

# Global Sediment Observations for the Dredging Industry

Coastal engineering and dredging companies often require an assessment of the suspended sediment concentrations. At the project proposal stage, this information is needed to assess the amount of work to be done and the costs involved and once dredging or construction is underway, information on suspended matter concentrations may be required for monitoring the environmental impact of the dredging or construction work. ARGOSS has developed a new service to produce maps of suspended sediment concentrations, based on satellite remote sensing data. The service has been demonstrated successfully in the Berbice estuary, an area of slowly migrating mudbanks in Guyana, and is now literally available for all oceans and coastal areas.

The coastal engineering and dredging industry is often interested in suspended sediment concentration information. Dredging companies require information, for example, at the project proposal stage to gather sufficient background knowledge of an area to assess the amount of work to be done and the costs involved. Furthermore, once dredging or construction is underway, information on suspended matter concentrations may be required for monitoring the environmental impact of the dredging or construction work. In both cases, it is essential that such information is global, cost effective and rapidly available. Satellite remote sensing of suspended sediment concentrations may satisfy these requirements.

A new service has been launched by ARGOSS, which delivers a sequence of maps of suspended sediment concentration [Hesselmans et al. 2000]. These maps can be analysed to assess seasonal and tidal effects on the sediment concentrations. The analysis makes use of information available through the Internet service [www.waveclimate.com](http://www.waveclimate.com).

In order to demonstrate the service, ARGOSS and Royal Boskalis Westminster, one of the world's foremost dredging contractors, have teamed up. Each year, Boskalis carries out a wide variety of projects in more than 30 countries. As such a project example, in 1995 Boskalis deepened a 25 km long access channel running through nearshore mudbanks into the mouth of the Berbice River in Guyana. Boskalis undertook the design of the channel and the pre-dredging channel siltation estimate on the basis of limited available in situ measurements from past site studies. In order to anticipate the dredging method required in an area of slowly migrating mudbanks, as is the case in the Berbice estuary, spatial information is needed on the tidal, seasonal and annual fluctuations in the suspended sediment regime.

## Berbice Estuary

The Berbice River is situated in Guyana, South America. In general, two wet and two dry seasons occur. There is a gentle and constant trade wind, blowing from the east-north-east with an average speed of approximately 12 knots. In the shallow coastal areas, a varying wind drift occurs. The long ocean swell loses most of its energy on the soft bottom inshore, and wave heights are small to moderate [Stuip, 1984].

Most of the mud off the coast of Guyana originates from the water and sediment discharge of the Amazon River, which is transported in suspension westwards by the ocean currents aided by the trade winds. The discharge of the Amazon River and the wind-driven currents together give rise to a circulation system. The system results in the deposition of transported sediment in mud banks in a wave like pattern in the near-shore area (20 to 50 km from the shoreline, with an average migration speed in a north-west direction of about 1.5 km per year creating an alteration of shoals and troughs.

A small proportion of the sediment, especially sand, originates from the local rivers. Some of the sand offshore migrates through the mud zone towards the coast and is added to the sand supplied by the rivers. Relatively little is known about the Berbice River discharges. As an indication the suspended sediment concentrations in the Berbice River may vary between ca. 50 and 1,000 mg/l.

The access channel running into the river cuts through near-shore mud banks. Because of the alongshore migration of these large-scale mud banks the suspended sediment regime is also changing in time. The Berbice River does not have the support of a larger river and the run-off is not able to maintain the dredged access channel against the pushing power of the westward drift of sand, silt and water along the coast. Therefore maintenance dredging is needed and since 1995, Boskalis International has been carrying out such dredging.

## Remote Sensing Data

Suspended sediment concentrations are indirectly obtained from the signal received by a satellite sensor, in this case the SeaWiFS sensor which is part of the payload of the OrbView-2 satellite (launched on 4 August 1997). The sensor has a very wide field of view of 58.3° to either side of the track, which gives a swath width of 2,800 km. SeaWiFS was designed mainly for use over oceans, and can be used for monitoring mesoscale observations in coastal waters. Its high field of view enables it to scan 90 per cent of the ocean surface every two days. The SeaWiFS data acquisition started on 16 September 1997. Images can be downloaded by approximately 70 ground stations all over the world. SeaWiFS is a spectroradiometer, which measures visible light and near-infrared light. The 54 SeaWiFS LAC products that were used for the study have a nadir resolution of 1.1 km<sup>2</sup> and were recorded in the period October 1997 to June 2000.

## Data Analyses

For processing images, the SeaWiFS Data Analysis System™ (SeaDAS) software package is used for the processing of SeaWiFS ocean colour data. The SeaDAS software package is extended with a module for turbid water conditions [Ruddick et al., 2000]. To obtain the Total Suspended Matter (TSM) concentration from the water-leaving radiance detected by the optical sensor, a so-called geophysical product retrieval algorithm is applied [Hoogenboom et al., 1999]. The algorithm uses Specific Inherent Optical Properties (SIOP) of North Sea waters obtained during a cruise in 1998. At the client's request in situ water samples can be analysed to obtain more accurate SIOPs of the area of interest.

## Results

All 54 SeaWiFS images were processed at ARGOSS, including geo-referencing, atmospheric correction and TSM retrieval. As an example a TSM map based on the SeaWiFS image recorded 1 July 1999 is shown in Figure 1. The TSM pattern is realistic and the concentrations are consistent with observation, recorded 1 km interval along the channel route shown in Figure 1 at the entrance of the Berbice river. These observations have been carried out by Hydronamic, the hydromorphological engineers of Boskalis [Nipius, 1999].

For examining this possible seasonal variation in sediment concentration, suspended sediment concentrations are plotted against date of recording, for a few kilometre markers. Figure 2 shows the result. A wave-like variation in sediment concentration can be observed. Therefore a sine is fitted through the logarithm of the data using the method of least squares, presuming a period of one year. The deviation from this sine is illustrated by determining the range of concentrations which cover 80 per cent of the observations. This means that 10 per cent is above and 10 per cent is beneath the interval. Results are reflected in Figure 2.

Wind is thought to affect suspended sediment concentrations by generating waves and turbulence, causing sediment to stir up. Especially strong winds occurring during storms are thought to be important. Mean wind speed shows seasonal differences, as can be observed in Figure 3a. In the Berbice area lowest mean wind speed occurs in July and August. Mean wind speed is highest in January and February. Strong winds also occur from June till August, but weak winds prevail in this period. A strong correlation could be expected between wind speed and wave height. Figure 3b shows significant wave height during the year.

When the observed differences in significant wave height during the year, strongly correlated to wind speed, are plotted against seasonal differences in suspended sediment concentrations, a strong correlation appears. In Figure 4 monthly mean values for TSM concentrations, derived from the images, are plotted against monthly mean values of significant wave heights. The trend line in Figure 4 describes the correlation between monthly mean significant wave height and monthly mean total suspended matter.

## Conclusions

Hydronamic has evaluated the results of the service: sediment maps, seasonal and tidal analysis. Most user requirements have been met and it was concluded that the main achievement of this project is that remote TSM data collection - as an alternative for in-situ measurements - is technically and commercially attractive for the assessment of natural year-round suspended sediment concentrations.

## References

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