INTERNATIONAL GEOSCIENCE PROGRAMME (IGCP)

Annual Report* of IGCP Project No.495

*The information in this report will also be used for publication in 'Geological Correlation' (please feel free to attach any additional information you may consider relevant to the assessment of your project).

IGCP Project short title: **Quaternary Land-Ocean Interactions**

Duration: **5 years 2004 – 2009**

Project leaders:

Professor Antony J. Long[1] and Professor M. Shahidul Islam[2]

[1]Department of Geography
Durham University
Science Site
South Road
Durham DH1 3LE
England
Tel: 44 191 334 1913
Fax: 44 191 334 1907
Email: A.J.Long@Durham.ac.uk

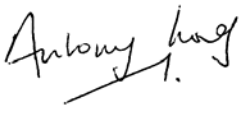
and

[2]Department of Geography
University of Chittagong
Chittagong-4331
Bangladesh
Email: msi@abnetbd.com

Project Secretary:

Mrs Niamh McElherron
Department of Geography
Durham University
Science Site
South Road
Durham DH1 3LE
England
Tel: 44 191 3341896
Fax: 44 191 3341907
Email: C.N.McElherron@durham.ac.uk

Date of submission of report: **8th December 2006**

Signature of project leader: 

Guidelines for Annual Reports of IGCP Projects

(September 2005)

Please use the following headlines to report the present status and scientific achievements of your project (write N/A where not applicable) and explain abbreviations you use in your report.

1. Website address(es) related to the project

The IGCP495 web site can be accessed at the following address:

http://www.geography.dur.ac.uk/Projects/Default.aspx?alias=www.geography.dur.ac.uk/projects/igcp495

This includes a project description, information of forthcoming and past field meetings and conferences as well as a list of project members and their contact details. It is hosted by Durham University and is regularly maintained.

2. Summary of major past achievements of the project

See section 3.2 below.

3. Achievements of the project this year

*3.1. List of countries involved in the project (please *indicate the countries active this year and make the distinction between:*

Argentina*, Australia, Bangladesh, Belgium*, Brazil*, Canada, China, Denmark, Ecuador, Estonia, Ethiopia, Fiji, Finland*, France*, Germany*, Greece, India*, Indonesia, Israel, Italy*, Jamaica*, Japan, Kenya, Mexico*, Morocco, New Zealand, Norway, Poland, Portugal*, Puerto Rico*, Republic of Ireland*, Russia, Spain*, South America*, Taiwan, The Netherlands*, Turkey, United Kingdom*, United Arab Emirates, Uruguay, United States of America*, and Venezuela.

3.2. General scientific achievements (including societal benefits) (Meetings are not considered as scientific achievements, they should be listed under heading 3.3.)

In our original project design we identified a series of milestones, detailed in Table 1 below, against which progress so far in the project can be gauged:

Provisional programme and actual activities

2004

Task	Achievements
Approval of project;	Approval received in March 2004
Announce project approval to all project participants;	Announcement to all project participants 6th April 2005
Announce plans for first international project meeting in Maine/New England.	Announcement of field meeting on June 15th 2005 to all project colleagues
Formation of working groups listed in Attachment 1 and arrange liaison with	Working group subject areas confirmed at first international meeting

other international programmes (including existing IGCP projects, INQUA, PAGES, LOICZ etc.);	in Maine. Links to other projects have been reviewed and contacts established.
First international meeting in Maine / New England with particular emphasis on driving mechanisms of coastal change (including ocean circulation and climate);	First meeting held in Bar Harbour, Maine, October 14-17th 2005.
First training workshop on data collection. Agree format for manual publication;	The field trip associated with the Bar Harbour conference provided opportunities for reviewing methods of data collection, notably high resolution salt marsh records of sea-level change from the late Holocene. Discussions were held regarding a manual publication.
Establish National working groups and encourage and partial sponsoring of regional meetings (in developed and developing countries);	National working groups have been established in developing and developed countries.
Establish web site and participant address list;	Web site established in April 2005 and updated on a regular basis. It includes details of project, contacts, meetings and meeting reports.
Publication of first annual report.	Short report submitted to UNESCO in December 2004.

2005

Task	**Achievements**
Edited collection of papers in a journal special issue addressing the theme of oceanic forcing, sea level and coastal change over a variety of Quaternary to recent (particular emphasis on the last 1000 years) and future timescales;	This did not occur. It was too soon in the project to warrant a special publication capable of demonstrating real scientific progress. It was agreed to defer this until the second year of the project when more progress had been made.
Publicity of the project objectives, including summaries of current research activities and their relevance to the service of society in a range of international and national magazines that are widely available to communities and learned scientific societies;	Dissemination of IGCP495 activities has occurred primarily via the web and also by National Committees. A press release was issued before the 2005 international meeting.
Second international project meeting in Indonesia with particular emphasis on coastal archaeology and coastal evolution, tsunami impact as well as monsoonal controls on past and future sea-level change and coastal flooding;	The second international meeting was held in Indonesia, September 24th-29th 2005.

2006

Task	**Achievements**
Publication of journal special issue on sea-level changes, tsunami and coastal archaeology, addressing vertical changes in sea-level and human responses, submerged archaeology, ancient and more recent coastal defence work and their impacts of	12 papers are nearing completion of the review process for a Special Issue of Marine Geology. Expected publication date in 2008.

landscape change and coastal processes;	
Contribution at the AGU (American Geophysical Union) Fall Meeting, San Francisco, 11th – 15th December 2006	*AGU Fall Meeting 2006, session PP11 on Palaeotsunami research (Brady Rhodes, Martitia Tuttle, Ben Horton)* Other IGCP495 meetings held in 2006, not previously planned include: GSA meeting Philadelphia, USA. October 2006: *Holocene sea-level change in North America: a post Katrina assessment* (Torbjörn Törnqvist and Ben Horton) *First International Tsunami Field Symposium, Bonaire, 2006 IGCP 495* (also sponsored by the Commission on Coastal Systems of IGU), March 2006 (Anja Scheffers and Dieter Kelletat) *Status of coastal zone studies and future trends: special reference to western India* (Vadodara, Nikhil Desai, February 2006)
Third international project meeting in Brazil. Emphasis on reconstructing sediment flux from terrestrial to coastal and nearshore depositional environments, as well as ocean – atmosphere forcing of sea-level change;	A third international meeting was held in Brazil in 17-22nd September 2006 – see attached full meeting report.
On-going maintenance and review of the web site	A new design has been developed and the web site is continually updated with meeting reports and other links.

In our project design and in our first annual report, we identified two main aims to the project. As in our report from 2005, these form a logical structure against which to review scientific developments again from the last 12 months.

A. The vertical dimension of sea-level change. Correlating sea level and coastal stratigraphic data with data derived from a variety of terrestrial (including ice core) and marine depositional records.

A.1 Quaternary sea-level change and ice-sheet volume

Quaternary records

In the final project meeting of IGCP Project 437, the predecessor to the current project, IGCP495, we held our final international project meeting at Barbados, a benchmark locality for the study of Quaternary sea-level changes. At the time we were presented the results of an extensive programme of research conducted by Ulrich Radtke and Gerhard Schellmann. This work is currently being published and Radtke and Schellman (2006) report evidence for the uplift history along the Clement Nose Traverse on the west coast of Barbados during the last 0.5 Ma. Most

significantly, these authors demonstrate that contrary to many previous studies, there is a high probability that this key region for global sea-level studies has not experienced a uniform rate of uplift during the late Quaternary. Variations in uplift rates on active plate boundaries are further demonstrated by Riker-Coleman et al. (2006), who develop a new estimate of uplift based on the analysis of Th-230 dates from uplifted Holocene coral reefs from the eastern margin of New Britain, Papua New Guinea. These authors suggest a much lower rate of uplift (1.6 ± 0.4 m / ka) compared with the better known rates from the Huon Peninsula of 2 to 3 m / ka.

Other research on Late Quaternary coastal sequences include a detailed analysis of the diatom succession preserved in a near-complete sedimentary record of the Eemian (MIS 5e) interglacial preserved in annually laminated sediments preserved in north Germany (Haila et al., 2006). This study notes that the culmination of the marine transgression coincided broadly with the climatic optimum of the interglacial. In contrast to the high precision dating afforded by such annually laminated sediments, Hanebuth et al. (2006) describe the results of their analysis of parts of a 60m-long core from the lower Red River delta in northern Vietnam. Here the existing radiocarbon ages suggest the presence of an important MIS 3 deposit, based on radiocarbon dating. Comparisons of the sea-level reconstructions based on this record with those from elsewhere in the Indochina Sea of a comparable age suggests significant differences in crustal motions across the region, perhaps in response to sediment loading and compaction of the shelf compared with more central cratoritic areas. However, chronology is the key here, since Hanebuth et al. (2006) note that significant contamination of the radiocarbon database by old carbon may mean that the deposits they analyse are in fact from MIS 5.

The Late Quaternary coastal deposits of the North Atlantic and Mediterranean are studied in several papers. Aboumaria et al. (2006) describe the Quaternary marine terraces on the southern sice of Gibralta strait, Morocco, whilst Tuccimei et al. (2006) use high precision U-series data from phreatic overgrowths on speleotherms, to reconstruct last interglacial sea-level changes on Mallorca Island. The record includes evidence for three highstands that correspond to MIS 5c and MIS 5a.

Three papers address the last interglacial deposits in the Mediterranean (Italy). Ferranti et al. (2006) review data from 246 Italian sites and describe significant differences in elevation of the MIS 5e deposits, ranging from +175 m to -125 m asl, that they attribute to the complex interplay between regional and local tectonic influences. Antonioli et al. (2006a, b) also review in detail the evidence for the last interglacial highstand from Sicily, primarily using the fossil *Strombus bubonis*. These authors further demonstrate the highly variable patterns of tectonic movements and Late Quaternary RSL change in this part of the Mediterranean.

Postglacial records

As in our last annual report, there has been considerable progress in reconstructing trends in vertical RSL since the last glacial maximum (LGM) in near, intermediate and far-field sites. The evidence for ice sheet / ocean interactions during deglaciation at the end of the LGM is especially important because of the very large volumes of water that exchanged between its solid and liquid form, with associated changes in temperature and ocean circulation. Yokoyama et al. (2006) present new findings on the nature of sea-level during the late glacial period based on an examination of ooids recovered from the Capricorn Channel in the southern Great Barrier Reef. Dating from 16,800 cal. yrs BP, these deposits formed immediately prior to the meltwater 1a event, at a time when RSL in this area of Australia lay at least 100 m below present level. We have known for some time that the impact of the meltwater 1a event was significant, triggering a major re-organisation of the thermohaline circulation in the North Atlantic. However, Tarasov and Peltier (2006) and Peltier et al. (2006) cast new light on this event as by developing a new

deglacial drainage chronology for the North American ice sheet. They argue that the Laurentide ice sheet was responsible for delivering a significant fraction of the meltwater pulse 1a (c. 1.5dSv or larger) into both the Gulf of Mexico and the eastern Atlantic, and less than 1 dSv into the Arctic Ocean.

Meltwater pulse 1a was associated with significant calving from the North American ice sheet, and the distribution of large amounts of ice rafted debris across the North Atlantic during what is termed "Heinrich 1" (H1). A question that is currently the focus of considerable attention it the way in which other ice sheets in the northern hemisphere responded to this event. Roberts et al. (2006) use a combination of observations on the age and altitude of glacio-marine sediments and postglacial RSL histories from the north Irish Sea to examine the controls on deglaciation and crustal motions in this area since H1. Using new data from the Isle of Man, these authors argue that current geophysical model predictions of RSL during the period 21-16 ka cal. yrs BP are too low, and that thicker ice or a thinner lithosphere is required to match predictions to observations.

Other near-field reconstructions of early post-glacial RSL histories are presented by Shaw et al. (2006) from Atlantic Canada, Keigwin et al. (2006) from the Chukchi Sea, and from Greenland (Long et al. 2006; Sparrenbom et al. 2006a, b). The former presents a conceptual model for the deglaciation of Atlantic Canada, highlighting the role played by ice streams in influencing the deglacial chronology, a theme also explored by Long et al. (2006) from Disko Bugt in Greenland. The Chuckchi Sea work is based on three shelf sediment cores retrieved from present water depths of c. 50 m. The cores record evidence for an initial transgression of the shelf at c. 12 ka cal. yrs BP. After 7 ka cal. yrs BP, the records indicate a lack of significant sediment accumulation, which is consistent with a reduction in the supply of terrigenous sediment derived from fluvial sources after the deglaciation of Alaska was complete (Keigwin et al. 2006).

Records of vertical sea-level change during the Holocene include a critical review of the mid to late Holocene RSL histories from Brazil by Angulo et al. (2006). Those who attended the international IGCP meeting to Brazil in September 2006 were able to see Rodolfo Angulo and colleagues in the field, presenting the results of their impressive investigations into the sea-level record of the Brazilian coast (see separate report, conference field guide and abstracts volume). Elsewhere, Glosan et al. (2006) describe the formation of the Holocene Danube delta after c. 5000 years ago. This work is important since it demonstrates that there is little evidence for sudden changes in sea-level since this period, indicating that the submergence of several ancient settlements around the Black Sea may be explained by local factors such as subsidence rather than large-scale basin-wide sea-level fluctuations.

Morhange et al. (2006) describe new evidence from Lebanon, in the eastern Mediterranean for two episodes of regional crustal motions since c. 6000 cal. yrs BP. Precise radiocarbon dates from biological indicators show evidence for a higher shoreline, c. +1.2 to 1.4 m above present sea-level, that formed between 6000 and 3000 cal. yrs BP. A second, lower shoreline at c. 0.8 m asl formed between the fifth and sixth century AD. Morhange et al. (2006) suggest that the younger shoreline may have formed as a result of fault movements during the "Early Byzantine Tectonic Paroxysm".

Several of the papers detailed above involve the application of new approaches and techniques to data collection. One particular problem that besets RSL studies in many settings, is the effect of sediment compaction. This year saw the publication of five papers that address this topic in different ways. Edwards et al. (2006) approach the problem using stratigraphic data as a means to estimate the amount of compaction experienced by individual sea-level index points, and asses the

robustness of their approach by comparing "corrected" sea-level reconstructions with the outputs of a geophysical model. Long et al. (2006) use evidence from the Romney Marsh area of southern England (a site visited by the UK IGCP annual field meeting in 2006) to quantify the magnitude and timing of late Holocene compaction of a thick peat bed. They estimate that the surface of this peat was lowered by c. 3 m during the late Holocene, and argue that this process was responsible for the destruction of coastal wetlands throughout the UK and other parts of northwest Europe. Massey et al. (2006) attempt to quantify the magnitude of compaction in a detailed study of the early Holocene back-barrier deposits from South Devon, UK. Their model involves a geotechnical correction based on the nature of the lithostratigraphic units encountered in a series of sample cores. They suggest that compaction in these settings can account for between <0.1 m to >2 m for deposits of variable organic content. The last study with a compaction lean is that by Tornqvist et al. (2006), who present RSL data from basal peats from the Mississippi delta to demonstrate that there is limited differences in subsidence across the delta, or between the delta and the Caribbean. These authors argue that the well-documented subsidence observed near the birdfoot of the Mississippi is a result of compaction of Holocene strata.

In contrast to these long-term studies, Argow et al. (2006) note that the organic-rich *Spartina patens* high saltmarshes of New England experience significant seasonal compaction, and that ice thicknesses >10 cm depress the marsh surface by 2 mm for each cm of total ice thickness. The organic nature of the marsh deposits means, however, that the marshes recover to a pre-compaction level within a few weeks of ice removal and this is therefore a short-term and reversible form of compaction.

The link between changes in RSL and patterns of coastal and shelf evolution is an important research focus under IGCP495. As well as the Tarasov and Peltier (2006) and Shaw et al. (2006) papers referred to already, several other authors demonstrate the major changes in ice extent that occurred at the LGM. In Antarctica, for example, Evans et al. (2006), Mosla et al. (2006) and Wellnaer et al. (2006) each report on the extent and dynamics of the West Antarctic Ice Sheet at LGM, presenting detailed evidence that demonstrates that a grounded ice sheet reached the outer shelf in many areas and to the shelf edge itself in several areas. During the postglacial period, four other studies use a variety of sedimentological and microfossil data to reconstruct the history of estuary infill in Argentina, South Australia, northern Spain and north Norfolk (UK) respectively (Stutz et al., 2006; Hassan et al., 2006; Cann et al., 2006; Sloss et al., 2006; Anton et al., 2006; Boomer and Horton 2006).

Links with the geophysical modelling community

One of the strengths of IGCP495 is the link between field scientists and geophysical modellers, each providing complementary expertise in our efforts to understand the driving mechanisms of global to local sea-level change and coastal evolution. This collaboration operates over different spatial and temporal scales. Thus, Lambeck et al. (2006) use glacial rebound models to invert observations on crustal rebound and sea-level change to estimate ice thickness for the major late Devensian glaciations over northern Eurasia. In contrast, Shennan et al. (2006) use RSL data from western Scotland to test models of glacio-isostatic rebound and ice sheet reconstructions associated with the British ice sheet at the LGM. Geophysical models are becoming ever-more sophisticated, especially as a new generation of models that incorporate 3-D earth structure are developed (e.g. Whitehouse et al., 2006). A further application of these models is in constraining the tidal evolution of the continental shelves, as elegantly demonstrated by Uehara et al. (2006) for the northwest European shelf sea since the LGM.

A.2 Quaternary coastal evolution and fluvial archives of environmental change

This aspect of IGCP495 seeks to better understand the linkages between the fluvial and coastal archives of environmental change. As such, it has natural affinities to a sister project, IGCP449, that aims to compile a global dataset of fluvial archives (Bridgland et al., 2006). Deltas provide superb opportunities to examine large-scale interactions between fluvial and coastal systems; indeed, it is the intention of IGCP495 to visit Bangladesh in 2008 for its international project meeting for this very reason. Tanabe et al. (2006) reconstruct river mouth morhodynamics in relation to sediment supply and sea-level in the Song Hong (Red River) or northern Vietnam. They conclude that river mouth changed during the Holocene from a funnel to a straight coast after c. 6 ka cal. yr BP, largely due to an increase in sediment discharge at this time as a result of deforestation. In the US, Flocks et al. (2006) present high resolution stratigraphic data from the Mississippi subdelta-lobe in the Barataria Bight, north-central Gulf of Mexico. The scope of this study is the last 4000 years and provides a useful context for interpreting the current coastal retreat experienced in the area.

Seismic investigations provide powerful means of reconstructing the former topography and infill of now drowned valley systems. Baldwin et al. (2006), for example, map several generations of the ancestral Pee Dee River system beneath the South Carolina Grand Strand shoreline and the adjacent Long Bay inner shelf. Successive generations of groups of palaeochannels record a regional, southwestward migration of the river system that started in the late Pliocene and was primarily driven by barrier-island deposition during eustatic highstands. More recently, Tornqvits et al. (2006) use a geophysical model to compute lowstand shoreline positions in the Bay of Biscay and the Gulf of Mexico. In the former the modeled shoreline was well landward of the shelf edge, raising significant questions regarding the mechanisms of source-to-sink sediment flux across the shelf at lowstands, sequence stratigraphic models that predict deep marine sedimentation during lowstands, and the formation of palaeovalleys on the continental shelf.

A.3 Quaternary sea-level and ocean circulation

As part of our project's effort to identify driving mechanisms behind sea-level change and coastal evolution, IGCP495 seeks to encourage research that seeks to test hypotheses regarding the link between changes in ocean circulation and sea-level change. The geochemistry of corals provides a powerful means whereby coastal organisms can be used to reconstruct changes in ocean circulation and / or temperature. Ayling et al. (2006), for example, use Sr/Ca and delta 0-18 from fossil coral skeletons to reconstruct seasonal sea surface temperatures in the southeast Pacific during the MIS 9 interglacial (c. 339-303 ka). Their analyses suggest an annual cycle of 4.7 ± 0.75 degrees C, exceeding the modern range by 15% but within error. Gallup et al. (2006) use Sr/Ca valus from modern and fossil samples of *Acropora palmata* corals from the Caribbean. They reconstruct LGM sea surface temperatures that were -7 degrees C cooler than present. Finally, Sivan et al. (2006) report an investigation into the "*Glycymeris* query" along the coastal and shallow coast of Israel. Here, high abundances of dead valves of this genus are attributed first to population expansion caused by changes in the trophic status of shelf waters 5500 years ago, and expansion of sandy habitats in the late Holocene, followed by a reduction in nutrients and marine productivity in the eastern Mediterranean after c. 2000-1500 years ago.

A.4 Global to local relative sea-level change during the last 1000 years

In our last report we reviewed the emerging RSL data from the saltmarshes of the Atlantic coast of the US. Donnelly (2006) reports a revised late Holocene sea-level record from northern Massachusetts derived from AMS dating of basal high marsh peats from Romney Marsh. This study notes an acceleration in the rate of sea-level rise during the recent historic times, a trend that is evident in several other records

from the region. This correlation with known changes in regional climate around the North Atlantic at this time suggests that regional-scale sea-level fluctuations may be driven by climate forcing. However, Donnelly (2006) suggests that this may not have been the case for earlier periods in time suggesting that the link between sea surface temperature variability and sea-level changes remains poorly resolved.

Transfer functions, which use regression analyses to link contemporary to fossil microfossil assemblages and thus derive quantitative sea-level reconstructions, continue to be developed by the IGCP community. They are particularly powerful in the last 150 years or so, where their reconstructions can be directly related to observed (tide gauge) records. Horton et al. (2006) develop a diatom-based transfer function from the Outer Banks, North Carolina, which has a precision of ± 0.08 m. Their work suggests a rise in RSL of 0.7 m over the last 150 yrs, consistent with other previous data from the area.

B. The lateral dimension of sea-level change. The role of terrestrial and oceanic processes in driving patterns of RSL change and coastal evolution.

B.1 Sediment fingerprinting in the coastal zone

Geochemical proxies and archaeological data are likely the most useful techniques for sourcing sediment fingerprints in the coastal zone. This is a relatively under-researched field but Steinke et al. (2006) present a detailed study of the influence of sea-level and monsoon climate over the South China Sea freshwater budget during the last 22 ka, based on an analysis of the Mg/Ca and oxygen isotopes preserved in planktonic foraminifera recovered from the glacial river mouths of several rivers that formerly drained across the Sunda Strait. A deglacial trend of increasing salinity records the progressive retreat of the shoreline from the sample sites during shelf flooding. Lower salinity than present in the early Holocene reflects an increase in summer monsoon precipitation and hence enhanced freshwater discharge across the shelf. This theme is explored further by Zong et al. (2006) who reconstruct Holocene monsoon history from the Pearl River Estuary in southern China using diatoms and carbon isotopes. They too record a significant influx of freshwater during the early Holocene (after c. 8500 cal. yr BP) as a result of enhanced summer monsoon activity, although the strength of the freshwater flux has decreased since 6000 cal. yr BP.

Several other papers address emerging techniques for reconstructing land-ocean interactions based on geophysical and sediment analyses. Ground penetrating radar and electrical resistivity techniques have significant potential in mapping detailed stratigraphic architecture in coastal lowlands, although both approaches are be-deviled by the presence of saltwater tables (Massey et al., 2006; Buynevich 2006). Stramski and Field (2006) examine the terrigenous sediment trapped by macroalagae on a Hawaiian reef flat, noting the significance of this process in controlling reef sediment budgets and nutrient dynamics in reef flat environments. Tracking the source of particulate and dissolved organic matter is a challenge addressed using delta C-13 and C-14 data from the St Lawrence River and its source (the Great Lakes outlet) by Helie and Hillaire-Marcel (2006). This study shows that in this catchment at least, the overall bulk DOC is relatively recent and in the estuary of the St Lawrence is derived mainly from recent organic matter from topsoils within the watershed.

Several papers address the potential of aeolian deposits as proxy markers of land-ocean interactions. Thus, Molodkov et al. (2006), Moldkov and Bitinas (2006) and Bolikhovskaya and Molodkov (2006) report on the potential of Eurasian loess as an archive linking ocean and continental records of climate and environmental change. In a coastal setting, Carr et al. (2006) present a new OSL chronology for dune

activity from the coastal Agulhas Plain in South Africa. Here, distinct phases of lunette accretion appear to be partially controlled by variations in sea level-induced changes in the groundwater table. Lunette orientation provides a strong indication of wind direction during periods of low sea level stands.

B.2 Human impact on coastal evolution and sea-level change

B.2.1 Observations of human impact on coastal evolution

Humans have had a direct and indirect impact on coastal evolution for many thousands of years. In the Mediterranean, we see ample evidence for large-scale changes in coastal geometry caused by human impact on landscape stability (e.g. Heyvaert and Baeteman, 2006). Thus, in Akarania, NW Greece, Vott et al. (2006a, b) use extensive vibracore records to reconstruct changes in shoreline position since c. 5500 cal. yr BP. The Palairos coastal plain received large volumes of fluvial sediments that infilled a large coastal lake after c. 4000 cal. yr BP. Geoarchaological techniques are also used by Marriner et al. (2006) in their discovery of the harbours of Tyre and Sidon, two of Phoenicia's most important city states. This work traces the origin of these ports from the Bronze Age until their silting up and burial in the medieval period. Other records of human-coastal interactions from further afield are presented by Anderson et al. (2006) and Kumar et al. (2006) from the Sigatoka Valley, Viti Levu island, Fiji. New radiocarbon and OSL dating demonstrates that the dunes in this area preserve evidence for three main phases of occupation spanning Fijian prehistory, with the longest phase of stability, between c. 2500-2300 cal. yrs BP, coinciding with relatively low ENSO activity. Significant changes to this system occurred after c. AD 1300, as increased population densities led to enhanced supply of terrigenous sediment to the coast and the development of high dunes visible today.

Over more recent timescales (during the last few hundred years), IGCP495 members are addressing a range of human-coastal interactions. For example, Pierre (2006) reports the results of a detailed survey of the retreat rates of the clay and sandstone cliffs of the northern Boulonnais (France) coast based on sterophotogrammetry. Retreat rates are much lower than previously thought, with rates closely linked to shore platform morphology and dynamics.

B2.2.2 Methodological aspects of human / coastal interactions:

The examples above in B2.2.1 illustrate the impact of land-use patterns of coastal sedimentation extend in the Mediterranean back into the Bronze Age. Less direct but equally significant impacts of human activity have also been identified in coastal lowlands around the Southern North Sea. Here, peat cutting, wetland drainage and the construction of sea defences are increasingly identified as major disruptors to the natural processes of coastal change. For example, prehistoric human activity can play an important role in "conditioning" the coast for change (Baeteman 2006; in press). In Romney Marsh, southeast England, Waller et al. (2006) demonstrate how an extensive deposit of coastal peat became desiccated as a result of water table lowering and various forms of land management. This meant that the peat stopped accumulating sediment for several hundreds to thousands of years. This case study demonstrates the challenges associated with using radiocarbon dates from the top of peat beds to infer chronologies of sea-level and coastal change.

B2.2.3 Modelling human-coastal interactions:

A theme that runs through IGCP495 is the desire to link observations with modelling in order to develop predictive capacity and enhance ability to mitigate deleterious changes in the world's coastal zone as a result of natural and anthropogenic processes. Our approach here is to develop quantitative models of sediment and

water / nutrient flux to the coastal zone. Examples of the former include research by Umigiesser et al. (2006) examining sand transport in the Treporti channel, northern Venice lagoon, detailed reconstruction of sediment budgets for the Indus delata shore since c. AD 1900 (Giosan et al., 2006). An illustration of the latter is provided by de Voogd et al. (2006) who show the use of remotely sensed data in predicting the spatial turnover of diverse coastal species such as sea sponges. Their work demonstrates the adverse impact that human settlement can have on sponge populations as a result of negative impacts on water quality.

"The past is the key to the future" is a much quoted adage in coastal science and Plater et al. (2006) demonstrate the value of this approach in their analysis of the potential for perimarine wetlands as an ecohydrological and phytotechnological management tool in the Guadiana estuary, Portugal. These authors argue that coastal wetlands are well able to accommodate RSL rise at rates of 3-6 mm / yr and conditions of low sediment supply. They conclude by advocating the increased use of perimarine wetlands as "natural" coastal defences. The sustainability of coastal management options is further explored by Speybroeck et al. (2006) in their assessment of the impact of beach nourishment on beach ecosystems. These authors stress the need to match the newly supplied beach material with that already present in terms of grain size, to avoid sediment compaction by heavy machinery and to time the nourishment to coincide with periods of low beach use by birds and other animals.

B.3 The role of earthquakes, tsunami and storms as driving mechanisms of Quaternary RSL change and coastal evolution

IGCP495 members continue to research the impacts of past earthquakes and tsunami on coastal lowlands, with research into prehistoric activity on-going on several plate margins. In Alaska, Shennan and Hamilton (2006) report on patterns of coseismic and interseismic land and sea-level movements over six earthquake cycles as recorded in stratigraphic sequences from the Cook Inlet. An important aspect of this work is the identification of a short period of pre-seismic RSL rise in the years immediately prior to an earthquake. On the Hikurangi subduction zone, New Zealand, Cochran et al. (2006) present paleoecological evidence from three Holocene sedimentary sequences in a transect across the forearc or the subduction zone. Large amounts of coseismic displacement (>1.5 m) are suggested from the coincidence of tsunami inundation with sudden subsidence of the coastal zone. Lastly, Dumont et al. (2006) review the evidence for a large earthquake c. 3200-2800 cal. yrs BP in the Esmeraldas-Tumaco seismic zone of South America. Changes in river position and discharge consequent to the earthquake is recorded by coastal beach ridges that formed as a result of these processes.

More recently, several papers address large plate boundary earthquakes during the historic period. Natawidjaja et al. (2006), for example, explore the source parameters of the Sumatran megathrust earthquakes of 1797 and 1833 using data from coral micro-atolls, whilst Walters et al. (2006a, b) develop a numerical model to predict tsunami run-up generated by submarine landslides off the northeast coast of New Zealand. In Hawaii, Goff et al. (2006) reconstruct the magnitude of the 1975 Kalapana tsunami, the largest local tsunami recorded in the 20th century in this region. The tsunami had waves that ran up to 14.6 m high and which deposited a veneer of basalt boulder and carbonate sand across the coast.

A major highlight of the last year was the *First International Tsunami Field Symposium, Bonaire* (also sponsored by the Commission on Coastal Systems of IGU) held in March 2006 and organized by Anja Scheffers and Dieter Kelletat (see separate field trip report). This provided a superb opportunity for 27 IGCP delegates from eleven countries to examine and discuss the response of coasts to extreme wave events. An excellent field guide (Scheffers 2005) has been published.

One theme addressed at the meeting was the Identifications and characterization of the magnitude and frequency of storm events. Away from Bonaire, Culver et al. (2006) report a detailed foraminiferal and sedimentary record from Pea Island, North Carolina, and explore the role of storm overwash, inlet processes and human processes in influencing coastal evolution. The impact of storms is also felt in the offshore zone, and Diesing et al. (2006) report from the German Bight, in the southeast North Sea, evidence for the role of extreme storms in generating sorted bedforms that are subsequently modified by tidal currents to develop and maintain their final form. Hurricane landfall is perhaps the most extreme form of storm impact and van de Plassche et al. (2006) provide a meticulous reconstruction of the saltmarsh stratigraphy of a southern New England saltmarsh that they believe contains evidence for two phases of significant erosion. The authors suggest that this erosion was most likely caused by hurricane landfalls, and their work demonstrates the sensitivity of saltmarshes to such events.

Identifying and characterizing the magnitude and frequency of storm events is becoming ever more pressing as concern regarding the impacts of future climate change on storm occurrence increase. Culver et al. (2006) report a detailed foraminiferal and sedimentary record from Pea Island, North Carolina, and explore the role of storm overwash, inlet processes and human processes in influencing coastal evolution. The impact of storms is also felt in the offshore zone, and Diesing et al. (2006) report from the German Bight, in the southeast North Sea, evidence for the role of extreme storms in generating sorted bedforms that are subsequently modified by tidal currents to develop and maintain their final form.

Hurricane landfall is perhaps the most extreme form of storm impact and van de Plassche et al. (2006) provide a meticulous reconstruction of the saltmarsh stratigraphy of a southern New England saltmarsh that they believe contains evidence for two phases of significant erosion. The authors suggest that this erosion was most likely caused by hurricane landfalls, and their work demonstrates the sensitivity of saltmarshes to such events.

3.3. List of meetings with approximate attendance and number of countries

Three field meetings were held in 2006. The first was a tsunami field symposium held in Bonaire, Netherlands Antilles, and the second, a joint UK sea-level IGCP-INQUA conference (Romney Marsh, Kent, UK). The third was our annual international field meeting and conference (with business meeting) which was held in Brazil. Numbers attending and countries represented at these three meetings (and those held previously under IGCP495) are listed below. Full meeting reports can be viewed on the project web site.

Title of Meeting	Date	Venue	No. of delegates	No. of Countries represented
Quaternary Land-Ocean Interactions: Driving Mechanisms & Coastal Responses	14th to 17th October 2004	Bar Harbor, Maine, United States of America	39	11
Late Quaternary Coastal Changes Sea Level, Sedimentary Forcing and Anthropogenic Impacts	28th June to 2nd July 2005	Dunkerque, France	74	12
Quaternary Ocean and Land Interaction: Climatic, Tectonic and Anthropogenic Influence	24th to 30th September 2005	Anyer-Carita, Banten-Sunda Strait area, Indonesia	32	10
First International Tsunami Field Symposium	2nd – 4th March 2006	Bonaire, Netherlands Antilles	27	11
Holocene land-ocean interactions: driving mechanisms and coastal responses	9th – 12th July 2006	Romney Marsh, Kent	26	7
Quaternary Land-Ocean Interaction: Natural and Human Forcings on Coastal Evolution	17th to 22nd September 2006	Balneário Camboriú, Santa Catarina, Brazil	22	6

3.4. Educational, training or capacity building activities

As advised in our 2005 Annual Report, we continue to encourage students to attend our meetings to give papers and also to explain their research in the field wherever possible.

3.5. Participation of scientists from developing countries

The project provides a particular focus on the support and training of colleagues from developing countries. IGCP495 is co-led by Professor Islam who is based in Bangladesh and is very aware of the issues relating to sea-level change, coastal evolution and climate change and how these may impact on developing countries. The project addresses this issue in three ways.

Firstly, we have ensured that the budget allocated from UNESCO is used only to support attendance of colleagues from developing countries to the project meetings (the conferences are self-financing in all other respects). In 2004, delegates from Kenya, Indonesia, Brazil and the Philippines were able to attend the conference directly as a result of UNESCO-funded support. One of these has subsequently embarked on a PhD programme in Australia as a direct result of this conference. At our Indonesian and Brazilian meetings, funds were dedicated to support attendance of local delegates and those from countries affected by the Indian Ocean tsunami. To-date, 18 colleagues were directly supported by UNESCO funds. Secondly, the project uses additional commitments from colleagues in developed countries to provide additional support to enable attendance from poorer countries. In the first two years this has amounted to a 50% increase to the core support provided by UNESCO and was used to support delegates attending the Maine and Indonesia meetings. Thirdly, we stated in our original project design that the project will hold at least two of its project meetings in developing world countries (in fact, it is likely that we will increase this to three). This will reduce costs for delegates attending and also show-case the research in these countries.

The following colleagues have participated in the project by attending the Maine, USA, Indonesian, Bonaire and Brazilian meetings:

1. Pamela Abuodha	Kenya
2. Kumaresan Anbarasu	India
3. Rodolfo José Angulo	Brazil
4. José Carlos Branco	Brazil
5. Marcos Antonio da R. Ferreira	Brazil
6. Maria Cristina de Souza	Brazil
7. Sérgio Rebelo Dillenburg	Brazil
8. Lulil Gustiantin	Indonesia
9. Antonio Henrique de Fontoura Klein	Brazil
10. Lina Handayani	Indonesia
11. Shahid Islam	Bangladesh
12. Hamza Latief	Indonesia
13. Marcelo Renato Lamour	Brazil
14. Bambang Edhi Leksono	Indonesia
15. Guilherme Lessa	Brazil
16. Aurelio Mercado-Irizarry	Puerto Rico
17. Rafael Mueller Peterman	Brazil
18. Jacob Rais	Indonesia
19. Tjoek Aziz Soeprapto	Indonesia
20. Seshachalam Srinivasalu	India
21. S. Susilohadi	Indonesia
22. Yuliana Susilowait	Indonesia
23. Igan S. Sutawidjaja	Indonesia
24. Fernando Alvim Veiga	Brazil
25. Siti Zulaikah	Indonesia

3.6. List of most important publications (including maps)
Distinguish between peer review literature and other (no abstracts).

Angulo, R. J., Lessa, G. C. and M. C. de Souza. (2006). “A critical review of mid- to late-Holocene sea-level fluctuations on the eastern Brazilian coastline.” *Quaternary Science Reviews* **25**(5-6): 486-506.

Antonioli, F., Ferranti, L., Lambeck, K., Kershaw, S., Verrubbi, V. and G. D. Pra. (2006). "Late Pleistocene to Holocene record of changing uplift rates in southern Calabria and northeastern Sicily (southern Italy, Central Mediterranean Sea)." *Tectonophysics* **422**(1-4): 23-40.

Carr, A. S., Thomas, D. S. G. and M. D. Bateman. (2006). "Climatic and sea level controls on Late Quaternary eolian activity on the Agulhas Plain, South Africa." *Quaternary Research* **65**(2): 252-263.

Donnelly, J. P. (2006). "A revised late Holocene sea-level record for northern Massachusetts, USA." *Journal of Coastal Research* **22**(5): 1051-1061.

Edwards, R. J. (2006). "Mid- to late-Holocene relative sea-level change in southwest Britain and the influence of sediment compaction." *Holocene* **16**(4): 575-587.

Goff, J., Dudley, W., de Maintenon, M. J., Cain, G. and J. P. Coney. (2006). "The largest local tsunami in 20th century Hawaii." *Marine Geology* **226**(1-2): 65-79.

Horton, B. P., Corbett, R., Culver, S. J., Edwards, R. J. and C. Hillier. (2006). "Modern saltmarsh diatom distributions of the Outer Banks, North Carolina, and the development of a

transfer function for high resolution reconstructions of sea level." *Estuarine Coastal and Shelf Science* **69**(3-4): 381-394.

Keigwin, L. D., Donnelly, J. P., Cook, M. S., Driscoll, N. W. and J. Brigham-Grette. (2006). "Rapid sea-level rise and Holocene climate in the Chukchi Sea." *Geology* **34**(10): 861-864.

Long, A. J., Waller, M. P. and P. Stupples. (2006). "Driving mechanisms of coastal change: Peat compaction and the destruction of late Holocene coastal wetlands." *Marine Geology* **225**(1-4): 63-84.

Marriner, N., Morhange, C., Doumet-Serhal, C. and P. Carbonel. (2006). "Geoscience rediscovers Phoenicia's buried harbors." *Geology* **34**(1): 1-4.

Massey, A. C., Paul, P. M., Gehrels, W. R. and D. J. Charman. (2006). "Autocompaction in Holocene coastal back-barrier sediments from south Devon, southwest England, UK." *Marine Geology* **226**(3-4): 225-241.

Morhange, C., Pirazzoli, P. A., Marriner, N., Montaggioni, L. F. and T. Nammour. (2006). "Late Holocene relative sea-level changes in Lebanon, Eastern Mediterranean." *Marine Geology* **230**(1-2): 99-114.

Plater, A. and J. Kirby (2006). "The potential for perimarine wetlands as an ecohydrological and phytotechnological management tool in the Guadiana estuary, Portugal." *Estuarine Coastal and Shelf Science* **70**(1-2): 98-108.

Radtke, U. and G. Schellmann (2006). "Uplift history along the Clermont Nose Traverse on the West Coast of Barbados during the last 500,000 years - Implications for paleo-sea level reconstructions." *Journal of Coastal Research* **22**(2): 350-360.

Shennan, I., Hamilton, S., Hillier, C., Hunter, A., Woodall, R., Bradley, S., Milne, G., Brooks, A. and S. Bassett. (2006). "Relative sea-level observations in western Scotland since the Last Glacial Maximum for testing models of glacial isostatic land movements and ice-sheet reconstructions." *Journal of Quaternary Science* **21**(6): 601-613.

Shennan, I. and S. Hamilton (2006). "Coseismic and pre-seismic subsidence associated with great earthquakes in Alaska." *Quaternary Science Reviews* **25**(1-2): 1-8.
Tornqvist, T. E., Bick, S. J., van der Borg, K. and A. F. M. de Jong. (2006). "How stable is the Mississippi Delta?" *Geology* **34**(8): 697-700.

Tornqvist, T. E., Wortman, S. R., Mateo, Z. R. P., Milne, G. A. and J. B. Swenson. (2006). "Did the last sea level lowstand always lead to cross-shelf valley formation and source-to-sink sediment flux?" *Journal of Geophysical Research-Earth Surface* **111**(F4).

van de Plassche, O., Erkens, G., van Vliet, F., Brandsma, J., van der Borg, K. and A. F. M. de Jong. (2006). "Salt-marsh erosion associated with hurricane landfall in southern New England in the fifteenth and seventeenth centuries." *Geology* **34**(10): 829-832.

Yokoyama, Y., Purcell, A., Marshall, J. F. and K. Lambeck. (2006). "Sea-level during the early deglaciation period in the Great Barrier Reef, Australia." *Global and Planetary Change* **53**(1-2): 147-153.

Zong, Y., Lloyd, J. M., Leng, M. J., Yim, W. W. S. and G. Huang. (2006). "Reconstruction of Holocene monsoon history from the Pearl River Estuary, southern China, using diatoms and carbon isotope ratios." *Holocene* **16**(2): 251-263.

Waller, M. P., Long, A. J. and J. E. Schofield. (2006). "Interpretation of radiocarbon dates from the upper surface of late-Holocene peat layers in coastal lowlands." *Holocene* **16**(1): 51-61.

Vott, A., Bruckner, H., Schriever, A., Luther, J. and M. Handl. (2006). "Holocene palaeogeographies of the Astakos coastal plain (Akarnania, NW Greece)." *Palaeogeography Palaeoclimatology Palaeoecology* **239**(1-2): 126-146.

Bibliography (listed by author in alphabetical order with the most recent work listed first)

Please note that these references are additional to those reported in the last annual report.

Aboumaria, K., Gigliuto, L. G., Puglisi, D., Zaghloul, M. N., Aberkan, M. and A. Di Staso. (2006). "Quaternary marine terraces on the southern side of the Gibraltar strait and on the Northern Atlantic Coast of Morocco: lithostratigraphy, provenance and drainage patterns." *Bollettino Della Societa Geologica Italiana* **125**(1): 93-104.

Anderson, A., Chappell, J., Gagan, M. K. and R. Grove. (2006). "Prehistoric maritime migration in the Pacific islands: an hypothesis of ENSO forcing." *Holocene* **16**(1): 1-6.

Anderson, A., Roberts, R., Dickinson, W., Clark, G., Burley, D., de Biran, A., Hope, G. and P. Nunn. (2006). "Times of sand: Sedimentary history and archaeology at the Sigatoka Dunes, Fiji." *Geoarchaeology-an International Journal* **21**(2): 131-154.

Angulo, R. J., Lessa, G. C. and M. C. de Souza. (2006). "A critical review of mid- to late-Holocene sea-level fluctuations on the eastern Brazilian coastline." *Quaternary Science Reviews* **25**(5-6): 486-506.

Anton, M. G., Romera, G. G., Pages, J. L., and A. A. Millan. (2006). "The Holocene pollen record in the Villaviciosa Estuary (Asturias, North Spain)." *Palaeogeography Palaeoclimatology Palaeoecology* **237**(2-4): 280-292.

Antonioli, F., Ferranti, L., Lambeck, K., Kershaw, S., Verrubbi, V. and G. D. Pra. (2006). "Late Pleistocene to Holocene record of changing uplift rates in southern Calabria and northeastern Sicily (southern Italy, Central Mediterranean Sea)." *Tectonophysics* **422**(1-4): 23-40.

Antonioli, F., Kershaw, S., Renda, P., Rust, D., Belluomini, G., Cerasoli, M., Radtke., U and S. Silenzi. (2006). "Elevation of the last interglacial highstand in Sicily (Italy): A benchmark of coastal tectonics." *Quaternary International* **145**: 3-18.

Argow, B. A. and D. M. FitzGerald (2006). "Winter processes on northern salt marshes: Evaluating the impact of in-situ peat compaction due to ice loading, Wells, ME." *Estuarine Coastal and Shelf Science* **69**(3-4): 360-369.

Ayling, B. F., McCulloch, M. T., Gagan, M. K., Stirling, C. H., Anderson, M. B. and S. G. Blake. (2006). "Sr/Ca and delta O-18 seasonality in a Porites coral from the MIS 9 (339-303 ka) interglacial." *Earth and Planetary Science Letters* **248**(1-2): 462-475.

Baeteman, C. (2006). De laat Holocene evolutie van de Belgische kustvlakte: Sedimentatieprocessen versus zeepiegelschommelingen ed Duinkerke transgressies. In: de Kraker, A.M.J., Borger, G.J. (Eds), Veen-Vis-Zout. Landschappelijke dynamiek in de zuidwestelijke delta van de Lage Landen. Geoarcheologische en Bioarcheologische Studies 8, Vrije Universiteit Amsterdam.

Baeteman, C. (In Press). Roman peat-extraction pits as possible evidence for the timing of coastal changes: An example from the Belgian coastal plain. Liber amicorum. Prof. Dr. Guus Borger, Uitgeverij Aksant, Amsterdam.

Baldwin, W. E., Morton, R. A., Putney, T. R., Katuna, M. P., Harris, M. S., Gayes, P. T., Driscoll, N. W., Denny, J. F. and W. C. Schwab. (2006). "Migration of the Pee Dee River system inferred from ancestral paleochannels underlying the South Carolina Grand Strand and Long Bay inner shelf." *Geological Society of America Bulletin* **118**(5-6): 533-549.

Bolikhovskaya, N. S. and A. N. Molodkov (2006). "East European loess-palaeosol sequences: Palynology, stratigraphy and correlation." *Quaternary International* **149**: 24-36.

Boomer, I. and B. P. Horton (2006). "Holocene relative sea-level movements along the North Norfolk Coast, UK." *Palaeogeography Palaeoclimatology Palaeoecology* **230**(1-2): 32-51.

Bridgland, D. R., Antoine, P., Limondian-Lozouet, N., Santisteban, J. I., Westaway, R. and M. J. White. (2006). "The Palaeolithic occupation of Europe as revealed by evidence from the rivers: data from IGCP 449." *Journal of Quaternary Science* **21**(5): 437-455.

Buynevich, I. V. (2006). "Coastal environmental changes revealed in geophysical images of Nantucket Island, Massachusetts, USA." *Environmental & Engineering Geoscience* **12**(3): 227-234.

Cann, J. H., Murray-Wallace, C. V., Riggs, N. J. and A. P. Belperio. (2006). "Successive foraminiferal faunas and inferred palaeoenvironments associated with the postglacial (Holocene) marine transgression, Gulf St Vincent, South Australia." *Holocene* **16**(2): 224-234.

Carr, A. S., Thomas, D. S. G. and M. D. Bateman. (2006). "Climatic and sea level controls on Late Quaternary eolian activity on the Agulhas Plain, South Africa." *Quaternary Research* **65**(2): 252-263.

Cochran, U., Berryman, K., Zachariasen, J., Mildenhall, D., Hayward, B., Southall, K., Hollis, C., Barker, P., Wallace, L., Alloway, B. and K. Wilson. (2006). "Paleoecological insights into subduction zone earthquake occurrence, eastern North Island, New Zealand." *Geological Society of America Bulletin* **118**(9-10): 1051-1074.

Culver, S. J., Ames, D. V., Corbett, D. R., Mallinson, D. J., Riggs, S. R., Smith, C. G. and D. J. Vance. (2006). "Foraminiferal and sedimentary record of Late Holocene barrier island evolution, Pea Island, North Carolina: The role of storm overwash, inlet processes, and anthropogenic modification." *Journal of Coastal Research* **22**(4): 836-846.

de Voogd, N. J., Cleary, D. F. R., Hoeksema, B. W., Noor, A. and R. W. M. van Soest. (2006). "Sponge beta diversity in the Spermonde Archipelago, SW Sulawesi, Indonesia." *Marine Ecology-Progress Series* **309**: 131-142.

Diesing, M., Kubicki, A., Winter, C. and K. Schwarzer. (2006). "Decadal scale stability of sorted bedforms, German Bight, southeastern North Sea." *Continental Shelf Research* **26**(8): 902-916.

Donnelly, J. P. (2006). "A revised late Holocene sea-level record for northern Massachusetts, USA." *Journal of Coastal Research* **22**(5): 1051-1061.

Dumont, J. P., Santana, E., Valdez, F., Tihay, J. P., Usselmann, P., Iturralde, D. and E. Navarette. (2006). "Fan beheading and drainage diversion as evidence of a 3200-2800 BP earthquake event in the Esmeraldas-Tumaco seismic zone: A case study for the effects of great subduction earthquakes." *Geomorphology* **74**(1-4): 100-123.

Edwards, R. J. (2006). "Mid- to late-Holocene relative sea-level change in southwest Britain and the influence of sediment compaction." *Holocene* **16**(4): 575-587.

Evans, J., Dowdeswell, J. A., Cofaigh, C. O., Benharn, T. J. and J. B. Anderson. (2006). "Extent and dynamics of the West Antarctic Ice Sheet on the outer continental shelf of Pine Island Bay during the last glaciation." *Marine Geology* **230**(1-2): 53-72.

Ferranti, L., Antonioli, F., Mauz, B., Amorosi, A., Pra, G. D., Mastronuzzi, G., Monaco, C., Orru, P., Pappalardo, M., Radtke, U., Renda, R., Romano, P., Sanso, P. and V. Verrubbi. (2006). "Markers of the last interglacial sea-level high stand along the coast of Italy: Tectonic implications." *Quaternary International* **145**: 30-54.

Flocks, J. G., Ferina, N. F., Dreher, C., Kindinger, J. L., Fitzgerald, D. M. and M. A. Kulp. (2006). "High-resolution stratigraphy of a Mississippi subdelta-lobe progradation in the Barataria Bight, north-central Gulf of Mexico." *Journal of Sedimentary Research* **76**(3-4): 429-443.

Gallup, C. D., Olson, D. M., Edwards, R. L., Gruhn, L. M., Winter, A. and F. W. Taylor. (2006). "Sr/Ca-Sea surface temperature calibration in the branching Caribbean coral Acropora palmata." *Geophysical Research Letters* **33**(3).

Giosan, L., Constantinescu, S., Clift, P. D., Tabrez, A. R., Danish, M. and A. Inam. (2006). "Recent morphodynamics of the Indus delta shore and shelf." *Continental Shelf Research* **26**(14): 1668-1684.

Giosan, L., Donnelly, J. P., Constantinescu, S., Filip, F., Ovejanu, I., Vespremeanu-Stroe, A., Vespremeanu, E. and G. A. T. Duller. (2006). "Young Danube delta documents stable Black Sea level since the middle Holocene: Morphodynamic, paleogeographic, and archaeological implications." *Geology* **34**(9): 757-760.

Goff, J., Dudley, W., de Maintenon, M. J., Cain, G. and J. P. Coney. (2006). "The largest local tsunami in 20th century Hawaii." *Marine Geology* **226**(1-2): 65-79.

Haila, H., Miettinen, A. and M. Eronen. (2006). "Diatom succession of a dislocated Eemian sediment sequence at Mommark, South Denmark." *Boreas* **35**(2): 378-384.

Hanebuth, T. J. J., Saito, Y., Tanabe, S., Vu, Q. L. and Q. T. Ngo. (2006). "Sea levels during late marine isotope stage 3 (or older?) reported from the Red River delta (northern Vietnam) and adjacent regions." *Quaternary International* **145**: 119-134.

Hassan, G. S., Espinosa, M. A. and F. I. Isla. (2006). "Modern diatom assemblages in surface sediments from estuarine systems in the southeastern Buenos Aires province, Argentina." *Journal of Paleolimnology* **35**(1): 39-53.

Helie, J. F. and C. Hillaire-Marcel (2006). "Sources of particulate and dissolved organic carbon in the St Lawrence River: isotopic approach." *Hydrological Processes* **20**(9): 1945-1959.

Heyvaert, V. M. A. and C. Baeteman. (2006) The Holocene sedimentary record of the Lower Khuzestan plain (SW Iran): A Footprint of Palaeogeographical Changes. Program and Abstracts. Broadening Horizons, Multidisciplinary approaches to the study of past landscapes, Gent, Belgium, 27-28 February 2006.

Heyvaert, V., Ooghe, B., Weerts, H. and C. Baeteman. (2006). The impact of channel shifting of the river Karkheh on the late Holocene evolution of the northern part of the Lower Khuzastan plain (Persian Gulf, SW Iran): integrating geological and historical data.

Horton, B. P., Corbett, R., Culver, S. J., Edwards, R. J. and C. Hillier. (2006). "Modern saltmarsh diatom distributions of the Outer Banks, North Carolina, and the development of a transfer function for high resolution reconstructions of sea level." *Estuarine Coastal and Shelf Science* **69**(3-4): 381-394.

Keigwin, L. D., Donnelly, J. P., Cook, M. S., Driscoll, N. W. and J. Brigham-Grette. (2006). "Rapid sea-level rise and Holocene climate in the Chukchi Sea." *Geology* **34**(10): 861-864.

Kumar, R., Nunn, P. D., Field, J. S. and A. de Biran. (2006). "Human responses to climate change around AD 1300: A case study of the Sigatoka Valley, Viti Levu Island, Fiji." *Quaternary International* **151**: 133-143.

Lambeck, K., Purcell, A., Funder, S., Kjaer, K. H., Larsen, E. and P. Moller. (2006). "Constraints on the Late Saalian to early Middle Weichselian ice sheet of Eurasia from field data and rebound modelling." *Boreas* **35**(3): 539-575.

Long, A. J., Roberts, D. H. and S. Dawson. (2006). "Early Holocene history of the west Greenland Ice Sheet and the GH-8.2 event." *Quaternary Science Reviews* **25**(9-10): 904-922.

Long, A. J., Waller, M. P. and P. Stupples. (2006). "Driving mechanisms of coastal change: Peat compaction and the destruction of late Holocene coastal wetlands." *Marine Geology* **225**(1-4): 63-84.

Marriner, N., Morhange, C., Doumet-Serhal, C. and P. Carbonel. (2006). "Geoscience rediscovers Phoenicia's buried harbors." *Geology* **34**(1): 1-4.

Massey, A. C., Paul, P. M., Gehrels, W. R. and D. J. Charman. (2006). "Autocompaction in Holocene coastal back-barrier sediments from south Devon, southwest England, UK." *Marine Geology* **226**(3-4): 225-241.

Massey, A. C., Taylor, G., Gehrels, W. R. and D. J. Charman. (2006). "Electrical resistivity of coastal back-barrier sediments from south Devon, south-west England, United Kingdom." *Journal of Coastal Research* **22**(5): 1179-1191.

Mathys, M., Baeteman, C. and M. De Batist. (2006). The Quaternary geological evolution of the Belgian Continental Shelf: A sneak preview. 2nd Belgian Geological Congress, 7-8 September 2006, Liége.

Molodkov, A. and A. Bitinas (2006). "Sedimentary record and luminescence chronology of the Lateglacial and Holocene aeolian sediments in Lithuania." *Boreas* **35**(2): 244-254.

Molodkov, A. N. and N. S. Bolikhovskaya (2006). "Long-term palaeoenvironmental changes recorded in palynologically studied loess-palaeosol and ESR-dated marine deposits of Northern Eurasia: Implications for sea-land correlation." *Quaternary International* **152**: 37-47.

Morhange, C., Pirazzoli, P. A., Marriner, N., Montaggioni, L. F. and T. Nammour. (2006). "Late Holocene relative sea-level changes in Lebanon, Eastern Mediterranean." *Marine Geology* **230**(1-2): 99-114.

Mosola, A. B. and J. B. Anderson (2006). "Expansion and rapid retreat of the West Antarctic Ice Sheet in eastern Ross Sea: possible consequence of over-extended ice streams?" *Quaternary Science Reviews* **25**(17-18): 2177-2196.

Natawidjaja, D. H., Sieh, K., Chlieh, M., Galetzka, J., Suwargadi, B. W., Cheng, H., Edwards, R. L., Avouac, J. P. and S. N. Ward. (2006). "Source parameters of the great Sumatran megathrust earthquakes of 1797 and 1833 inferred from coral microatolls." Journal of Geophysical Research-Solid Earth **111**(B6).

Peltier, W. R., Vettoretti, G. and M. Stastna. (2006). "Atlantic meridional overturning and climate response to Arctic Ocean freshening." *Geophysical Research Letters* **33**(6).

Pierre, G. (2006). "Processes and rate of retreat of the clay and sandstone sea cliffs of the northern Boulonnais (France)." *Geomorphology* **73**(1-2): 64-77.

Pieters, M., Schietecattel, L., Zeebrook, I., Baeteman, C., Bastiaens, J., Deforce, K., Jansen, I., Meylemans, E. & J. Van Laecke (2006). 3.2. The Belgian Polders, Flanders: a test case 2002-2006, In. Dyson, L., Heppell, E., Johnson, C. and Pieters, M. (Eds) Archaeological Evaluation of Wetlands on the Planarch Area of North West Europe. Maidstone**,** 39-54.

Plater, A. and J. Kirby (2006). "The potential for perimarine wetlands as an ecohydrological and phytotechnological management tool in the Guadiana estuary, Portugal." *Estuarine Coastal and Shelf Science* **70**(1-2): 98-108.

Radtke, U. and G. Schellmann (2006). "Uplift history along the Clermont Nose Traverse on the West Coast of Barbados during the last 500,000 years - Implications for paleo-sea level reconstructions." *Journal of Coastal Research* **22**(2): 350-360.

Riker-Coleman, K. E., Gallup, C. D., Wallace, L. M., Webster, J. M., Cheng, H. and R. L. Edwards. (2006). "Evidence of Holocene uplift in east New Britain, Papua New Guinea." *Geophysical Research Letters* **33**(18).

Roberts, D. H., Chiverrell, R. C., Innes, J. B., Horton, B. P., Brooks, A. J., Thomas, G. S. P., Turner, S. and S. Gonzalez. (2006). "Holocene sea levels, last glacial maximum glaciomarine environments and geophysical models in the northern Irish Sea Basin, UK." *Marine Geology* **231**(1-4): 113-128.

Roe, H. and C. Baeteman (2006). Pleistocene coastal evolution and sea-level change of the lowlands of western Belgium: The record from the Woumen borehole, near Diksmuide. 2nd Belgian Geological Congress, 7-8 September 2006, Liége.

Scheffers, A. (2005). *Coastal responses to extreme wave events: hurricane and tsunami on Bonaire -* 1. Auflage – Essen: Selbstverlage (Essener Geographische Arbeiten 37, pp100).

Shaw, J., Piper, D. J. W., Fader, G. B. J., King, E. L., Todd, B. J., Bell, T., Batterson, M. J. and D. G. E. Liverman. (2006). "A conceptual model of the deglaciation of Atlantic Canada." *Quaternary Science Reviews* **25**(17-18): 2059-2081.

Shennan, I., Hamilton, S., Hillier, C., Hunter, A., Woodall, R., Bradley, S., Milne, G., Brooks, A. and S. Bassett. (2006). "Relative sea-level observations in western Scotland since the Last Glacial Maximum for testing models of glacial isostatic land movements and ice-sheet reconstructions." *Journal of Quaternary Science* **21**(6): 601-613.

Shennan, I. and S. Hamilton (2006). "Coseismic and pre-seismic subsidence associated with great earthquakes in Alaska." *Quaternary Science Reviews* **25**(1-2): 1-8.

Sivan, D., Potasman, M., Almongi-Labin, A., Mayer, D. E. B. Y., Spanier, E. and E. Boaretto. (2006). "The Glycymeris query along the coast and shallow shelf of Israel, southeast Mediterranean." *Palaeogeography Palaeoclimatology Palaeoecology* **233**(1-2): 134-148.

Sloss, C. R., Murray-Wallace, C. V. and B. G. Jones. (2006). "Aminostratigraphy of two Holocene wave-dominated barrier estuaries in southeastern Australia." *Journal of Coastal Research* **22**(1): 113-136.

Sparrenbom, C. J., Bennike, O., Bjorck, S. and K. Lambeck. (2006). "Holocene relative sea-level changes in the Qaqortoq area, southern Greenland." *Boreas* **35**(2): 171-187.

Sparrenbom, C. J., Bennike, O., Bjorck, S. and K. Lambeck. (2006). "Relative sea-level changes since 15 000 cal. yr BP in the Nanortalik area, southern Greenland." *Journal of Quaternary Science* **21**(1): 29-48.

Speybroeck, J., Bonte, D., Courtens, W., Gheskiere, T., Grootaert, P., Maelfait, J. P., Mathys, M., Provoost, S., Sabbe, K., Stienen, E. W. M., Van Lancker, V., Vincx, M. and S. Degraer. (2006). "Beach nourishment: an ecologically sound coastal defence alternative? A review." *Aquatic Conservation-Marine and Freshwater Ecosystems* **16**(4): 419-435.

Stamski, R. E. and M. E. Field (2006). "Characterization of sediment trapped by macroalgae on a Hawaiian reef flat." *Estuarine Coastal and Shelf Science* **66**(1-2): 211-216.

Steinke, S., Chiu, H. Y., Yu, P. S., Shen, C. C., Erlenkeuser, H., Lowemark, L. and M. T. Chen. (2006). "On the influence of sea level and monsoon climate on the southern South China Sea freshwater budget over the last 22,000 years." *Quaternary Science Reviews* **25**(13-14): 1475-1488.

Stutz, S., Prieto, A. R. and F. I. Isla. (2006). "Holocene evolution of the Mar Chiquita coastal lagoon area (Argentina) indicated by pollen analysis." *Journal of Quaternary Science* **21**(1): 17-28.

Tanabe, S., Saito, Y., Vu, Q. L., Hanebuth, J. J., Ngo, Q. L. and A. Kitamura. (2006). "Holocene evolution of the Song Hong (Red River) delta system, northern Vietnam." *Sedimentary Geology* **187**(1-2): 29-61.

Tarasov, L. and W. R. Peltier (2006). "A calibrated deglacial drainage chronology for the North American continent: evidence of an Arctic trigger for the Younger Dryas." *Quaternary Science Reviews* **25**(7-8): 659-688.

Tornqvist, T. E., Bick, S. J., van der Borg, K. and A. F. M. de Jong. (2006). "How stable is the Mississippi Delta?" *Geology* **34**(8): 697-700.

Tornqvist, T. E., Wortman, S. R., Mateo, Z. R. P., Milne, G. A. and J. B. Swenson. (2006). "Did the last sea level lowstand always lead to cross-shelf valley formation and source-to-sink sediment flux?" *Journal of Geophysical Research-Earth Surface* **111**(F4).

Tuccimei, P., Gines, J., Delitala, M. C., Gines, A., Gracia, F., Fornos, J. J. and A. Taddeucci. (2006). "Last interglacial sea level changes in Mallorca island (Western Mediterranean). High precision U-series data from phreatic overgrowths on speleothems." *Zeitschrift Fur Geomorphologie* **50**(1): 1-21.

Uehara, K., Scourse, J. D., Horsburgh, K. J., Lambeck, K. and A. P. Purcell. (2006). "Tidal evolution of the northwest European shelf seas from the Last Glacial Maximum to the present." *Journal of Geophysical Research-Oceans* **111**(C9).

Umgiesser, G., De Pascalis, F., Ferrarin, C. and C. L. Amos. (2006). "A model of sand transport in Treporti channel: northern Venice lagoon." *Ocean Dynamics* **56**(3-4): 339-351.

van de Plassche, O., Erkens, G., van Vliet, F., Brandsma, J., van der Borg, K. and A. F. M. de Jong. (2006). "Salt-marsh erosion associated with hurricane landfall in southern New England in the fifteenth and seventeenth centuries." *Geology* **34**(10): 829-832.

Vott, A., Bruckner, H., Handl, M. and A. Schriever. (2006). "Holocene paleogeographies of the Palairos coastal plain (Akarnania, northwest Greece) and their geoarchaeological implications." *Geoarchaeology-an International Journal* **21**(7): 649-664.

Vott, A., Bruckner, H., Schriever, A., Luther, J. and M. Handl. (2006). "Holocene palaeogeographies of the Astakos coastal plain (Akarnania, NW Greece)." *Palaeogeography Palaeoclimatology Palaeoecology* **239**(1-2): 126-146.

Waller, M. P., Long, A. J. and J. E. Schofield. (2006). "Interpretation of radiocarbon dates from the upper surface of late-Holocene peat layers in coastal lowlands." *Holocene* **16**(1): 51-61.

Walters, R., Barnes, P., Lewis, K. and J. R. Goff. (2006). "Locally generated tsunami along the Kaikoura coastal margin: Part 2. Submarine landslides." *New Zealand Journal of Marine and Freshwater Research* **40**(1): 17-28.

Walters, R. A., Barnes, P. and J. R. Goff. (2006). "Locally generated tsunami along the Kaikoura coastal margin: Part 1. Fault ruptures." *New Zealand Journal of Marine and Freshwater Research* **40**(1): 1-16.

Wellner, J. S., Heroy, D. C. and J. B. Anderson. (2006). "The death mask of the Antarctic Ice Sheet: Comparison of glacial geomorphic features across the continental shelf." *Geomorphology* **75**(1-2): 157-171.

Whitehouse, P., Latychev, K., Milne, G. A., Mitrovica, J. X. and R. Kendall. (2006). "Impact of 3-D Earth structure on Fennoscandian glacial isostatic adjustment: Implications for space-geodetic estimates of present-day crustal deformations." *Geophysical Research Letters* **33**(13).

Yokoyama, Y., Purcell, A., Marshall, J. F. and K. Lambeck. (2006). "Sea-level during the early deglaciation period in the Great Barrier Reef, Australia." *Global and Planetary Change* **53**(1-2): 147-153.

Zong, Y., Lloyd, J. M., Leng, M. J., Yim, W. W. S. and G. Huang. (2006). "Reconstruction of Holocene monsoon history from the Pearl River Estuary, southern China, using diatoms and carbon isotope ratios." *Holocene* **16**(2): 251-263.

3.7. Activities involving other IGCP projects or the IUGS

None to report.

4. Activities planned

4.1. General goals

Planned meetings in the next 12 months:

We plan to combine the next international IGCP495 meeting with the INQUA Congress in Cairns (Australia) 28 July – 3 August 2007. There will be two joint INQUA-ICGP495 sessions as well as several other INQUA sessions run by the Commission on Coastal and Marine Processes. There will be at least one IGCP495 field meeting.

4.2. Specific meetings and field trips (please indicate participation from developing countries)

As in previous meetings, we will encourage attendance by colleagues from developing countries by offering financial support and, in the case of the Cairns meeting, directly by allocation of IGCP495 conference support resources.

5. Project funding requested

We seek continued support at the level received in the second year of this project (US $5,500). We will continue to provide additional funds from individual project members to boost this budget and further support attendance at the project meetings by attendees from developing countries.

6. Request for extension, on-extended-term-status, or intention to propose successor project

None required at this stage.

7. Financial statement

The IGCP Scientific Board would like to be informed how the IGCP funds were used and if additional funding could be obtained from different sources.

We have ensured that the budget allocated from UNESCO is used only to support attendance of colleagues from developing countries to the project meetings – see attached appendices.

8. Attach any information you may consider relevant

Conference reports for IGCP UK Working Group Conference, *Holocene land-ocean interactions: driving mechanisms and coastal responses* Romney Marsh, Kent, 9th – 12th July 2006, The Third annual IGCP Conference, Quaternary Land-Ocean Interaction: Natural and Human Forcings on Coastal Evolution, Balneário Camboriú, Santa Catarina, Brazil, 17th to 22nd September 2006 and the First International Tsunami Field Symposium, Bonaire, 2006.

Report on the International Geological Correlation Program (IGCP) Project 495 UK Working Group Conference and Fieldtrip to Romney Marsh and the Dungeness Foreland

"Quaternary land-ocean interactions: driving mechanisms and coastal responses."

Wye College, Romney Marsh, UK
9th-12th July 2006

Introduction

Nestled in the picturesque town of Wye, Kent, Wye College provided the backdrop to the second annual meeting of the UK IGCP Working Group for IGCP project 495 (Quaternary Land-Ocean Interactions: Driving Mechanisms and Coastal Responses). The meeting was jointly organised by Antony Long (Durham University), Andy Plater (University of Liverpool), Martyn Waller (Kingston University) and Jason Kirby (Liverpool John Moores University). The meeting consisted of a one-day scientific session (consisting of both academic papers and posters), which was followed by a two day field trip to the coastal lowlands and gravel forelands of Romney Marsh and Dungeness.

The registration evening was somewhat unusual as it coincided with the 2006 World Cup Final. After initial ideas by the organisers to move the event, it was decided that perhaps the millions of television viewing public would be a little put out, so the delegates were instead treated to a postponed 'welcome/poster' session after a thrilling three hours of football with the occasional head-butt thrown in. The evening welcome, given by Antony after the penalties, promised a very full programme over the coming days. A brief background was given to research in the Romney and Dungeness area so as to both prepare and 'wet the appetite' for the two day field excursion.

Monday 10th July

The first full day of the conference was given over to the scientific meeting which was arranged into three thematic sessions, each detailed below:

Session 1 – Methodologies for reconstructing and dating

The first paper of the day was given by **Robin Edwards** (Trinity) on 'Foraminiferal transfer functions and sea-level: Accuracy or precision?' A stimulating first talk introduced by Robin as being "statistics after breakfast". This didn't put people off though and the second talk of the day, given by **Wil Marshall** (Plymouth), entitled 'Dating recent salt-marsh sediments with radionuclides: a tentative look inside the 'Black Box'' caused a flurry of questions about the application of dating techniques in the coastal environment. This was followed by a presentation by **Sarah Woodroffe** (Durham) of her Doctoral work, 'Foraminifera-based reconstructions of mid-late Holocene sea-level change from North Queensland, Australia'. This particular paper encouraged a lively debate to develop concerning the problems of the use of transfer functions in coastal studies, which integrated nicely with the first paper of the session given by Robin. **Joseph Kelley** (Maine) then gave a paper on the 'Investigations of lower-than-present sea-level positions: Methods and results from Northern Ireland and Maine, USA' which provided a fascinating insight into the use of vibro-cores, their relative positioning and absolute number considering the large costs involved. It served to highlight the growing need for high levels of pre-coring surveys where off-shore coring programmes are to be developed. The final paper of the session was given by **Matthew Brain** (Durham) who also presented work from his Doctoral work entitled 'Autocompaction behaviour of mineralogenic

intertidal sediments'. As with the start of the session, statistics made a comeback. Matthew carefully guided the audience through the various models for Autocompaction of salt marsh sediments and the inherent problems that currently belie the methodology used by many to adjust for altitudinal correction. It provided a fitting end to a session that served to highlight that methodologies for reconstructing sea level data are far from resolved.

Session 2 – Coastal resilience

The first paper of the second session was given by **Roland Gehrels** (Plymouth), and was concerned with 'Coastal subsidence in southwest England'. Roland's paper was aimed at current policy makers and their reliance on specific documents that essentially can be misleading. This talk provided an excellent start to the second session as a lively debate followed about the use of data and what actually makes a good sea level index point. The second paper of the session presented by **Andrew Cooper** (Ulster), 'Beach morphological evolution during falling sea level: Millin Bay, Northern Ireland', presented new evidence for a coastal site that had many in the audience wanting to visit the area. So much so, Andrew has been charged with the organisation of a future meeting of the IGCP to Northern Ireland to see his fantastic sites. The third paper was given by **Simon Jennings** (London Metropolitan University) and concentrated on the 'Gravel transport along the East Sussex coast since the mid-Holocene'. The many different palaeogeographical maps that were presented were most fitting for this particular meeting as they provided further background to the coastal development of the area we were to visit on the two field days that were to follow. The fourth paper was given by **Sytze van Heteren** (TNO, Netherlands) and was a departure from the original advertisement due to a technical difficulty. The paper, entitled 'Detailed marine mapping: channel fills and other small-scale features' was an excellent stand by as it served to highlight the points made by Joseph in the first session about the need for detailed off-shore survey prior to expensive coring exercises. The next paper, given by **Sue Dawson** (St Andrews), was about 'Sedimentological and geomorphological coastal change: evidence from the Jan 11th 2005 storm in the Outer Hebrides, NW Scotland'. Again, as with Andrew's pictures of Northern Ireland, the Outer Hebrides stirred something in the audience and the Western Isles look like being yet another site for a future meeting. The final paper in this session was given by **Jason Kirby** (John Moores) and was entitled 'Coastal response to Holocene water level changes in the Humber Estuary'. This paper introduced the idea of coastal lagoons developing in the peri-tidal zone and provided the backdrop for a lively debate about lagoonal sedimentation that continued over the break for tea.

Session 3 –Human coastal interactions

The final session began with an extremely interesting paper given by **Vanessa Heyvaert** (Geological Survey of Belgium) on 'The impact of channel shifting of the river Karkheh on the late Holocene evolution of the northern part of the Lower Khuzestan plain (Persian Gulf, SW Iran): integrating geological and historical data'. The integration of geomorphology and archaeology/historical record was impressive in an area that essentially saw the birth of civilisation. The constant thought of working in the border country between Iran and Iraq was quite daunting. The second paper saw another of the Dutch contingent from TNO Built Environment and Geosciences, Geological Survey of the Netherlands, **Peter Vos**, present a paper on 'Geoarchaeology and palaeogeography of the northern Netherlands'. It should perhaps be pointed out at this stage that our IGCP European partners supported the Romney Marsh meeting extremely well and constantly provided excellent feedback and questioning of all the papers presented. Peter's paper was based around the 'geogenetic approach' which saw a high level of integration between geology, geomorphology and archaeology in order to reconstruct palaeoenvironments. The final paper of the session and indeed the day was given by **Henk Weerts** (TNO, Netherlands). Henk's paper, 'The engulfing of the Groote Waard (The Netherlands)',

was thought provoking as it took historical reference and folklore of coastal flooding events in the Netherlands, and with the aid of high resolution geological work, aimed to prove and disprove certain theories with the production of a number of palaeogeographical maps.

The day was rounded off with a trip to Lympne Castle where the conference dinner was served in magnificent surroundings overlooking the coastal area of Romney Marsh (obscured slightly by the rain and low cloud). The castle setting was quite spectacular and was rounded off by a presentation by Andy Plater (aided by Jason Kirby) of the entire delegates alter egos via a very amusing set of web-based searches. It was amazing to learn of our exploits outside of our academic lives thanks to our namesakes, although some were worried what the web would associate with our names due to previous Google-search exploits.

Tuesday 11th July

With the scientific sessions over, the second day of the meeting was devoted to field visits in the Romney Marsh area. We were all provided with a large 'Field Guide and Abstracts' document that will no doubt provide many hours of light reading for the weeks that follow the trip. The provision of vast amounts of maps and diagrams to everybody was excellent though and helped no end with an understanding of the geomorphology of the area.

The first stop was Appledore (Mill Mount) where the four field trip leaders, Antony Long, Martyn Waller, Andy Plater and Jason Kirby, introduced the early Holocene history of the Romney Marsh depositional complex whilst overlooking Walland and Romney Marshes (see Plate 1).

Plate 1. The early Holocene history of the Romney Marsh depositional complex was introduced at Appledore (Mill Mount) (Photo courtesy of Roland Gehrels)

The second stop of the day was Pett Level (Wickham Manor). Here, Martyn Waller explained the destruction of the late Holocene wetlands and the first of a number of

'hands-on' coring exercises was undertaken (see Plate 2). The group coring exercise produced mixed results that were blamed on a number of different things, involving over enthusiastic coring technique, lack of coring technique or perhaps the wrong technique. All in all the English summer weather was perhaps too much for some coupled with the strain of penetrating the metre or so of hard clay.

Plate 2. Group coring exercise at Pett Level (Wickham Manor) (Photo courtesy of Roland Gehrels)

The lunch stop at Old Winchelsea provided another excellent opportunity to look out across Romney Marsh, further strengthening the understanding of the surroundings in relation to the extensive research that has been undertaken in the area. Although incredibly complex, the depositional history was starting to make sense.

The third main stop of the day, Moneypenney Farm and Walland Marsh, saw Martyn Waller and Antony Long introduce the history to the tidal inlets and tidal channels that underlie the area. A further coring exercise was undertaken with the supervision of Andy Plater in order to investigate fine laminations in the infilling of the Wainway Channel. Again, mixed results made sure that those with the incorrect technique were not allowed near the coring equipment again! Andy was quick to point out that the deposits were somewhat sporadic and perhaps not everybody should have found the same sedimentary, signal although it was felt that perhaps he was being somewhat accommodating.

The final stop of the day was at Jury's Gap where Andy Plater introduced the barrier/marshland interface. A short talk about SSSI designation was given by Brian Banks (English Nature) who pointed out that of the many SSSIs around the country, few are given over to geomorphological/geological areas.

Wednesday 12th July

The focus for the final day of the field trip was the coastal fringe of Dungeness. The first stop of the day was at the Dungeness Foreland (Muddymore Pit), where Andy

Plater gave a complete depositional history of the area. We were all treated to a plethora of talks about the palaeoreconstruction of the Foreland area with a number of demonstrations of the sediments that can be found in-between the shingle ridges. One of the particular demonstrations that will stay with many, involved Anthony Long introducing us all to the 'leaping' technique of gouge coring, effective but perhaps far too energetic for some.

The next stop at the Dungeness Lighthouse allowed everybody to get a fantastic view of both the shingle deposition in the area and the imposing figure that is Dungeness nuclear power station. This was followed by an introduction to the coastal management of Dungeness by members of the shoreline management committee who also represented English Nature and the Power Company. The need for shingle dredging and beach nourishment was obvious in terms of protecting the nuclear power installation, but to hear how policy is constantly changing made many baulk at the prospects for the future of the area. As this was the last stop, it was decided that it would make a fitting place to take a group photo (see Plate 3). It was felt that this IGCP meeting was both productive and enjoyable and all involved thanked the organisers for such a marvellous effort.

Plate 3. The delegates of the 2006 IGCP 495 UK working group meeting on the Dungeness Foreland, overlooking the Dungeness Lighthouse (Photo courtesy of Roland Gehrels)

For more information and/or free membership of IGCP Project 495, please contact Roland Gehrels (wrgehrels@plymouth.ac.uk). Further information regarding the IGCP is available on the Web (www.geography.dur.ac.uk/research/qec/igcp.html).

Jason Jordan
Department of Geography, Environment & Disaster Management
Coventry University

Third International Conference and Field Meeting of IGCP Project 495 "Quaternary Land-Ocean Interactions: Driving Mechanisms and Coastal Responses"
Santa Catarina and Paraná,

Brazil September 17-22nd 2006.

IGCP495 members at the Tijucas beach

International Geoscience Programme (IGCP) Project 495 seeks to improve our understanding of Quaternary land-ocean interactions, with a particular focus on the driving mechanisms responsible for lateral and vertical changes in sea-level over a range of spatial and temporal scales. The project runs from 2004 to 2009 and, having held its first two international meetings in Maine (2004) and Indonesia (2005), converged on the coastal city of Balneário Camboriú, some 400 km south of Sao Paulo, for its third conference and field meeting.

The conference organisers, Dr Rodolfo Angulo and Dr Maria Cristina de Souza (Universidade Federal do Paraná) and Dr Antônio Klein (Universidade do Vale do Itajaí) are to be congratulated on all their efforts in welcoming over 30 colleagues from around the world to Brazil for two days' of academic papers followed by a three-day field trip to the spectacular coasts of Santa Catarina and Paraná.

Muddy foreshore sediments at the Tijucas beach

The scientific paper session opened with two excellent overview papers of the Brazilian coast bays, estuaries and coastal barriers by Dr Guilherme Lessa and Dr Rodolfo Angulo. The coast of Brazil, like many others in the low latitudes, has experienced a fall in relative sea-level (RSL) since a mid-Holocene highstand. This quite modest fall in RSL, always less than about

3-4 m, resulted in major changes in coastal geomorphology and processes, most notably colossal coastal progradation with estuaries contracting in size and coastal barriers developing.

Three papers followed that addressed late Holocene coastal change in Belgium (Cecile Baeteman), the Holocene infilling of Algarve estuaries in Portugal (Thomaz Boski) and evidence for 20th century sea-level acceleration based on a meticulous analysis of a New Zealand saltmarsh (Roland Gehrels). The related themes of vertical changes in RSL and lateral shifts in shoreline position continued to be addressed by Vanessa Heyvaert who outlined a new model for the development of the Mesopotamian marshes (Iran) driven by progradation of the Karun-mega fan during the late Holocene.

The impacts of the mid Holocene deceleration in global RSL change had profound impacts of wetland development throughout the World and Ben Horton proposed a warmly debated hypothesis that linked these changes in wetland dynamics and the associated increase in coastal margin productivity with the emergence of civilisations. The final two papers of the day tackled a further set of driving mechanisms for coastal change. Philip Lane presented an impressive palaeoarchive of New England hurricanes obtained from coastal pond sediments based on grain size and geochemical data, a theme returned to later in the conference by Jon Woodruff. Finally, Antony Long detailed the first RSL curve from the south east coast of Greenland and explored the implications of this record for the interpretation of recently collected mass balance data by the Gravity and Climate Change Experiment (GRACE).

Coastal erosion at Brava Beach

Following a delicious conference dinner in a local restaurant, day two of the scientific papers opened with a panoramic overview of the geomorphology of the Brazilian coastal barriers by Sérgio Dillenburg. Discussion here, as in day one of the meeting, included consideration of the source of the abundant volume of sediment that must have been available throughout much of the Holocene to nourish these large coastal landforms and their associated back-barrier infills. Moving to a more northern theme, Arto Miettinen then presented a careful review of the late Holocene RSL history from the south west coast of Finland based on isolation basins. Arto identified evidence for differential uplift perhaps associated with tectonic movements, a theme touched on previously by the Guilherme Lessa in his review of the Brazilian coastal bays.

The development of quantitative reconstructions of RSL change based on transfer functions has been a theme of the last two international meetings of IGCP 495. This approach provides a potentially powerful means of defining continuous records of RSL change based on the statistical relationships between contemporary microfossil assemblages and their fossil counterparts. Roland Gehrels had already demonstrated the potential of such an approach in his reconstruction of a New Zealand saltmarsh RSL record on day one of the meeting and two further papers also used this approach. The first, by Sarah Woodroffe, used a foraminiferal-based transfer function to reconstruct late Holocene RSL records from north Queensland, Australia. The second, by Katie Szkornik, tackled the late Holocene evolution of Ho Bugt in Denmark using diatoms as the preferred microfossil group. Each of the authors advocated caution in the use of the transfer function approach, perhaps more so than in previous IGCP meetings, yet nevertheless demonstrated the power of the method when judiciously applied in combination with careful consideration of litho and chronostratigraphic data. The final paper of the day returned to the theme of hurricane reconstruction, and Jon Woodruff presented a wonderful overview of his research into the overwash and RSL histories of several coastal ponds in the West Indies. Despite the challenges of collecting sediments from these settings, Jon provided fascinating evidence for significant changes in hurricane frequency and magnitude during the late Holocene, especially after about 1000 AD.

Rodolfo Angulo cleaning a section in the

Pleistocene beach deposits on the Paraná

coastal plain

A poster session allowed delegates to listen to brief project summaries that addressed a variety of IGCP 495 themes. I was particularly impressed by two posters by Brazilian colleagues, one that reported preliminary research concerning the submerged beachrocks of southern Brazil (Fernando Veiga) and a second on some spectacular late Pleistocene (presumed MOI Stage 5e) coastal barrier stratigraphies exposed at Paraná, southern Brazil (José Branco), which we were to later visit in the field trip.

The first day of the field trip focused on the Tijucas coastal plain and the Piçarras beach and Pleistocene barrier, both located to the south of the conference venue. The extensive Holocene coastal plains of Santa Catarina and Paraná are locally backed by late Pleistocene barrier deposits of presumed MOI Stage 5e, although their exact age is yet to be determined. We began our visit to the rain-drenched Tijucas lowlands by standing atop a narrow fringe of Pleistocene barrier that abuts the coastal hills, some 3 m or so above the younger, Holocene shorelines. Duncan FitzGerald led much of the day and demonstrated the enormous potential of ground penetrating radar (GPR) in mapping the internal structures of the Pleistocene and Holocene beaches in Brazil. Duncan had previously shown the ability of GPR to identify the internal bedding geometry of beach facies, as well as erosional layers marked by heavy mineral concentrations on the IGCP495 Maine field meeting in 2004. The results here were equally impressive and the 20 km of GPR profiles collected to date have the potential to yield very high resolution (perhaps even annual) records of coastal progradation and storm activity.

From the Pleistocene barrier we embarked on a transects across the Tijucas coastal plain, traversing a variety of back-barrier mangrove, sandy beach and chenier deposits before finally reaching the present coastline. The present beach is remarkable for its thin veneer of muddy sediments that drape the shoreface sands, which owe their origin to the high near-shore suspended sediment concentrations sourced by the Tijucas river. Discussion focussed on the source of the sediment for the Tijucas coastal plain and on the driving mechanism(s) for the change to a more mud-dominated system in the late Holocene.

The second stop of the day was to a small pocket beach at Taquaras (Laranjeiras) where, in contrast to the large, open drift cell of Tijucas, only a narrow coastal plain exists. The steep and reflective beach profile here is sculptured by well-developed beach cusps and survives on the internal recycling of sediment within the headland embayment. The rain was beginning to let-up by lunchtime, but our hopes of an overview of the Balneário Camboriú beach from the top of a cable car were dashed by low cloud, reminding us that there is a sound climatic reason for the presence of the extensive “Mata Atlântica” rain forests that mantle so much of the landscape here. Undaunted we paused for lunch on an airy look-out tower and speculated on the invisible geomorphology several hundred meters below us!

Ilha do Mel

Back at sea-level we stopped at the southern end of the Balneário Camboriú beach to hear of the disastrous attempts to replenish the beach with locally dredged sediment from the adjacent Camboriú river. In 2002, nearly 50,000 m^3 of sediment were deposited along 800 m of the beach and, whilst the scheme was approved by the Santa Catarina State, the project lacked any environmental impact assessment. The result was predictable with extensive ecotoxicological pollution and large accumulations of shell hash on the replenished beach. The beach grain size became coarser whilst there was a significant increase in deposition of silt and clay onto the continental shelf. The problems of beach erosion on this highly developed and rapidly expanding coast continue.

Rodolfo Angulo with vermetid remains

Travelling north we climbed to an excellent viewing point at Cruz Hill, overlooking Itajaí city. Duncan FitzGerald presented further GPR and stratigraphic observations from the large Navegantes strandplain, contrasting the depositional history of this system with that of the coarser-grained Tijucas strandplain visited that morning. One hypothesis for the contrast in grain size between the two is that the coarser sediment from the Navegantes river may be deposited within the river mouth instead of across the adjacent beaches. The penultimate stop of the day was to visit a narrow deposit of MOI Stage 5e beach deposits at Piçarras in the north coast of Santa Catarina state, before continuing on to the delightful coastal city of Guaratuba. Shortly before reaching our hotel our coach pulled off the road at Saí-Guaçu next to a 10 m high, heavily vegetated mound which on closer

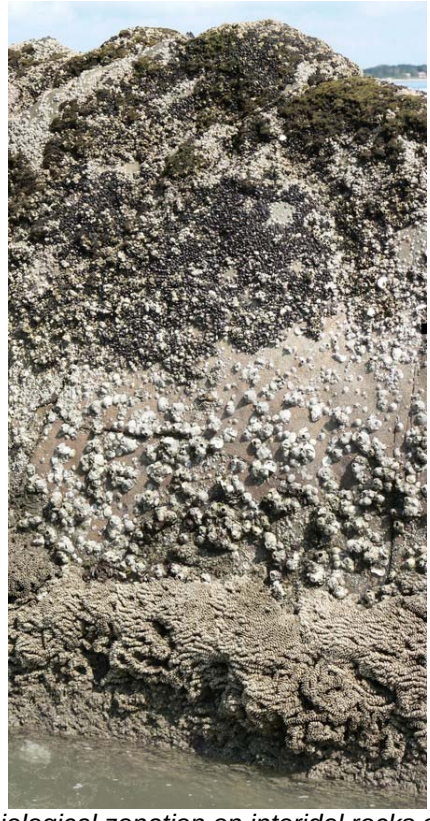
inspection proved to be a huge shell-midden comprised mainly of *Anomalocardia brasiliana* and *Ostrea* sp. shells. Shells from the surface of the midden date from about five thousand years ago, close to the time of the mid Holocene sea-level highstand. Shell middens like the Saí-Guaçu example are numerous in Brazil and well over one thousand are known to exist. The middens have been used by some authors in efforts to reconstruct RSL but most now agree that they have little value for such reconstructions but rather more significance as indicators of prehistoric activity, including burial practices and territory demarcation.

Panaoramic view from the Morro do Farol das Conchas, on the Ilha do Mel (R. Gehrels)

One day two of the field trip we continued our northward tour, crossing by ferry the mouth of the Guaratuba estuary and viewing the extensive ebb tidal delta that has developed at the mouth of this, and other estuaries, along this section of the Brazilian coast. They sheer scale of the landforms daunted most of the non-Brazilian delegates used to working on much smaller depositional complexes. Our next stop was in the Paranaguá coastal plain where we were to remain for the rest of the field trip. We began with a visit to a large sand quarry which provided spectacular exposures of the Pleistocene barrier facies at the inner part of the estuary complex. The deposits here comprised well-sorted, medium and fine quartzose sand, as well as heavy minerals, silt and clay. In composition they are significantly coarser than their Holocene counterparts, presumably reflecting a greater fluvial input to these early barrier systems. The Holocene barrier deposits began prograding after c. 4-5 thousand years ago, after the highstand had been reached. Indeed, radiocarbon dates suggest that the Paranaguá barrier prograded 3.5 km in the last 2000 years with a fall in RSL of about 2 m.

By now a consistent pattern of coastal evolution was beginning to emerge, with the infilling of the Paranaguá, Guaratuba and Tijucas all following a broadly similar pattern. During the rising limb of RSL in the early to mid Holocene, large volumes of sediment were transported into the tidal basins and the systems infilled. Uninterrupted longshore drift along the Santa Catarina and Paraná coasts was precluded by the numerous large tidal inlets and by the net transport of sediment into these systems by flood-dominated tidal channels. However, as RSL began to fall from its highstand so the estuaries infilled and a switch occurred from flood to ebb-dominance and large ebb tidal deltas formed. The infilling of the embayments provided the conditions for the establishment of a large south to north drift system that steadily depleted sediment from coasts to the south of Santa Catarina state, nourishing the prograding beach systems in the north.

At the coastal port of Paranaguá we transferred from the coach to a small boat that took us on a sun-drenched two-hour trip to the Ilha do Mel, an island positioned at the mouth of the Baía de Paranaguá. Porpoises kept us company as we motored gently past the mangroves of the outer estuary, whilst a barbeque lunch on the back of the boat provided welcome sustenance. Once on the Ilha do Mel we trecked across the sand tracks that criss-cross this small island to a secluded set of beach apartments overlooking the Atlantic Ocean. A climb to the lighthouse on the Morro do Farol das Conchas provided a stunning panorama of the Baía de Paranaguá, including its vast ebb tidal deltas delimited by pounding surf.



Biological zonation on interidal rocks on the Ilha do Mel (R. Gehrels)

After a comfortable night listening only to the sound of the waves, and with not a street-light in view or car engine in ear-shot, we spent the final morning of the trip exploring the rock coast of the Praia do Farol in search of vermetid remains. Living specimens of these gastropods recently disappeared from this part of the Brazilian coast for an unknown reason, but their fossilised remains, hidden in crevasses beneath large blocks bedrock, provide powerful constraints on former Holocene sea-levels. Rodolfo Angulo has used these indicators extensively in RSL research and adeptly scrambled beneath rocks of various sizes to extract samples for delegates to view. Now thoroughly sun-burnt, we headed back to the boat that returned us to the mainland before driving up the coastal mountains of the Serra do Mar via the Graciosa road, which provided stunning views across the rainforest, before continuing to the city of Curitiba where the meeting ended and colleagues dispersed.

I know that I speak on behalf of all the delegates who attended this meeting in thanking the conference organisers, Rodolfo Angulo, Antônio Klein and Cristina de Souza and their able support team (especially Thammy Barreto

and Niamh McElherron (Durham University, UK) for providing such an interesting an enjoyable field meeting. In the spirit of IGCP meetings, they effortlessly combined excellent science with a relaxed and informal atmosphere that means all of us will remember the spectacular coastlines of Santa Catarina and Paraná for many years to come.

A programme and abstracts, as well as two field guides are available as pdf files on the IGCP 495 website listed below.

Further information on IGCP495 “Quaternary Land-Ocean Interactions: Driving Mechanisms and Coastal Responses” can be found from the UK National Correspondent, Dr Roland Gehrels (University of Plymouth, R.W.Gehrels@Plymouth.ac.uk) or the project web site at:

http://www.geography.dur.ac.uk/Projects/Default.aspx?alias=www.geography.dur.ac.uk/projects/igcp495

Professor Antony Long
Department of Geography
Durham University
Science Site
South Road
Durham DH1 3LE
A.J.Long@Durham.ac.uk

AEQUA - GTPEQ

First International Tsunami Field Symposium, Bonaire, 2006

IGCP 495
(also sponsored by the Commission on Coastal Systems of IGU)

Captain Don's Habitat, Bonaire, Netherlands Antilles

2nd - 4th March, 2006

Conference Report

As one of the activities of IGCP 495 the "First International Tsunami Field Symposium", organised by Anja Scheffers (Essen University, Germany) and co-sponsored by the NOAA Sea Grant Program by the efforts of Professor Aurelio Mercado from Puerto Rico, took place on Bonaire (Netherlands Antilles) March 2nd - 4th, 2006. It was attended by 24 scientists from 10 countries (Bonaire, USA, Puerto Rico, Jamaica, Argentina, South Africa, France, Spain, Italy and Germany). 15 paper presentations dealt with Paleo-tsunami field studies (Caribbean and Mediterranean), the SE-Asian tsunami of 2004, and differentiation of storm and tsunami deposits, tsunami forecasting as well as modelling techniques. The main emphasis of the meeting, however, was on three field trips, visiting nearly all coastlines of Bonaire. As Bonaire is a perfect natural laboratory for the study of extreme events on rocky shorelines and coral reefs, the different aspects of coarse hurricane deposits (from Lenny in 1999, Ivan in 2004, Tecla in 1877 and an older storm about 600 years ago) compared with the extreme forces of several Younger Holocene tsunami have been studied in detail. The extraordinary amount of deposits (several million tons during one event) as well as the size of dislocated boulders (50 to over 200 tons) led to discussions on transport mechanisms and the physics of wave impacts. Bonaire also presents the only place (so far identified) where a strong Holocene tsunami extinguished a well developed fringing reef, which had not recovered during the last 3000 years. On several subjects the field discussions came to a general consensus on processes, but still challenging is the perspective of different disciplines (geology, geomorphology), different approaches (deductive/inductive) methods in tsunami research, or the view angle of paleo-tsunami- versus modern tsunami researchers.

The proceedings of the meeting will be published as Special Volume 145 of Zeitschrift für Geomorphologie at the end of 2006.

It was agreed that a Second International Tsunami Field Symposium will be organized in 2008 in southern Italy by Professor Guiseppe Mastronuzzi and Professor Paolo Sansó and western Greece by Professor Helmut Brückner and Dr. Andreas Vött.

http://www.geography.dur.ac.uk/Projects/Default.aspx?alias=www.geography.dur.ac.uk/projects/igcp495

Professor Antony Long
Department of Geography
Durham University
Science Site
South Road
Durham DH1 3LE
A.J.Long@Durham.ac.uk