COAST
(Coastal earth Observation Application for Sediment Transport)

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As part of the British National Space Centre's initiative to promote civil applications of Earth observation, Smith System Engineering is leading a consortium of the Department of Oceanography, University of Southampton, Plymouth Marine Laboratory, HR Wallingford and Laser-Scan in a project (originally 1993-1995, but extended to 1996 in anticipation of the launch of SeaWiFS) to demonstrate the application of satellite and airborne EO data to monitoring of sediment transport in coastal waters. The National Rivers Authority (NRA) is also involved in an advisory capacity. The project is called "COAST: Coastal Earth Observation Application for Sediment Transport".

The COAST project aims to develop the techniques required for a coastal monitoring service, providing wide area (of order 100 km along- and at least 20 km off-shore) and local maps of sediment concentration and water quality parameters using remotely sensed imagery from satellite and aircraft sensors. The data collected from these sensors will be combined with advanced hydrodynamic models to generate maps of sediment transport in the coastal zone and maps of morphology of the sea bed and coastal land. A GIS will be used to store, manipulate and visualise the various coastal zone management data.

Large scale transport of sediment in coastal waters is a key factor affecting the overall morphology of the coastline. It impacts on the rates of erosion or accretion of coastal land and causes the formation or destruction of offshore sandbanks and beaches, important elements of the coast's natural flood defences. Understanding of sediment transport is of prime importance for management of the coastal zone, including coastal protection and beach management, planning and design of sea defence works, assessment of coastal and offshore engineering works and dredging. It is in these areas that the products and results of the COAST project will have direct relevance. Furthermore, techniques developed through COAST will be relevant to water quality monitoring such as in the detection of toxic algal blooms. Users of the resulting systems and products of the COAST project are expected to be organisations such as NRA, NERC, maritime district councils and local authorities, port and harbour authorities, extraction companies and water companies - as well as the many civil engineering companies involved in coastal projects.

This paper presents an overview of the COAST project.

1. OVERVIEW

The overall aims of the COAST project are:

– to develop a robust and practical methodology for extracting coastal zone management data from Earth Observation (EO) data;

– to initiate an operational Water Quality Information Service providing water quality information pertinent to coastal zone management.

The COAST project has three main elements:

– development of algorithms for atmospheric correction and retrieval of sediment concentration, mineralogy and water quality parameters from satellite and airborne data;

– development of a model of sediment vertical concentration profile so as to derive total column suspended sediment concentration from surface measurements, and use of the data to calibrate a model of sediment transport and coastal morphology;

– development of a GIS to store, manipulate and visualise the data.

Figure 1 outlines the concept of the COAST project which can be summarised as:
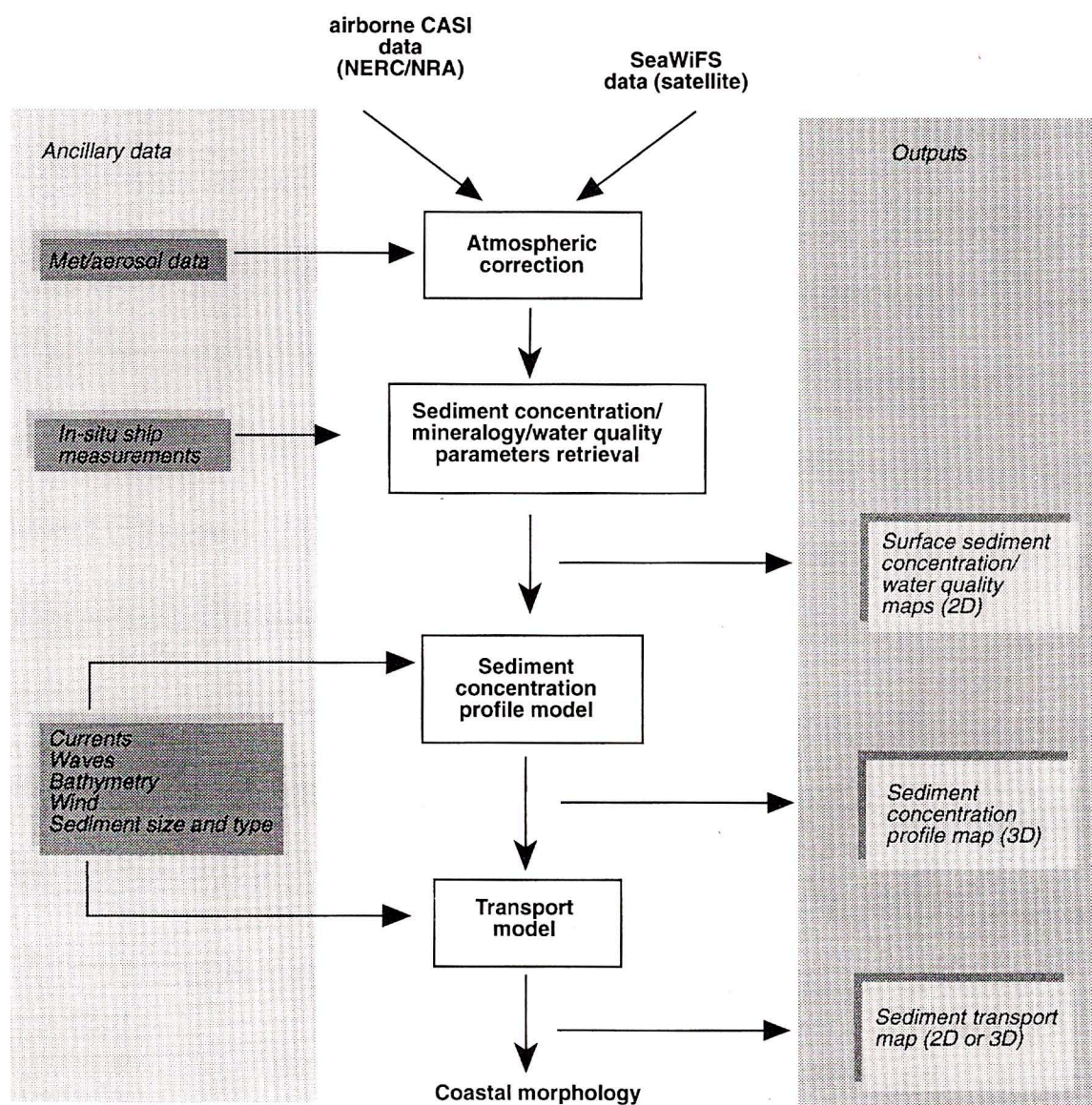
Figure 1 - The COAST concept

– Obtaining remotely sensed data from the SeaWiFS space based instrument and the CASI (Compact Airborne Spectrographic Imager) airborne scanner, as detailed below, together with ancillary data obtained via ground based measurements or publicly available.

– Performing an atmospheric correction on the data collected over sediment laden waters.

– Extracting surface sediment concentrations and total sediment water quality parameters from the satellite and airborne data.

– Deriving suspended sediment vertical profiles from which total column sediment concentrations can be inferred.

– Combining these data with an advanced hydrodynamic model to generate maps of sediment transport in the coastal zone and maps of morphology of the sea bed and coastal land.

The project involves a number of technical challenges. The feasibility of retrieving sediment information from EO data has previously been demonstrated but in most cases for single images under favourable conditions and relying on a considerable amount of in-situ data. Areas of research within the project will be the atmospheric correction algorithm (in particular over sediment laden coastal waters), the feasibility of determining sediment mineralogy, the

effects of particle size distribution and whitecaps, the portability of the techniques, the requirements for ancillary data (the trade-off between accuracy of results and ancillary data requirements being a critical issue) and the feasibility of inferring vertical concentration profiles from surface measurements.

2. DATA SOURCES

The COAST project will use data from the SeaWiFS instrument, the CASI airborne scanner and various types of ancillary data, as described below.

2.1 SeaWiFS

NASA's SeaWiFS (Sea-Viewing Wide-Field-of-View Sensor) is a scanning mapping radiometer which will be flown on the SeaStar spacecraft, with a mission duration of at least 5 years. The SeaStar spacecraft is due to be launched in during 1995/1996 into a circular sun-synchronous orbit such that the satellite will cross the equator at local noon each day. Daily SeaWiFS images (taken just before noon) should therefore be available for the UK coastal waters, although the presence of cloud cover will reduce the number of useful images of a given stretch of coastline to 50 to 100 per year (once or twice a week on average). The SeaWiFS instrument will provide wide area coverage (of order 100 kilometres) with a spatial resolution of approximately 1km.

The SeaWiFS payload will provide eight spectral bands of data, in the visible and near-IR regions of the spectrum, which will be used to infer various sediment and water quality related parameters. Details of the spectral bands and their intended use are included in **Table 1**. Unlike previous ocean colour remote sensing instruments, SeaWiFS has two channels in the near-IR included solely for aiding atmospheric correction.

The launch of SeaWiFS is expected to be followed by NASDA's Ocean Colour and Temperature Sensor (OCTS), ESA's Medium Resolution Imaging Spectrometer (MERIS) and NASA's Moderate Resolution Imaging Spectrometer (MODIS) sensors in the mid-1990s and possibly by a SeaWiFS-II (NASA's EOS COLOR). The spectral bands of the OCTS, MERIS and MODIS sensors will be compatible with those of SeaWiFS, hence ensuring continuity of data for the COAST concept beyond the year 2000.

Table 1 - SeaWiFS spectral characteristic

spectral band	centre wavelength (nm)	band width (nm)	intended use
1	412	20	gelbstoffe
2	443	20	chlorophyll absorption
3	490	20	pigment concentration
4	510	20	chlorophyll absorption
5	555	20	sediments
6	670	20	atmospheric correction
7	765	40	atmospheric correction
8	865	40	atmospheric correction

2.2 CASI

The Compact Airborne Spectrographic Imager, CASI, is an imaging spectrometer providing high spectral resolution data (up to 288 spectral channels of 3nm bandwidth which can be preselected by the user) in the wavelength range 400-915 nm. At a typical aircraft altitude of 10,000 ft, the spatial resolution of the system is of order 10 m with a swath width of 5 km. (The finest resolution is of order 10 cm for a low altitude flight.) The CASI system has a good radiometric response and is capable of fast turnaround. A GPS receiver is used for image registration and automated geometric correction.

The NRA presently conducts routine flights of the coastline four times a year using a CASI system and NERC plans to fly CASI campaigns as part of the LOIS project.

2.3 Ancillary data

A key issue will be the requirement for ancillary data and the trade-offs between performance (in terms of accuracy and portability) and availability of ancillary data. A number of physical measurements are planned so as to provide data for calibration of the remotely sensed data and sediment retrieval algorithms, input to the sediment transport model and validation of the model/algorithm outputs (see **Figure 1**). To this end, in addition to laboratory investigations of suitable water samples, a number of aircraft and ship campaigns have been organised, some of which are dedicated to the collection of ground truth data coincident with satellite and aircraft overpasses.

2.4 Data complementarity

The data from SeaWiFS and CASI are highly complementary. The fine spatial and spectral resolutions of the airborne scanner will enable resolution of sediment features and analysis of mineralogy and water quality parameters. The wide area coverage and daily update frequency of SeaWiFS will enable monitoring of temporal variations and examination of large scale phenomena as well as providing a context for the airborne data.

The airborne surveys will concentrate on the strip of coast immediately adjacent to the shore so as to provide the high resolution data where it is likely of be of greatest value. SeaWiFS data can be used to interpolate temporally between successive airborne data sets. Furthermore, intercomparison of the two independent sets of remotely sensed data will help provide cross-calibration of the sensors and allow refinement of the COAST algorithms.

3. TEST SITES

The principal test sites selected for the COAST project constitute two areas of contrasting water quality and geomorphology, namely Christchurch Bay/West Solent and the Humber Estuary/Holderness Coastline. **Figure 2** show the locations of these two sites. SeaWiFS and CASI data together with ancillary data relevant to these areas will be used in the development, calibration and validation of the various algorithms and models of the COAST project.

Figure 2 - COAST test sites

Christchurch Bay/West Solent is a sedimentologically mixed site displaying high gradients in suspended sediment concentrations. It has been studied extensively in the past. The beach is predominantly sandy at the western end, however shingle becomes progressively more prominent as one moves in the eastward direction. The western end and central frontage have high, soft clay cliffs which are being eroded to produce fine clay based particles. Further offshore there are sand deposits at the western end and shingle at the eastern end.

The Humber Estuary/Holderness Coastline is a sedimentologically mixed site with complex morphodynamics. Much of the coastline consists of soft clay cliffs which are eroding at an average rate of about 1.75 m per year. The coastal waters are dominated by relatively coarse suspended materials, principally sand from beach erosion and assorted fluvial inputs, the latter being relatively high in dissolved anthropogenic material. Overall levels of suspended particulate material (SPM) are high with variation coming more in particle composition than in concentration. The Humber Estuary/Holderness Coastline is to be the focus of extensive ground-based field measurements and other studies as part of the NERC funded LOIS (Land-Ocean Interaction Study) project which will yield data of direct relevance to the COAST project.

A number of other active research areas have been selected as potential sources of data for algorithm and model verification, each providing different SPM and water quality properties.

The objectives of the COAST project of developing robust and portable algorithms for extracting coastal zone management data will be achieved by initially developing the algorithms for the specified test sites and seasons with the intention that the site, seasonal and ancillary dependencies be minimised as the algorithms develop.

4. COAST PRODUCTS

Products available through the COAST Water Quality Information Service will include:

• Wide area (up to 100 km along-shore and at least 20 km off-shore) and local maps of:

– coastal surface sediment concentrations;

– water quality parameters (eg for detection of toxic algal blooms);

– coastal suspended sediment vertical profiles;

– rface sediment statistics, eg monthly mean concentra-
tions of surface sediment for the Humber Estuary during
1993;
– water quality statistics.

• Predictions, including forecasts, nowcasts and hindcasts,
of sediment transport, rates of accretion/erosion and
changes in coastal morphology. (The maximum fore-
cast period is at present of the order of a few weeks.)
These data products will be available in hard and soft
copy form (in a range of GIS compatible formats). Also
available will be:

• associated software and algorithms;

• atmospherically corrected data from SeaWiFS/CASI ins-
trument.

These products will be available for user specified loca-
tions and times (within the constraints of the satellite
ground track and cloud cover) on a routine basis (eg
weekly, yearly) as well as on-demand for the one-off user.

5. COAST GIS

The COAST demonstrator GIS will be based on Laser-
Scan's IGIS package, customised to facilitate the storage,
manipulation and visualisation of coastal zone data. IGIS
is a fully integrated raster and vector GIS designed to
address the issues of resource management, monitoring
and environmental protection. IGIS constitutes an effec-
tive management tool combining the benefits offered by
remote sensing (raster based systems) with the analytical
capabilities of a GIS, within a single system.

6. CONCLUSIONS

The COAST project aims to develop the techniques requi-
red for management of the coastal zone, providing data
derived from remotely sensed imagery from aircraft and
satellite.

Given the delay in the launch of SeaWiFS, emphasis is cur-
rently being placed on the use of CASI data. The atmos-
pheric correction and sediment retrieval algorithms toge-
ther with the sediment vertical profile model have now
been coded and are undergoing validation using the CASI
instrument. The project will be completed in Spring 1996,
after which time the software and data products will be
available through the COAST Water Quality Information
Service.

ACKNOWLEDGEMENTS