ELSEVIER

Quaternary Science Reviews 24 (2005) 1963–1968

QSR

Editorial

Quaternary coastal morphology and sea-level changes—an introduction

1. Introduction

Few things remain static in natural systems and perhaps no better illustrated than by changes in the level of the ocean surface with respect to the land over Quaternary timescales. The position of sea level (ultimate base level) and changes of sea level over geological timescales represent important controls in the evolution of coastal environments, and as an agent of profound geomorphological and environmental change in adjacent landscapes. Sea level determines the lower limit of continental denudation, to which fluvial, aeolian and other weathering and erosional processes may lower the landscape. Sea level also determines the volume and nature of terrestrially derived sediment deposited within coastal environments, sediment sourced from the inner continental shelf and acts as a major control in the formation of sedimentary carbonates.

The significance of relative sea-level changes has long been recognized across the various sub-disciplines of the Earth sciences and the historical development of the broader discipline has, in part, occurred in unison with increased understanding of changes in relative sea level, as well as the physical processes responsible for these changes. Since the early 1970s, successive International Geological Correlation Projects (IGCP), funded by UNESCO and the International Union of Geological Sciences (IUGS), examined Quaternary sea-level changes and their environmental significance. Since their inception in 1974, IGCP projects devoted to the study of sea-level changes include, Project 61 *Sea-level change during the last deglacial hemicycle* directed by Arthur L. Bloom (1974–1982), Project 200 *Sea-level correlation and applications* directed by Paolo A. Pirazzoli (1983–1987), Project 274 *Coastal evolution in the Quaternary* directed by Orson van de Plassche (1988–1993) and Project 367 *Late Quaternary coastal records of rapid change—application to present and future conditions* directed by David B. Scott (1994–1998).

This special issue of *Quaternary Science Reviews* comprises a selection of papers presented at the final annual meeting of IGCP Project 437 *Coastal Environmental Change During Sea-Level Highstands* (directed by Colin V. Murray-Wallace 1999–2003) in Otranto, Italy in September 2003, organized by Giuseppe Mastronuzzi and Paolo Sansò. The central objectives of IGCP Project 437 were to:

(1) compare and contrast the evolution of coasts during the present, Holocene sea-level highstand with earlier highstands (e.g. the Last Interglacial maximum; Marine Oxygen Isotope Substage 5e; MIS5e) and explain the geological and geophysical basis for any morphostratigraphic similarities or differences in these records;
(2) document through geological mapping and detailed stratigraphical analysis, the global distribution of highstand shoreline successions for the Holocene and Last Interglacial, and where possible, earlier highstands with the aim of elucidating the geological and geophysical basis for similarities and differences;
(3) quantify the magnitude of sea-level variation evident during highstands and document their basis (e.g. the contributions of glacio-hydro-isostatic processes, as well as relative sea-level changes associated with neotectonism);
(4) develop new, and refine existing technologies for the assessment of age of coastal sedimentary successions through the critical application of a range of Quaternary dating methods;
(5) evaluate the impact of human-induced environmental changes in coastal landscapes in the context of natural environmental changes.

In Project 437, the history of coastal environmental changes during the past few thousand years up to the present day was compared with similar intervals of sea-level highstands in the earlier geological record. During these episodes, sea levels were at their highest, or near highest points in the Milankovitch cycle of glacio-eustatic sea-level changes (i.e. broadly comparable with the present sea level). Thus, changes that occurred in

0277-3791/$ - see front matter
doi:10.1016/j.quascirev.2005.06.001

similar sea-level highstands during the last few hundred thousand years were examined, as a framework to model possible future changes.

Particular attention focused on the Last Interglacial maximum (MIS5e) as it represents the most recent and complete interglacial event in the geological record (cf. present, ongoing Holocene interglacial). In a similar manner, the Quaternary record of earlier highstands (i.e. interglacial maxima and interstadials) was regarded as important for refining the comparison of the Last Interglacial with the Holocene record, in terms of the coastal processes that have occurred during these intervals (e.g. changes in rates and nature of erosion and sedimentation in response to subtle changes in sea level).

A fundamental research question relevant to understanding coastal change in the present Holocene highstand, and possible future coastal change, centres on the duration of the Last Interglacial maximum (MIS5e). Estimates for the duration of the Last Interglacial maximum derive from a range of independent sources in terrestrial and marine situations and at present two views persist. A long duration for the Last Interglacial maximum has been argued based on dating of corals and speleothems which variously bracket MIS5e between 134 and 116 ka (Zhu et al., 1993; Eisenhauer et al., 1996) and at least 130–117 ka (Stirling et al., 1995). Kukla et al. (1997) and Winograd et al. (1997) favoured a longer duration for MIS5e based, respectively, on analyses of the Le Grande Pile pollen record in France and the Devils Hole $\delta^{18}O$ palaeotemperature record from Nevada. In contrast, the SPECMAP timescale, evidence from the Loess Plateau of China and laminated lake sediments in western Europe collectively favour a shorter duration of only 8–10 ka for MIS5e (Lowe and Walker, 1997). This represents a fundamental issue beyond simple academic interest as the present Holocene interglacial represents the last 10 ka, and thus there are major scientific challenges to resolve the types of coastal environmental changes that have occurred in the latter part of the Last Interglacial, as an actualistic model of possible future change in the present Holocene interglacial (notwithstanding the current controversy surrounding human impacts on climate in the Holocene (Ruddiman et al., 2005)). Accordingly, Project 437 placed considerable emphasis on the importance of the geological record in understanding present and future global change, an approach that is widely advocated by many researchers (Burke et al., 1990).

The juxtaposition of Last Interglacial and Holocene coastal sedimentary successions and landforms along many of the world's coastlines (apart from formerly glaciated regions where the MIS5e record has been largely destroyed by erosion) permits a comparative analysis of the evolutionary products of these two highstand events. Comparison of the geological record of these highstands raises several important research questions of global significance and considerable social relevance.

2. Sea-level behaviour during highstands

Although the nature and magnitude of relative sea-level changes has been well documented in general terms for the last glacial cycle (Chappell et al., 1996), the behaviour of the sea surface during the Last Interglacial maximum, as documented for the present, Holocene interglacial, in terms of glacio-hydro-isostasy, with some notable exceptions (Lambeck, 1990) has not been examined for much of the world's coastlines. Thus, a major research emphasis was, and still needs to be placed on comparing the empirical evidence (stratigraphical and geomorphological) from these two records and interpreting the results in terms of geophysical models of glacio-hydro-isostatic deformation. Observations of past sea levels derived from geomorphological and stratigraphical investigations still need to be carefully integrated with geophysical models, with an emphasis on spatial variations in relative sea level.

Project 437 also examined the relaxation times required for coastal systems to establish equilibrium following the culmination of the most recent post-glacial marine transgression, for different regions around the world, as well as the general response of coastlines to sea-level rise. In the near field of former ice sheets, knowledge of the rates of glacio-isostatic adjustment was further refined (Peltier, 2002; Shennan and Horton, 2002) and a unified explanation of mid-Holocene highstands in low latitude regions in response to the combined effects of continental levering and equatorial ocean syphoning was advanced (Mitrovica and Milne, 2002).

A further question to be addressed is the degree to which apparently short-term changes in relative sea level are a manifestation of short-term climate change (e.g. El Niño Southern Oscillation events, Little Ice Age), in contrast to the glacio-hydro-isostatic adjustment process over longer timescales (e.g. Haworth et al., 2002; Goodwin, 2003). Disentangling the evidence for these processes remains a major challenge within the discipline, as many field sites simply do not preserve the necessary stratigraphical information to resolve this problem, and the possibility of misattribution of cause remains.

3. Large-scale coastal behaviour and neotectonics

In recent years there has been an increasing recognition that geomorphological changes within coastal systems at a local scale need to be evaluated in terms of changes evident over longer temporal, and larger spatial scales. This is particularly significant when engineering solutions are sought for coastal problems. Large-scale coastal behaviour involves integration of computer modelling of recent coastal changes with results of geological studies that summarize longer histories of coastal change (Cowell and Thom, 1994). Such an approach addresses questions about coastal change over timescales that exceed the range of human instrumental monitoring and coastal morphodynamics represents an integral aspect of this research. Numerous research programs under the auspices of Project 437 examined short-term coastal change focusing on the relationship between form and process (Regnauld and Louboutin, 2002; Schwarzer et al., 2003; Battiau-Queney et al., 2003).

The theme of coastal neotectonics also represented a significant aspect of Project 437. Numerous investigations examined shoreline deposits of the Last Interglacial maximum to quantify geodetic changes (Calanchi et al., 2002; Murray-Wallace, 2002; DeDiego-Forbis et al., 2004) as well as emergent interstadial (Sasaki et al., 2004) and Holocene deposits (Mastronuzzi and Sansò, 2002; Ota and Yamaguchi, 2004). A further challenge represents the comparative analysis of the neotectonic shoreline displacement for deposits of contrasting ages for many localities.

4. Refinements in Quaternary geochronology

Studies of coastal evolution and relative sea-level changes increasingly demand refinements in Quaternary geochronological methods, particularly in terms of dating materials of smaller sample mass and with greater age resolving power. Thus, an inherent aspect of Project 437 was the continued refinement of geochronological methods. Project 437 also re-emphasized the need for applying multiple geochronological methods to specific field contexts to assist with data validation (Schellmann et al., 2004). With increasing demands to resolve palaeoenvironmental questions at the centennial and millennial scale, pressure will intensify on further refining Quaternary geochronological methods. The ability to date single foraminifera and ostracods by amino acid racemization, using Reverse Phase-HPLC (Kaufman, 2000) or molluscs by uranium-series disequilibrium using laser ablation ICP-MS (Eggins et al., in press) represent examples of recent advances in this direction.

5. Refinements in the definition of palaeosea-level indicators

Not surprisingly, accurate determination of former sea levels in the geological record requires sea-level proxies that are quantifiable with respect to palaeotidal datum. Considerable effort was undertaken in Project 437 to quantify palaeosea-level indicators based on the study of fossil faunal assemblages from a range of sedimentary environments and contrasting geographical settings. The development of more reliable transfer functions, for example, was undertaken for testate amoebae (modern and fossil; Charman et al., 2002; Roe et al., 2002), and foraminifera (Cann et al., 2000; Lloyd and Evans, 2002). Another approach for identifying former sea-level exploits geomorphological features such as shoreline notches and submerged speleothems (Antonioli et al., 2001; Bard et al., 2002) as well as archaeological data (e.g. wells and harbour structures) (Sivan et al., 2001; Morhange et al., 2001).

6. Extreme events and coastal hazards

In recent years there has been an increasing appreciation of the geomorphological significance and the historical legacy of extreme events. The geological significance of high magnitude storm events and tsunami have been increasingly recognized for the imprints that they leave in the stratigraphical record and in coastal landscapes (Bryant, 2001; Gianfreda et al., 2001; Keating and Helsley, 2002; Luque et al., 2002; Chagué-Goff et al., 2002; Mastronuzzi and Sansò, 2004; Scheffers, 2004; Smith et al., 2004). Recognition of the importance of extreme events has again served to refocus our understanding of uniformitarianism in that, in its strictest sense, and as originally intended by Lyell, is not simply gradualism, and that high magnitude, episodic events (in human terms) are very much a part of the geological record.

The papers presented in this issue highlight the diversity of research undertaken under the auspices of IGCP Project 437. Lambeck and Purcell (2005) present model predictions of sea-level changes since the Last Glacial Maximum for parts of the Mediterranean Basin. Pirazzoli (2005) summarizes empirical evidence for relative sea-level changes from the same region and evaluates possible eustatic, isostatic and tectonic contributions for the late Holocene.

Four papers focus on the theme of methods for sea-level analysis in different coastal and tectonic settings. Patterson et al. (2005) examine the application of foraminifera, diatoms and macrophytes as high-resolution indicators of sea-level changes based on a case study in British Columbia, Canada. Wilson et al. (2005) illustrate the potential of $\delta^{13}C$ and C/N analyses in palaeoenvironmental studies of the Mersey Estuary, UK. Roe and Van de Plassche (2005) explore the implications of modern pollen distributions in actualistic interpretations of palaeosea level. Hamilton et al. (2005) present evidence for five possible great earthquakes during the past 2500 years at Anchorage, Alaska and the problems of earthquake correlation and reconstruction based on radiocarbon ages and diatom stratigraphy.

On the theme of sea level and environmental changes, Carboni et al. (2005) attempt a palaeoclimatic reconstruction for the Late Quaternary based on evidence from a core from the Tyrrhenian Sea in the Mediterranean Basin, and Gehrels et al. (2005) explore the issue of recent, rapid sea-level rise as evidenced in the western Atlantic Ocean.

The final four papers deal with aspects of the geomorphological development of coastlines at various points in the sea-level cycle. Robustelli et al. (2005) examine the development of alluvial fan successions along the Tyrrhenian Sea coast of Calabria, southern Italy in response to tectonism and glacio-eustatic sea-level changes. In southern Calabria, Dumas et al. (2005) tackle the classical problem of inferring relative sea-level changes based on a detailed analysis of subtle contrasts in the elevation of marine terraces. Caldara and Simone (2005) attempt to unravel natural and human-induced environmental changes in the eastern Tavoliere Plain in Apulia, Italy, during the late Holocene and Baeteman (2005) examines the influence of subsoil morphology and erosional processes on the origin and morphological characteristics of late Holocene tidal channels of the Belgian coastal lowlands.

In summary, IGCP Project 437 proved very successful, particularly in generating opportunities for researchers to establish new collaborations and explore new dimensions of Quaternary coastal science that they had not previously considered. This special issue of *Quaternary Science Reviews*, in conjunction with special issues of other journals (*Sedimentary Geology*, 150, 1–2, 2002; *Journal of Quaternary Science*, 17, 5–6, 2002; *Marine Geology*, 194, 1–2, 2003; and *Quaternary International* 120, 1, 2004), attest to the collective enthusiasm of scientists committed to this project. It is to their continued commitment to Quaternary coastal science that we dedicate this special issue.

Acknowledgements

The efforts of many people have contributed to the success of IGCP Project 437, *Coastal Environmental Change During Sea-Level Highstands*. We acknowledge with gratitude funding from UNESCO and IUGS for IGCP Project 437 over the 5 years of the project (1999–2003). During the course of this project many people have worked assiduously, especially those who have hosted the project's annual international conferences. In particular, the following people are thanked for their respective international conference organization; Charles H. Fletcher III (Hawaii, 1999), Enrique J. Schnack (Patagonia, Argentina 2000); Ben Horton and Ian Shennan (England and Scotland, 2001); Ulrich Radtke and Gerhard Schellmann (Barbados, 2002) and Giuseppe Mastronuzzi and Paolo Sansò (Otranto—Taranto, Italy, 2003). Financial and other forms of in kind support for the final meeting of Project 437 in Italy were provided by the Italian Association of Physical Geography and Geomorphology, Italian Society of Environmental Geology, Dipartimento di Geologia e Geofisica, the Ph.D. School of Geomorphology and Environmental Dynamics and the Administration of the University of Bari and Dipartimento di Scienza dei Materiali, University of Lecce. The President of Regione Puglia, Mayors of Otranto, Taranto, Castri gnano del Capo, and Maruggio, the Dipartimento Militare Marittimo dello Jonio e del Canale d'Otranto, the Soprintendenza Archeologica della Puglia, the APT of Otranto, the Gruppo Speleologico Ndronico of Lecce, the Sud-Est Diving of Otranto. Finally, we express our gratitude to all the reviewers of the manuscripts published in this issue, and to all of the participants of the project since its inception.

References

Antonioli, F., Silenzi, S., Frisia, S., 2001. Tyrrhenian Holocene palaeoclimate trends from spelean serpulids. Quaternary Science Reviews 20, 1661–1670.

Baeteman, C., 2005. How Subsoil morphology and erodibility influence the origin and pattern of late Holocene tidal channels: case studies from the Belgian coastal lowlands. Quaternary Science Reviews, this issue, doi:10.1016/j.quascirev.2004.11.017.

Bard, E., Antonioli, F., Silensi, S., 2002. Sea level during the penultimate interglacial period based on a submerged stalagmite from Argentarola Cave (Italy). Earth and Planetary Science Letters 196, 135–146.

Battiau-Queney, Y., Billet, J.F., Chaverot, S., Lanoy-Ratel, P., 2003. Recent shoreline mobility and geomorphologic evolution of macrotidal sandy beaches in the north of France. Marine Geology 194, 31–45.

Bryant, E., 2001. Tsunami—The Underrated Hazard. Cambridge University Press, Cambridge 320pp.

Burke, K., Francis, P., Wells, G., 1990. Importance of the geological record in understanding global change. Palaeogeography, Palaeoclimatology, Palaeoecology (Global and Planetary Change Section) 89, 193–204.

Calanchi, N., Lucchi, F., Pirazzoli, P.A., Romagnoli, C., Tranne, C.A., Radtke, U., Reyss, J.L., Rossi, P.L., 2002. Late Quaternary relative sea-level changes and vertical movements at Lipari (Aeolian Islands). Journal of Quaternary Science 17, 459–467.

Caldara, M., Simone, O., 2005. Coastal changes in the eastern Tavoliere Plain (Apulia, Italy) during the Late Holocene: natural or anthropogenic? Quaternary Science Reviews, this issue, doi:10.1016/j.quascirev.2004.08.024.

Cann, J.H., Belperio, A.P., Murray-Wallace, C.V., 2000. Late Quaternary palaeosealevels and palaeoenvironments inferred from foraminifera, northern Spencer Gulf, South Australia. Journal of Foraminiferal Research 30, 29–53.

Carboni, M.G., Bergamin, L., Di Bella, L., Landini, B., Manfra, L., Vesica, P., 2005. Late Quaternary paleoclimatic and paleoenvironmental changes in the Tyrrhenian Sea. Quaternary Science Reviews, this issue, doi:10.1016/j.quascirev.2004.09.009.

Chagué-Goff, C., Dawson, S., Goff, J.R., Zachariassen, J., Berryman, K.R., Garnett, D.L., Waldron, H.M., Mildenhall, D.C., 2002. A tsunami (ca. 6300 years BP) and other Holocene environmental changes, northern Hawke's Bay, New Zealand. Sedimentary Geology 150, 89–102.

Chappell, J., Omura, A., Esat, T., McCulloch, M., Pandolfi, J., Ota, Y., Pillans, B., 1996. Reconciliation of late Quaternary sea levels derived from coral terraces at Huon Peninsula with deep sea oxygen isotope records. Earth and Planetary Science Letters 141, 227–236.

Charman, D.J., Roe, H.M., Gehrels, W.R., 2002. Modern distribution of saltmarsh testate amoebae: regional variability of zonation and response to environmental variables. Journal of Quaternary Science 17, 387–409.

Cowell, P.J., Thom, B.G., 1994. Morphodynamics of coastal evolution. In: Carter, R.W.G., Woodroffe, C.D. (Eds.), Coastal Evolution: Late Quaternary Shoreline Morphodynamics. Cambridge University Press, UK, pp. 33–86.

DeDiego-Forbis, T., Douglas, R., Gorsline, D., Nava-Sanchez, E., Mack, L., Banner, J., 2004. Late Pleistocene (Last Interglacial) terrace deposits, Bahia Coyote, Baja California Sur, México. Quaternary International 120, 29–40.

Dumas, B., Raffy, J., Guéremy, P., 2005. Evidence for sea-level oscillations by the "characteristic thickness" of marine deposits from raised terraces of southern Calabria (Italy). Quaternary Science Reviews, this issue, doi:10.1016/j.quascirev.2004.12.011.

Eggins, S., Grün, R., McCulloch, M., Pike, A., Chappell, J., Kinsley, L., Shelley, M., Murray-Wallace, C.V., Taylor, C.S.L., in press. In situ U-series dating by laser-ablation multi-collector ICPMS: new prospects for Quaternary geochronology. Quaternary Science Reviews, in press.

Eisenhauer, A., Zhu, Z.R., Collins, L.B., Wyrwoll, K.-H., Eichstät, R., 1996. The last interglacial sea level change: new evidence from the Abrolhos Islands. Geologische Rundschau 40, 39–50.

Gehrels, W.R., Kirby, J.R., Prokoph, A., Newham, R.M., Achterberg, E.P., Evans, H., Black, S., Scott, D.B., 2005. Onset of recent rapid sea-level rise in the western Atlantic Ocean. Quaternary Science Reviews, this issue, doi:10.1016/j.quascirev.2004.11.016.

Gianfreda, F., Mastronuzzi, G., Sansò, 2001. Impact of historical tsunamis on a sandy coastal barrier: an example from the northern Gargano coast, southern Italy. Natural Hazard and Earth System Sciences 1, 213–219.

Goodwin, I.D., 2003. Unravelling climatic influences on Late Holocene sea-level variability. In: Mackay, A., Battarbee, R., Birks, J., Oldfield, F. (Eds.), Global Change in the Holocene. Arnold, London, pp. 406–421.

Hamilton, S., Shennan, I., Combellick, R., Mulholland, J., Noble, C., 2005. Evidence for two great earthquakes at Anchorage, Alaska and implications for multiple earthquakes through the Holocene. Quaternary Science Reviews, this issue, doi:10.1016/j.quascirev.2004.07.027.

Haworth, R.J., Baker, R.G.V., Flood, P.G., 2002. Predicted and observed Holocene sea-levels on the Australian coast: what do they indicate about hydro-isostatic models in far field sites? Journal of Quaternary Science 17, 581–591.

Kaufman, D.S., 2000. Amino acid racemization in ostracodes. In: Goodfriend, G.A., Collins, M.J., Fogel, M.L., Macko, S.A., Wehmiller, J.F. (Eds.), Perspectives in Amino Acid and Protein Geochemistry. Oxford University Press, New York, pp. 145–160.

Keating, B.H., Helsley, C.E., 2002. The ancient shorelines of Lanai, Hawaii, revisited. Sedimentary Geology 150, 3–15.

Kukla, G., McManus, J.F., Rousseau, D.-D., Chuine, I., 1997. How long and stable was the last interglacial? Quaternary Science Reviews 16, 605–612.

Lambeck, K., 1990. Late Pleistocene, Holocene and present sea-levels: constraints on future change. Palaeogeography, Palaeoclimatology, Palaeoecology (Global and Planetary Change Section) 89, 205–217.

Lambeck, K., Purcell, A., 2005. Sea-level change in the Mediterranean Sea since the LGM: Model predictions for tectonically stable areas. Quaternary Science Reviews, this issue, doi:10.1016/j.quascirev.2004.06.025.

Lloyd, J.M., Evans, J.R., 2002. Contemporary and fossil foraminifera from isolation basins in northwest Scotland. Journal of Quaternary Science 17, 431–443.

Lowe, J.J., Walker, M.J.C., 1997. Reconstructing Quaternary Environments. 2nd ed. Longman, London 446pp.

Luque, L., Lario, J., Civis, J., Silva, P.G., Zazo, C., Goy, J.L., Dabrio, C.J., 2002. Sedimentary record of a tsunami during Roman times, Bay of Cadiz, Spain. Journal of Quaternary Science 17, 623–631.

Mastronuzzi, G., Sansò, P., 2002. Holocene uplift rates and historical rapid sea-level changes at the Gargano promontory, Italy. Journal of Quaternary Science 17, 593–606.

Mastronuzzi, G., Sansò, P., 2004. Large boulder accumulations by extreme waves along the Adriatic coast of southern Apulia (Italy). Quaternary International 120, 173–184.

Mitrovica, J.X., Milne, G.A., 2002. On the origin of late Holocene sea-level highstands within equatorial ocean basins. Quaternary Science Reviews 21, 2179–2190.

Morhange, C., Laborel, J., Hesnard, A., 2001. Changes of relative sea level during the past 5000 years in the ancient harbour of Marseilles, southern France. Palaeogeography, Palaeoclimatology, Palaeoecology 166, 319–329.

Murray-Wallace, C.V., 2002. Pleistocene coastal stratigraphy, sea-level highstands and neotectonism of the southern Australian passive continental margin—a review. Journal of Quaternary Science 17, 469–489.

Ota, Y., Yamaguchi, M., 2004. Holocene coastal uplift in the western Pacific Rim in the context of late Quaternary uplift. Quaternary International 120, 105–117.

Patterson, R.T., Dalby, A.P., Roe, H.M., Guilbault, J.P., Hutchinson, I., Clague, J.J., 2005. Relative utility of foraminifera, diatoms and macrophytes as high resolution indicators of paleo-sea level in coastal British Columbia, Canada. Quaternary Science Reviews, this issue, doi:10.1016/j.quascirev.2004.11.013.

Peltier, W.R., 2002. Global glacial isostatic adjustment: palaeogeodetic and space-geodetic tests of the ICE-4G (VM2) model. Journal of Quaternary Science 17, 491–510.

Pirazzoli, P.A., 2005. A review of possible eustatic, isostatic and tectonic contributions in eight late-Holocene relative sea-level histories from the Mediterranean area. Quaternary Science Reviews, this issue, doi:10.1016/j.quascirev.2004.06.026.

Regnauld, H., Louboutin, R., 2002. Variability of sediment transport in beach and coastal dune environments, Brittany, France. Sedimentary Geology 150, 17–29.

Robustelli, G., Muto, F., Scarciglia, F., Spina, V., Critelli, S., 2005. Eustatic and tectonic control on Late Quaternary alluvial fans along the Tyrrhenian Sea of Calabria (South Italy). Quaternary Science Reviews, this issue, doi:10.1016/j.quascirev.2004.08.025.

Roe, H.M., Charman, D.J., Gehrels, W.R., 2002. Fossil testate amoebae in coastal deposits in the UK: implications for studies of sea-level change. Journal of Quaternary Science 17, 411–429.

Roe, H.M., Van de Plassche, O., 2005. Modern pollen distribution in a Connecticut saltmarsh: implications for studies of sea-level change. Quaternary Science Reviews, this issue, doi:10.1016/j.quascirev.2004.11.015.

Ruddiman, W.F., Vavrus, S.J., Kutzbach, J.E., 2005. A test of the overdue-glaciation hypothesis. Quaternary Science Reviews 24, 1–10.

Sasaki, K., Omura, A., Murakami, K., Sagawa, N., Nakamori, T., 2004. Interstadial coral reef terraces and relative sea-level changes during marine oxygen isotope stages 3-4, Kikai Island, central Ryukyus, Japan. Quaternary International 120, 51–64.

Scheffers, A., 2004. Tsunami imprints on the Leeward Netherlands Antilles (Aruba, Curaçao, Bonaire) and their relation to other coastal problems. Quaternary International 120, 163–172.

Schellmann, G., Radtke, U., Potter, E.-K., Esat, T.M., McCulloch, M.T., 2004. Comparison of ESR and TIMS U/Th dating of marine isotope stage (MIS) 5e, 5c and 5a coral from Barbados—implications for palaeo sea-level changes in the Caribbean. Quaternary International 120, 41–50.

Schwarzer, K., Diesing, M., Larson, M., Niedermeyer, R.-O., Schumacher, W., Furmanczyk, K., 2003. Coastline evolution at different time scales—examples from the Pomeranian Bight, southern Baltic Sea. Marine Geology 194, 79–101.

Shennan, I., Horton, B., 2002. Holocene land- and sea-level changes in Great Britain. Journal of Quaternary Science 17, 511–526.

Sivan, D., Wdowinski, S., Lambeck, K., Galili, E., Raban, A., 2001. Holocene sea-level changes along the Mediterranean coast of Israel, based on archaeological observations and numerical model. Palaeogeography, Palaeoclimatology, Palaeoecology 167, 101–117.

Smith, D.E., Shi, S., Cullingford, R.A., Dawson, A.G., Dawson, S., Firth, C.R., Foster, I.D.L., Fretwell, P.T., Haggart, B.A., Holloway, L.K., Long, D., 2004. The Holocene Storegga Slide tsunami in the United Kingdom. Quaternary Science Reviews 23, 2291–2321.

Stirling, C.H., Esat, T.M., McCulloch, M.T., Lambeck, K., 1995. High-precision U-series dating of corals from Western Australia and implications for the timing and duration of the Last Interglacial. Earth and Planetary Science Letters 135, 115–130.

Wilson, G.P., Lamb, A.L., Leng, M.J., Gonzales, S., Huddart, D., 2005. $\delta^{13}C$ and C/N as potential coastal palaeoenvironmental indicators in the Mersey Estuary, UK. Quaternary Science Reviews, this issue, doi:10.1016/j.quascirev.2004.11.014.

Winograd, I.J., Landwehr, J.M., Ludwig, K.R., Coplen, T.B., Riggs, A.C., 1997. Duration and structure of the past four interglaciations. Quaternary Research 48, 141–154.

Zhu, Z.R., Wyrwoll, K.-H., Collins, L.B., Chen, J.H., Wasserburg, G.J., Eisenhauer, A., 1993. High-precision U-series dating of Last Interglacial events by mass spectrometry: Houtman Abrolhos Islands, Western Australia. Earth and Planetary Science Letters 118, 281–293.

Giuseppe Mastronuzzi
Dipartimento di Geologia e Geofisica, Università di Bari, Italy

Paolo Sansò
Dipartimeno di Scienza de Materiali, Università di Lecce, Italy

Colin V. Murray-Wallace*
School of Earth and Environmental Sciences, University of Wollongong, NSW, 2522, Australia
E-mail address: colin_murray-wallace@uow.edu.au

Ian Shennan
Department of Geography, University of Durham, Durham, DH1 3LE, UK

*Corresponding author. Tel.: +61 2 4221 4419; fax: +61 2 4221 4250.