



Managing European Shorelines and
Sharing Information on Nearshore Areas

messina

A Case Study Documenting the Dubai Coastal Zone Monitoring Programme – An International Example.

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North East South West
INTERREG IIIC

1. INTRODUCTION

A comprehensive coastal monitoring programme has been set up for the Dubai coastal zone following extensive infra-structural development over the last 20 years. The Dubai coastal zone, and in particular the Jumeirah frontage, has been identified as a key element in the expected dramatic expansion of tourism to the region. Considered together with an expected 300% increase in population within the next 20 years, it is likely that the coastal resource will be under tremendous pressure (Smit, F. et al, 2003).

The Dubai Municipality has long since recognised that along with the desire to live and work by the sea comes the difficulties of working with the dynamic forces of nature and, increasingly, the requirement to consider the natural environment (www.dubaicoast.org). As such, an Integrated Coastal Zone Management approach has been adopted in order to provide a good understanding of prevailing coastal processes in order to recommend optimum development approaches whilst still maintaining protection for vulnerable areas.

Previous monitoring data has been collected on an ad-hoc or a scheme-by-scheme basis. However, the need exists to capture coastal data in a more systematic manner to enable coastal planners and others to develop a full understanding of environmental conditions and how coastal developments will affect this process (www.dubaicoast.org). The initial monitoring programme began in 1997 with bathymetric and topographic baseline surveys being carried out. In addition to this, a directional wave rider buoy was deployed to provide information on nearshore wave activity. Subsequent surveys were carried out regularly over the following years up until 2002 when the monitoring programme was considerably expanded to include whole extent of the Dubai coast, from Al Mamzar Lagoon in the north to the Jebel Ali coast in the south.

The Dubai Coastal Zone Monitoring Programme utilises leading edge technology to assist Dubai Municipality with its management role in ICZM. The current initiative by the Municipality aims to build upon the existing data sets using industry recognised techniques, and will provide information required for the further development of its existing coastal zone management capability (www.dubaicoast.org).

2. GEOGRAPHICAL OUTLINE

The Emirate of Dubai, is part of the United Arab Emirates, and is located on the South Eastern coast of the Arabian Gulf, with a coastline of approximately 105 kilometres (Figure 1).



Figure 1. Location map of Dubai

In its natural state, the Dubai coastline consists primarily of long sandy beaches backed by dunes. However, its rapidly expanding tourist, trade and fishing industries has brought about extensive development which has interfered with the natural coastal processes of waves, tidal currents and sediment transport.

3. COASTAL ZONE MONITORING

The Dubai coastal monitoring programme began in 1997 when a baseline bathymetric and topographic survey of the Jumeirah coastline was undertaken. Additional data is now collected to supplement the original programme of measurements. Features of the current monitoring programme include regular topographic and bathymetric surveys, remote video monitoring of Dubai beaches, sediment sampling and analysis, nearshore directional wave and current recordings and intensive measurement exercises at selected locations using Acoustic Doppler Current Profiler (ADCP) equipment.

3.1. BATHYMETRIC AND TOPOGRAPHIC SURVEYS.

The Dubai coastal zone has been divided into units in order to facilitate the monitoring operations (Figure 2).

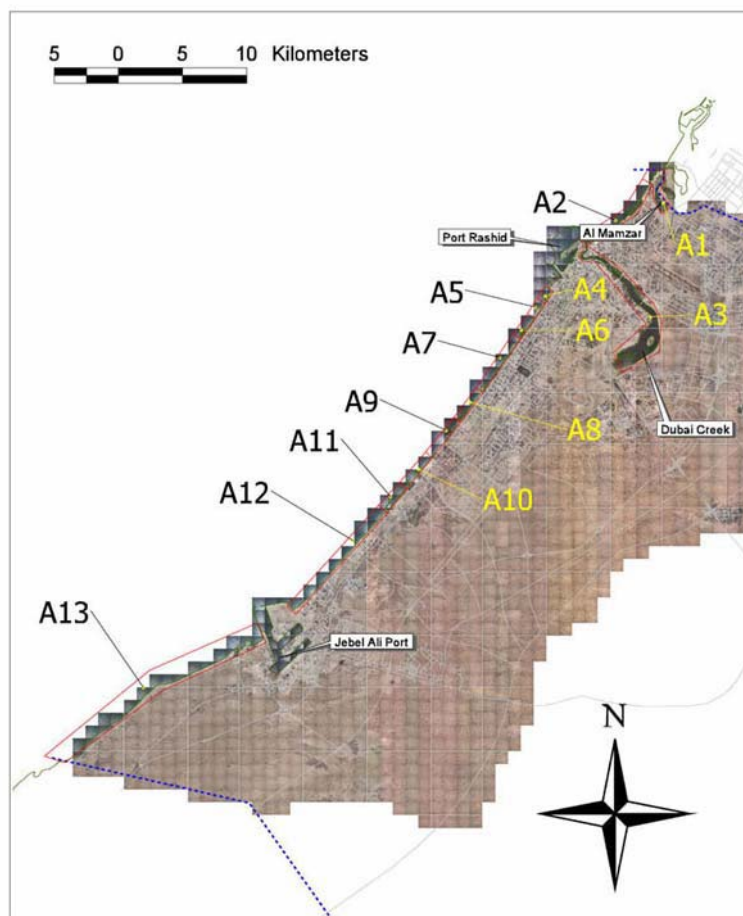


Figure 2. Management units of the Dubai coastline (Smit, et.al, 2003)

The frequency of surveys is decided on a risk-based approach, whereby those areas perceived to be at a greater threat from coastal erosion or inundation, are monitored more frequently than those seen to be less at risk. This risk assessment is reviewed on an annual basis in order to ensure the correct level of monitoring is being carried out within each unit.

The bathymetric survey element of the project involves full coverage of a 500m wide band along the entire coastline, with survey lines running perpendicular to the coast at 25m line spacings. Data is collected along pre-determined profile lines using a dual frequency echo sounder combined with the use of differential GPS in order to help position the survey vessel. Areas of particular interest or concern are resurveyed as and when necessary to monitor changes over time. Comparisons between survey data sets assist in substantiating the existing understanding of the sediment budget and transport processes along the Dubai coastline (www.dubaicoast.org).

Topographic surveys are carried out using a pre-defined set of profiles that run perpendicular to the shoreline down to mean water level +1.13m DMD (Dubai Municipality Datum). Scatter point surveys are also undertaken at 10 locations along the Dubai coast in order to produce a contour map of the beach by entering spot height data into a digital terrain model (DTM). Data is collected via RTK GPS (Real-Time Kinematic Geographical Positioning System), which allows for positional accuracies of up to 20mm to be recorded. A network of ground markers known as control points allows for all RTK points to be checked against a reference level in order to improve the quality control of the data.

3.2 NEARSHORE WAVE MEASUREMENTS

The Dubai Municipality has recorded directional wave information from January 1997 to February 2001 at a nearshore position just north of Jebel Ali Port in about 6 m water depth. Since 2002 an 1200 kHz ADCP with pressure sensor has been deployed at the same position. A second 1200 kHz ADCP has been deployed off the Jumeirah Public Beaches to provide directional wave information in the area of most immediate interest to the Municipality (Figure 3). This instrument provides a near real-time feed of wave

information to the Municipality offices as well as being made available to the general public on-line. The instrument measures currents throughout the water column using the return echo of an acoustic signal transmitted by the instrument (Smit, et.al, 2003).

A pressure sensor was also installed behind the northern arm of the T breakwater to provide information on water levels within the sheltered embayment. Variations in water depth (pressure head) induce corresponding resistivity readings in a piezo-electric device in the instrument. The value of resistance measured is proportional to the depth of water (www.dubaicoast.org). The data is used to gain an understanding of the hydrodynamic processes occurring along the coast, to calibrate and verify hydrodynamic models as well as to assess bather safety concerns. Over time, as a longer-term record is gathered, these will serve to update nearshore design wave and water level conditions for Dubai (Smit, et.al, 2003).

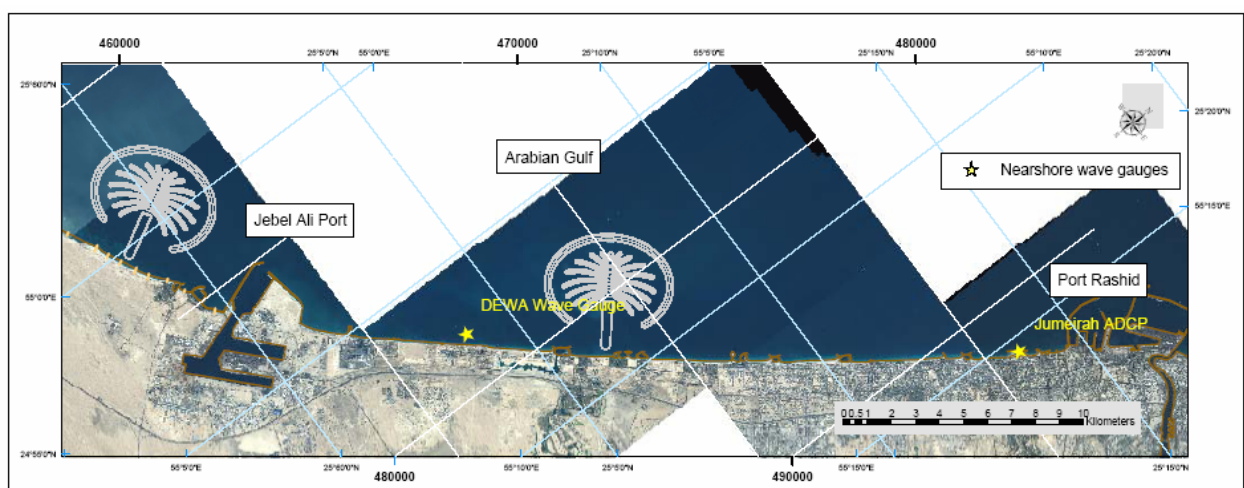


Figure 3. Location of nearshore wave gauges (Smit, et.al, 2003).

3.3 VIDEO MONITORING

Two video cameras have been installed on the 34th floor of the famous Burj Al Arab hotel located offshore on the Dubai coastline (Figure 4). These cameras capture time-lapse imagery of the Um Sequeim and Palace Beaches, which are geo-rectified using GPS corrected control points. The images are then processed and the ground control points are used in order to return an hourly "representative water line" (www.dubaicoast.org).

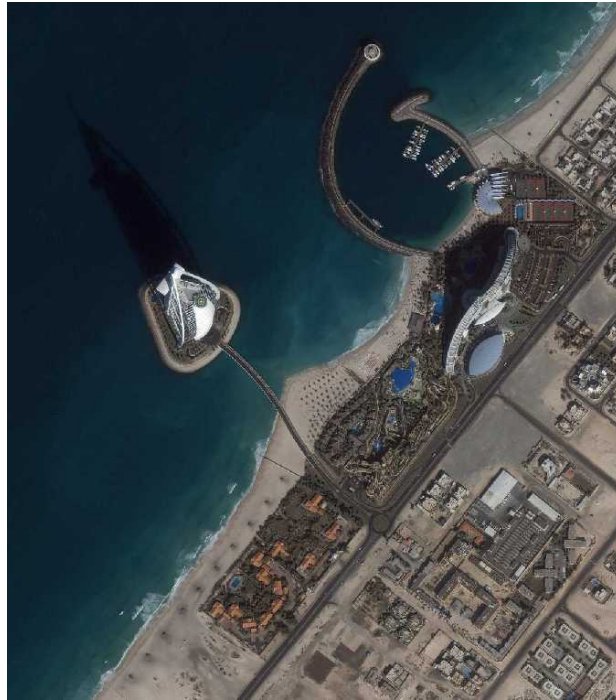


Figure 4. Aerial view of the Burj Al Arab Hotel

Analysis of data collected by the video camera has, until now, been used simply as a verification tool to compare extracted water levels from the images against real-time survey data. With verification complete, focus will now shift towards detailed analysis of water levels for the year's worth of images collected, the translation of these into profile dynamics and an investigation into bar dynamics and the extraction of nearshore current patterns using cross-image correlation (Smit, et.al, 2003).

3.4 METEOROLOGICAL DATA

A meteorological station has been installed at the Jumeirah Open Beach to provide additional information on wind speed and direction, barometric pressure and air temperature (Smit, et.al, 2003). The monitoring station is controlled and managed automatically by a custom built software package "EDEMS" (EmuDome Dubai Environmental Monitoring System) (www.dubaicoast.org). EDEMS allows real time data to be viewed by the client and project team and summary data to be processed and relayed to the project web site.

3.5. SEDIMENT SAMPLING

Sediment samples were collected during the initial data collection exercise in 1997 along all the Dubai beaches and in the nearshore zone. A limited sample gathering exercise has been undertaken to update this information. Samples are analyzed with regard to grain size and fall velocity and provide input to the coastline evolution, sediment transport and morphological models set up for the region (Smit, et.al, 2003).

4. COASTAL MONITORING OF THE JUMEIRAH OPEN BEACHES

An area of particular interest to the Dubai Municipality is the Jumeirah open beaches. This area consists of two beaches known as the Jumeirah Open Beach and the Jumeirah Salient Beach, separated by a 'T'-shaped breakwater (Figure 5).

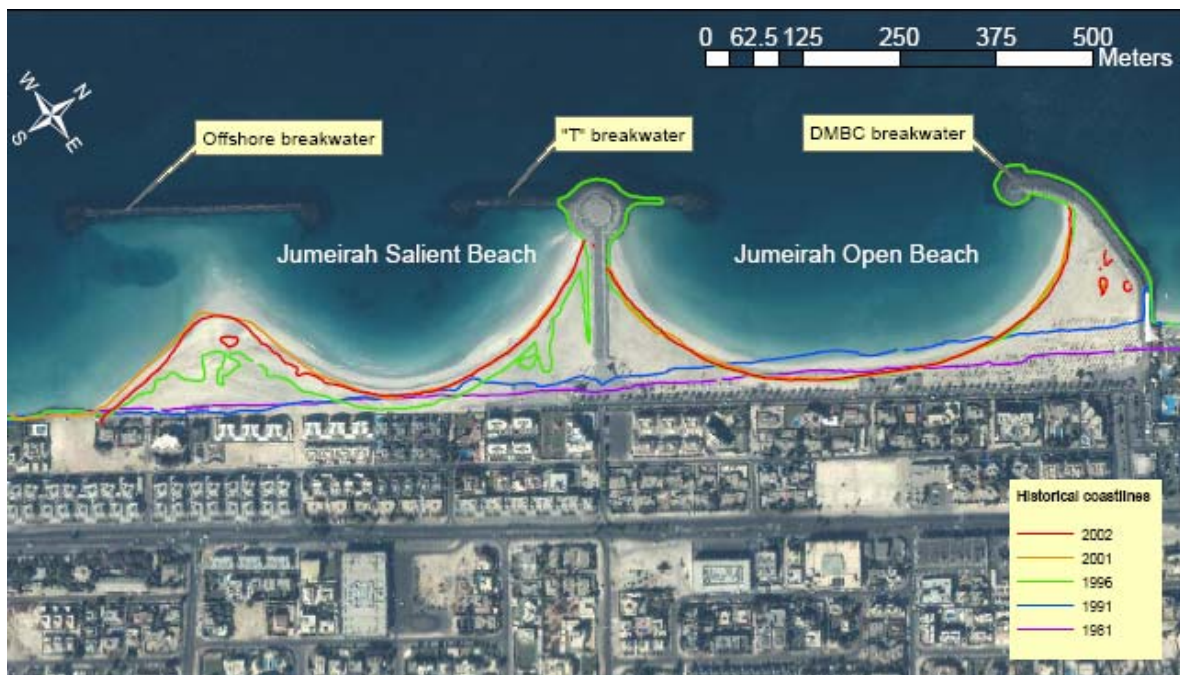


Figure 5. Aerial view of Jumeirah Open Beaches with historical coastlines indicated (Smit et al, 2003).

Prior to the construction of both the 'T'-shaped breakwater and the DMBC breakwater on the eastern side of the bay, the beaches were of a linear formation. The beaches then responded rapidly following the construction of the structures in 1994/1995 and assumed their present crescent shapes (Figure 6). A large amount of material accumulated in the salient with initial volume change figures somewhere in the region of 40,000m³ per year. The situation settled slightly over the next 8 years although total volume increase over the period was estimated as 169,000m³, an average transport rate of 21,125m³ per year.

Ongoing monitoring suggests that the open bay area is relatively stable over the longer term with increases in volume of 10,165m³ over 8 years, of which 9,500m³ was from a nourishment exercise and approximately 1,500m³ from installed Softrock®. Essentially,

there was a net loss of 835m³ over the 8-year period although this is deemed negligible as this would lie well within the obtainable survey accuracy over such an area (Smit, et.al, 2003).

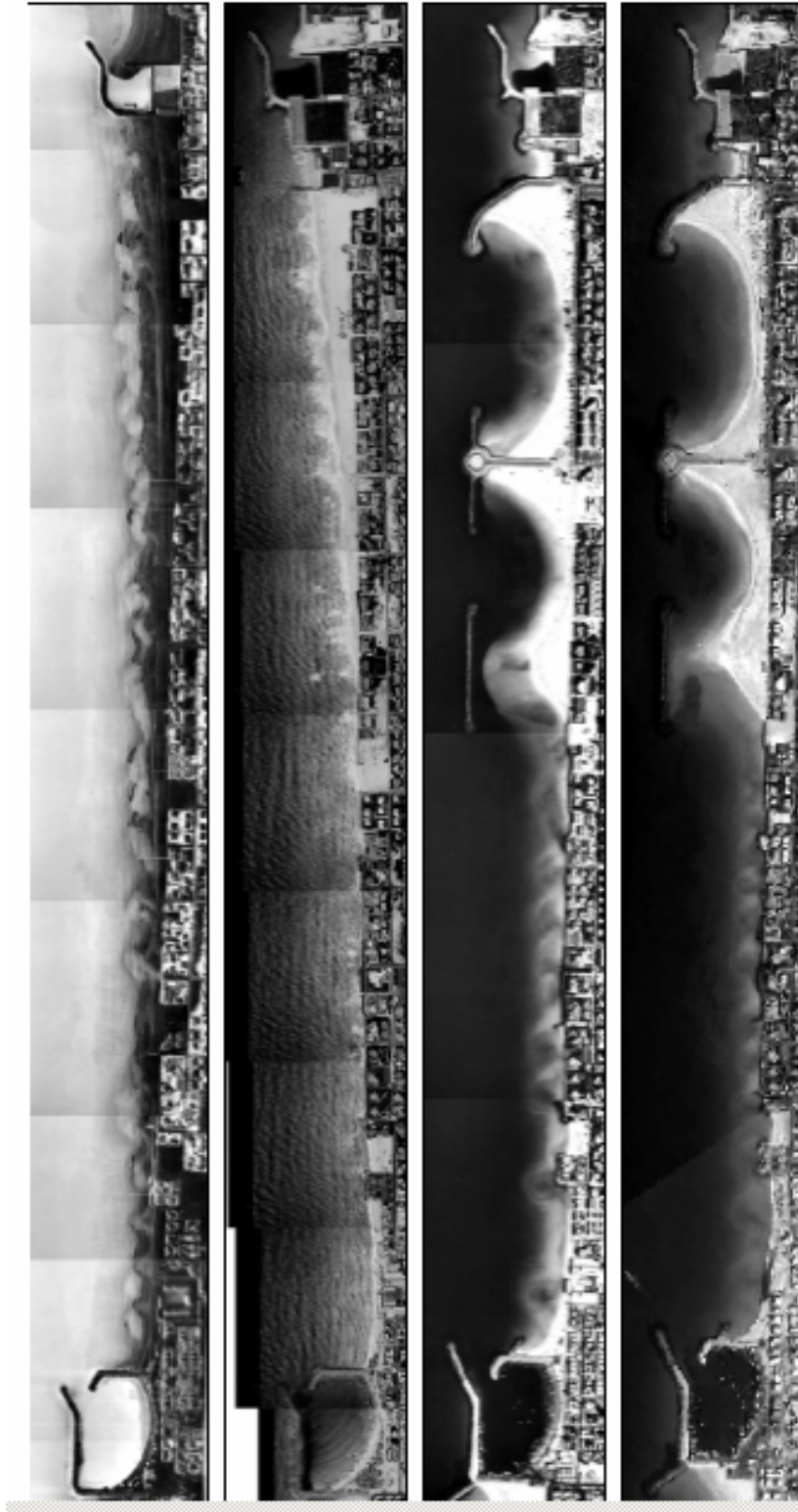


Figure 5. Aerial photographs showing changes in Jumeirah frontage for (top to bottom) 1981, 1991, 1996 and 2002 (Smit et al, 2003).

5. COASTAL MONITORING OF THE PALM ISLAND AREA

In 2001, one of Dubai's most famous coastal landmarks began to take shape (Figure 6). The Palm Islands are three artificial islands being built in shallow waters of the wide continental shelf found off Dubai, using millions of cubic metres of sand dredged from the approach channel to the Jebel Ali port (www.esa.int, 2006). *The Palm, Jumeirah* began construction in June 2001 and was originally expected to be completed in 2006. Due to design changes, the expected completion date now is 2008. Construction of *The Palm, Jebel Ali* began in October 2002 and expected completion time is late 2007. *The Palm, Deira*, set to be the largest of the three Palms began construction in November 2004.



Figure 6. Two of the Palm Islands (www.dubai-propertyagents.com, 2006)

The construction of major coastal developments such as the Palm Islands has caused the Dubai coastline to respond rapidly over the past year or more. The construction of the Jumeirah Island adjacent to the harbour of Mina Al Seyahi has caused the coastline in the southwest shadow of the Island to grow rapidly (Figure 6). Wave models have indicated that the northerly waves are essentially removed from the nearshore wave regime at Mina Al Seyahi through the presence of Palm Island. With these waves

removed the north-eastward directed net transport rate increased and the rapid build-up of the coastline occurred (Smit, et.al, 2003).

On the other side of Palm Island the opposite occurred. The coastline at this end had been steadily retreating as the harbour had effectively blocked sediment moving from the southwest and the net north-easterly directed transport had slowly eroded the beach. With the construction of Palm Island the nearshore wave regime changed as waves from a north-westerly direction are essentially removed and northerly waves assume a more prominent role. The net transport direction is effectively reversed with sediment now moving from the northwest to the southeast, resulting in the rapid build-up of sediment (Figure 7) (Smit, et.al, 2003).

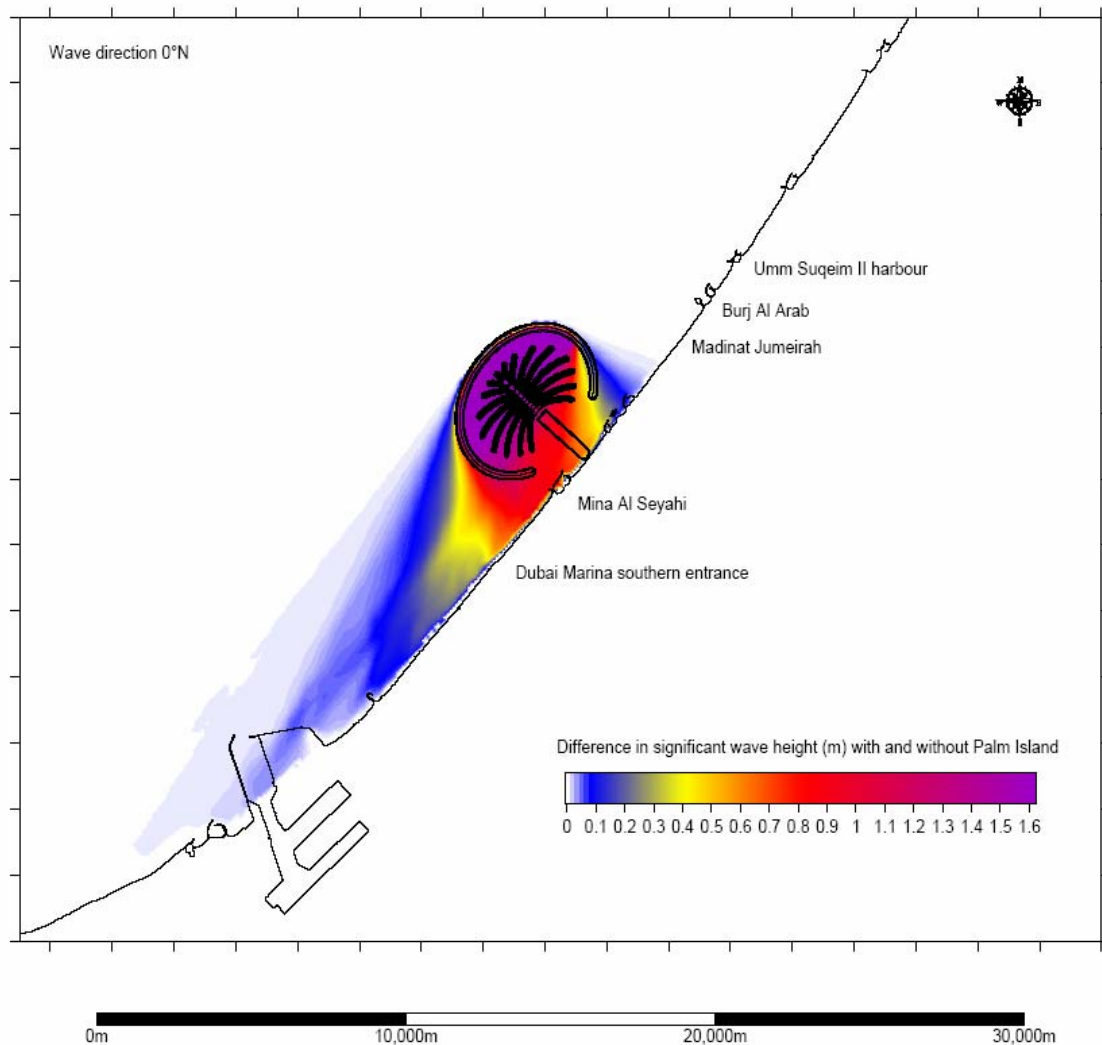


Figure 7. SWAN model showing the influence of Palm Island on the nearshore wave regime.

6. DATA ANALYSIS AND DISSEMINATION

The data collected from the Dubai Coastal Monitoring Programme is subjected to rigorous quality control checks to ensure acceptable data quality. Following the checks, data is made freely available to all interested parties and the general public via the project website www.dubaicoast.org. Captured data from the Jumeirah Open Beach ADCP, pressure sensor and meteorological station are uploaded to the website in near real-time. Wave and tide data, along with images from the video camera are also updated on a regular basis. Graphs for onshore and offshore tide levels and significant wave height, wave period and wave direction are displayed at 3-hourly intervals (Figure 8) and a summary of the most recent data is displayed on the homepage of the website. Historical data is also offered to coastal engineering consultants and other interested parties alike in order to provide a time-series account of coastal change.

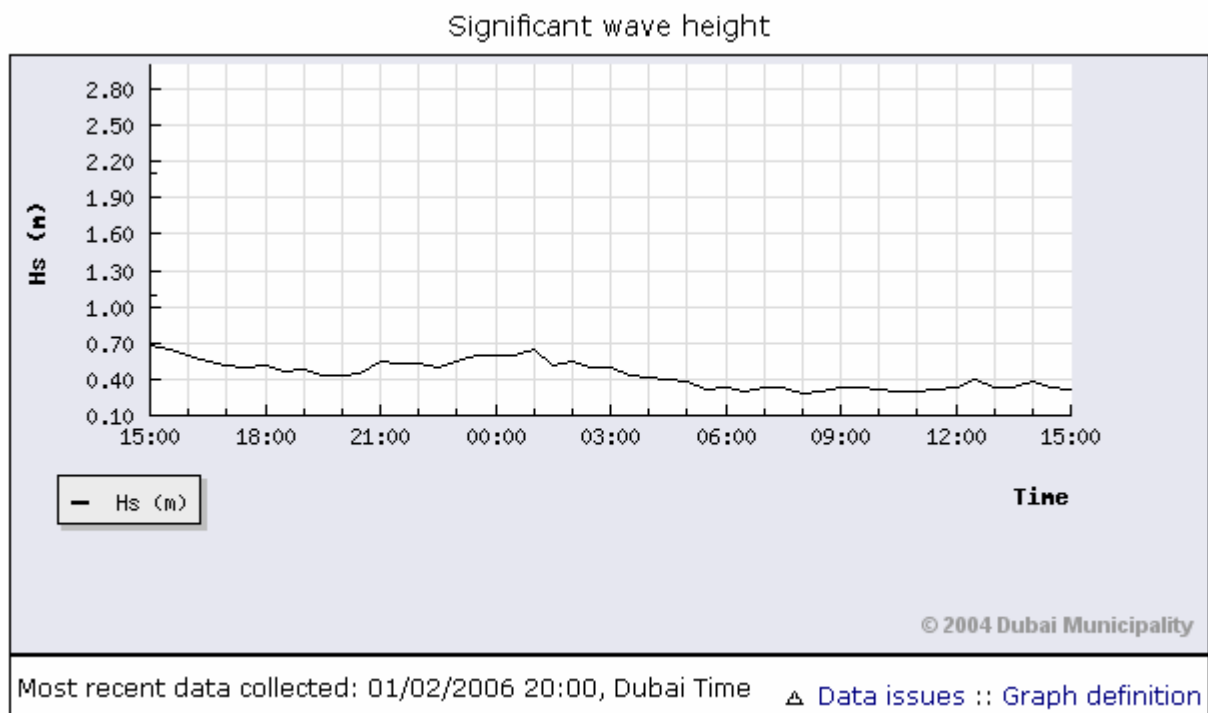


Figure 8. Example of the near real-time wave data

7. CONCLUSIONS

A comprehensive coastal monitoring programme has been established for the Dubai coastal zone. With the aid of pioneering technology, accurate and reliable results have been collected for the coast of Dubai which offer a valuable tool for coastal engineers in terms of design and understanding the coastal processes occurring along the coast. The bulk of the work to date has focused on the implementation of the programme and assuring the accurate and timely gathering of the required information. Focus will increasingly shift towards more in-depth analysis of data and the feeding of results to projects initiated by the Municipality (Smit, et.al, 2003). With rapid development and construction occurring on the Dubai coastline, the need for a sound understanding of coastal processes is essential. It is hoped that with the data collected as part of the Dubai Coastal Monitoring Programme, the coastal dynamics of the region can be understood and predicted for both the short term and for the longer term in response to potential climate change and sea-level rise.