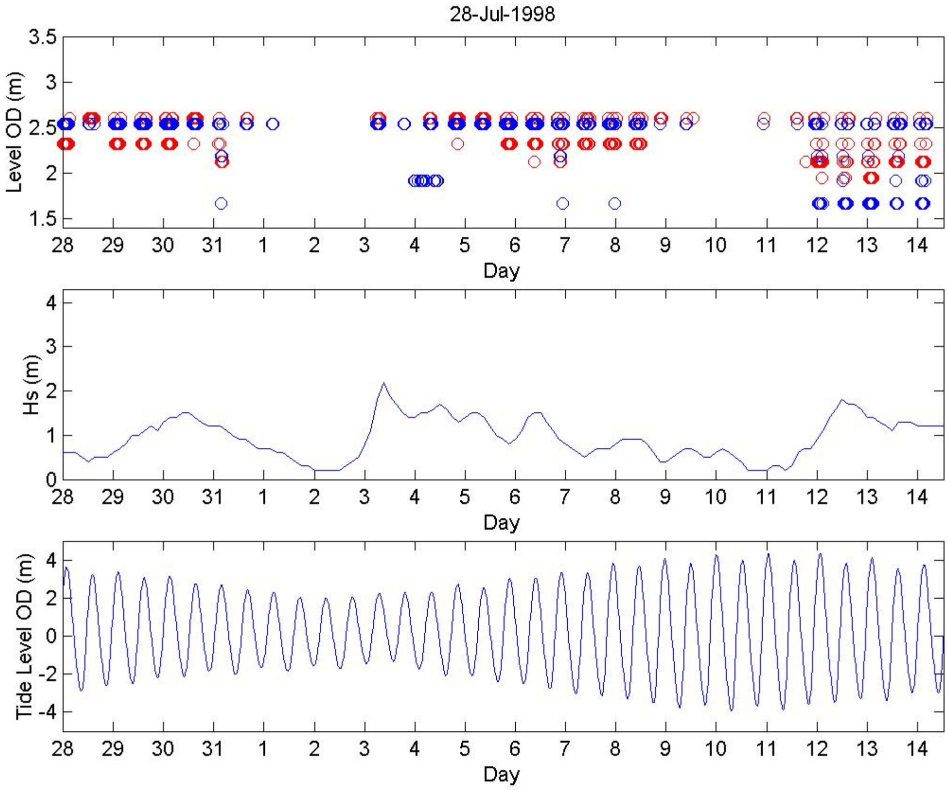


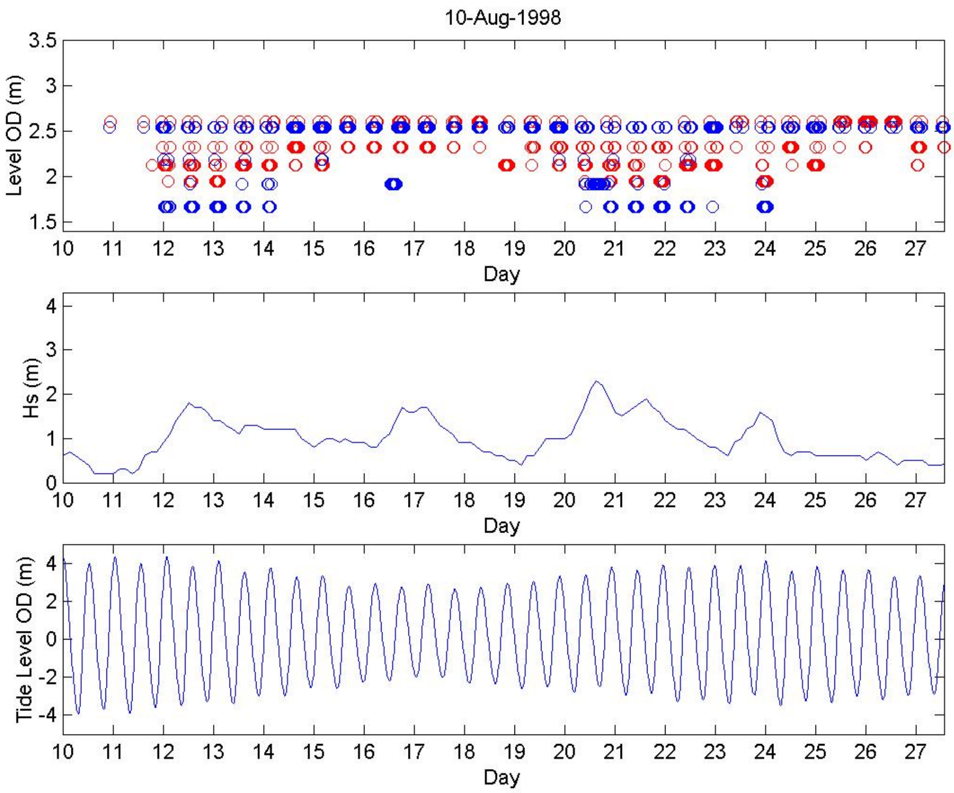

22-Feb-1998
Level OD (m)
Hs (m)
Tide Level OD (m)
Day

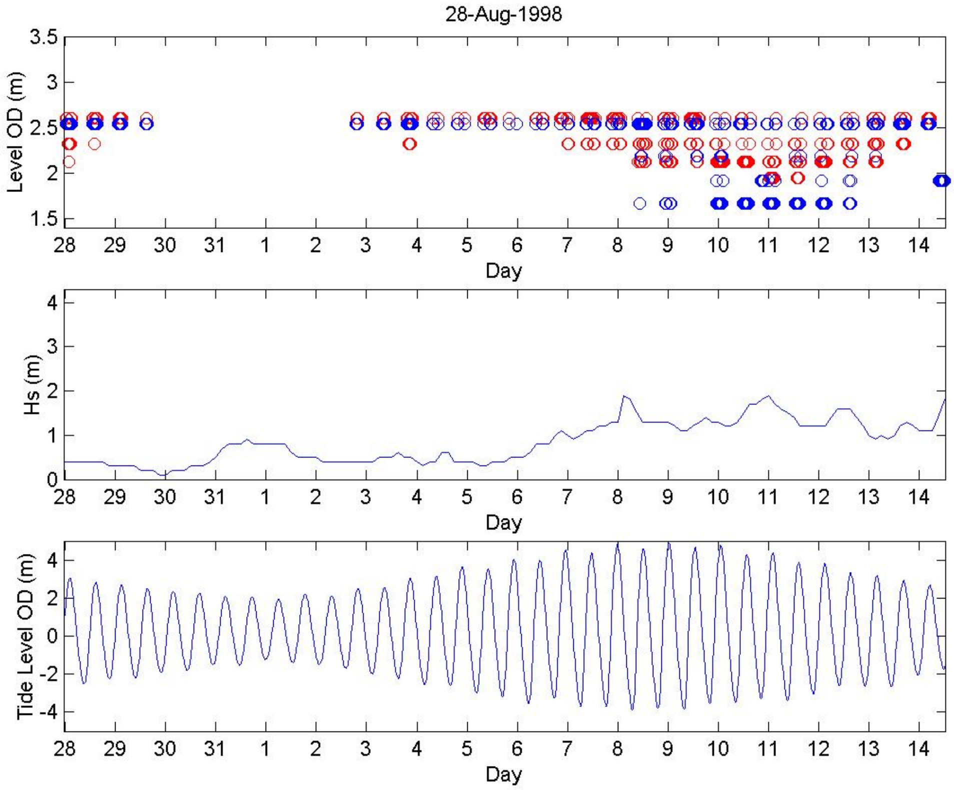

29-Mar-1998
Level OD (m)
Hs (m)
Tide Level OD (m)
Day

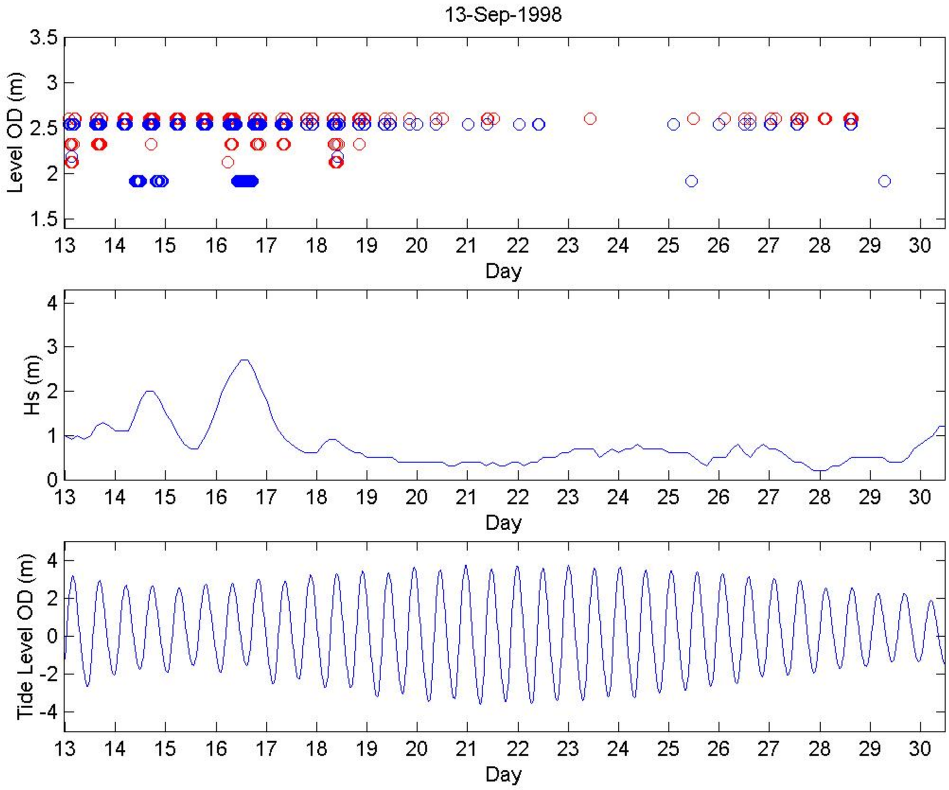

14-Apr-1998
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day

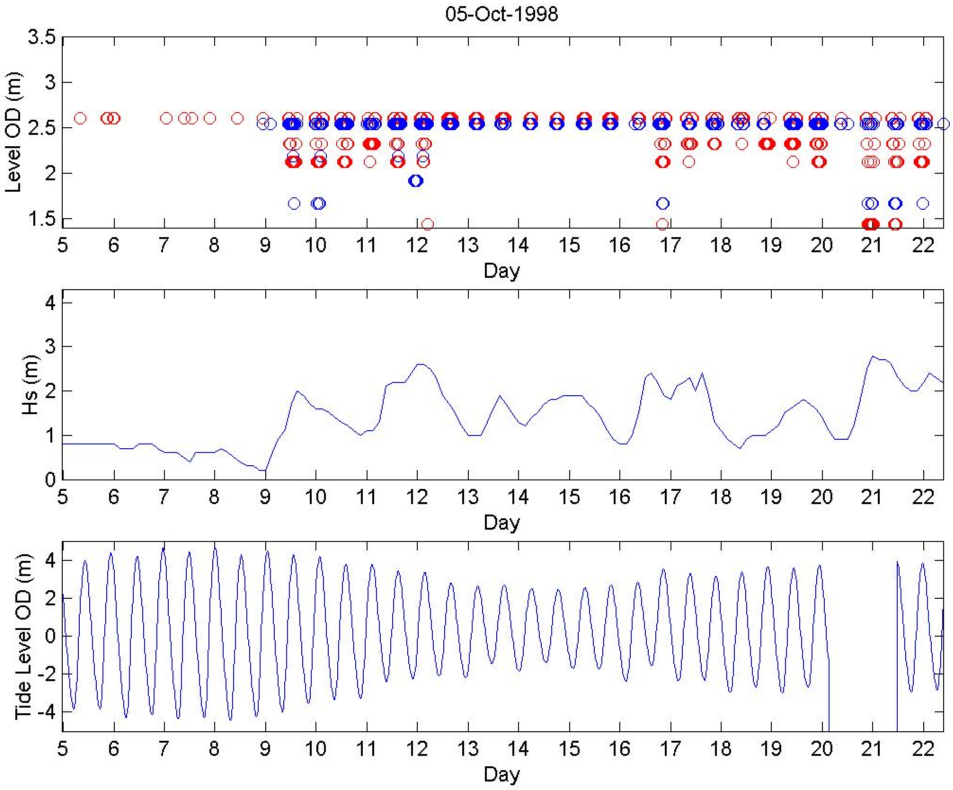

03-May-1998
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day


28-Jul-1998
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day


10-Aug-1998
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day


28-Aug-1998
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day


13-Sep-1998
Level OD (m)
Day
Hs (m)
Day
Tide Level OD (m)
Day


05-Oct-1998
Level OD (m)
3.5
3
2.5
2
1.5
Day
Hs (m)
4
3
2
1
0
Day
Tide Level OD (m)
4
2
0
-2
-4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
Day

Appendix 4 Combined data from 1999

Figures from 1999 will be added to TN CBS0726/04 Release 2.0.