S3.1 Natural hazards, sea level rise and coastal erosion

22 May, 08:30 (S3.1-4962) Plenary
Can we quantify the risk of large increases in sea level extremes?

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The impacts of future increases in sea level are potentially large and very costly. We assess the latest projections of 21st century sea level, focusing on results from the recent IPCC 4th assessment and new results produced by the Met Office Hadley Centre and the Proudman Oceanographic Laboratory. For time-average regional sea level we consider changes in ocean circulation and density, and the contribution from ice melt. For temporal extremes of sea level we also include the effects of changes in atmospheric storminess, using the impact on the European coastline as a case study. We conclude that whilst improvements in modelling techniques have led to a better understanding of some of the components of future sea level change there still remains considerable uncertainty. This is especially true for both the magnitude and risk of the physically plausible upper limit of 21st century sea level rise.

22 May, 10:35 (S3.1-4964) Invited
Coastal erosion under changing climates

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As a direct hazard to society, the problem of coastal erosion is seen as significantly smaller than that of coastal flooding - particularly in relation to increased sea level rise arising from global warming. However, we ignore the dynamics of erosion, and disconnect these from those of flooding at our peril. Recent decades have highlighted the importance of natural systems, which include mobile sediments and physical barriers, such as reefs, within soft coastal defence schemes. Such schemes are being seen as increasingly cost-effective under regimes of rapid environmental change, though the evolution and preservation of coastal barriers are themselves very vulnerable to erosion under high rates of climate change. Inherent uncertainties exist in the complex interrelationships between coastal management practices and natural systems; the linkage between these and societal impact needs to be understood on a wide range of scales. Future coastal zone management requires much greater interaction between scientists and decision-makers than in the past, and a shifting of research priorities. The focus of natural scientists should increasingly be on how coasts respond to storms – a subject that has been substantially neglected because of high observational costs and event infrequency. Similarly, social scientists need to address the valuation of coastal resources, ownership and population migration over short timescales – commonly somewhat subjective subjects with limited acceptance. The coastal erosion issues discussed will be illustrated using several examples that demonstrate also the extent of the challenges scientists and managers face in minimising societal costs of future coastal change.

22 May, 11:00 (S3.1-4799) Invited
Storm surges, perspectives and options

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This review paper attempts to summarise the scattered and fragmented knowledge about past and possible future changing storm surge statistics – with using the particularly well studied case of the North Sea as an example. For this region, a complete and robust analysis methodology has been developed in the past years. This methodology

is based on dynamical and statistical models. Using the concept of dynamical downscaling, the development during the past decades, when sufficiently good and homogeneous weather data exist, has been "reconstructed", and scenarios of possible future change are described. A "localisation" allows us to estimate changes at specific sites, e.g. harbours. Since local water level statistics do depend not only on climate variations but also on local modifications of the local bathymetry, new options for adaptation emerge. For the case of Hamburg, an option for such future adaptations are discussed.

22 May, 11:25 (S3.1-4592)

Improved ocean-warming estimates: implications for climate models and sea-level rise

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Changes in the climate system's energy budget are predominantly revealed in ocean temperatures and the associated thermal expansion contribution to sea-level rise. However, climate models do not reproduce the large decadal variability in globally-averaged ocean heat content inferred from the sparse hydrographic data set, even when volcanic and other variable climate forcings are included. Also, the sum of the observed contributions to sea-level rise has not adequately explained the historical rise. Here, we report improved estimates of near-global ocean heat content and thermal expansion for the upper 700 m of the ocean for 1950 to 2003, using a reconstruction method that allows for sparse data coverage and applying recent corrections to reduce systematic errors in the most common ocean temperature observations. Our linear trend in ocean heat content (thermal expansion) corresponds to an air-sea flux of 0.35 ± 0.08 W m^{-2} (0.52 ± 0.10 mm yr^{-1}) for 1961 to 2003, and 0.37 ± 0.28 W m^{-2} (0.80 ± 0.39 mm yr^{-1}) for 1993 to 2003, over the ocean surface area considered (3.3 x 10^{14} m^2). Compared to earlier estimates, our rates are about 50% larger for the historical period but about 40% smaller for the recent period, consistent with the recognition that previously estimated rates for the 1990s were biased high by instrumental errors. On average, the decadal variability of the climate models with volcanic forcing now agrees approximately with the observations but the multidecadal trends are smaller than observed. We add our observational estimates of upper ocean thermal expansion to other contributions to sea-level rise and find that the sum of contributions from 1961 to 2003 is about 1.5 ± 0.4 mm yr^{-1}, in good agreement with our updated estimate of near-global mean sea level of 1.6 ± 0.2 mm yr^{-1}.

22 May, 11:40 (S3.1-4553)

Two hundred years of sea-level rise reconstruction by combining instrumental and geological data from the southern Bay of Biscay

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Current concerns regarding global sea-level rise associated with anthropogenic warming of the atmosphere and oceans and its impact on coastal resources have increased the interest in past sea-level changes. The mean global rate of sea-level (RSL) rise has been estimated at ~1.8 mm/yr for the last century, while satellite altimetry data provide new estimates of ~3 mm/yr. Proxy records from salt marshes around the North Atlantic Ocean have provided indications that modern rates of sea-level rise (last ~100 years) may be more rapid than the rate of rise in preceding centuries, and that the timing of this acceleration may be indicative of a link with human-induced climate change. So far, these high resolution sea-level reconstructions have only come from the northwestern North Atlantic. This contribution seeks to address this knowledge gap by combining tide-gauge and high-precision foraminifera-based transfer function reconstructions of RSL for the southern Bay of Biscay. We have produced three transfer functions with a precision of between 0.19-0.11 m. We placed the foraminifera-based prediction of palaeomarsh elevation into a temporal framework through the ^{137}Cs, Pb concentrations, and ^{210}Pb-derived sediment accumulation rates. The resulting relative sea-level reconstructions imply a sea-level rise of 22±4 cm

in this geographical area for the 20th century, which is in general agreement with the local tide-gauge records and the long-term regional gauge from Brest. In a region where sea-level data are very scarce even for the second half of the 20th century, this study offers an alternative method to reconstruct former sea levels.

22 May, 11:55 (S3.1-4546)

The VANIMEDAT project: decadal and interdecadal sea-level variability in the Mediterranean Sea and the northeastern sector of the Atlantic Ocean

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We present a review of the results obtained in the framework of VANIMEDAT, a 3-year project funded by the Spanish Marine Science and Technology Programme. The main aim of the project is the study of the decadal and interdecadal sea-level variability of the Mediterranean Sea and the Atlantic sector surrounding the Iberian Peninsula. The results presented here will cover: 1) The consistency between the two major sea-level data sets: tide gauge records and altimetry. A key issue has been to evaluate the differences between both data sets and to determine whether they are due to the different observational techniques, to actual differences between coastal and open-sea level or to both. As an application, we will present a reconstruction of Mediterranean sea level that covers the last decades of the 20th century. 2) Sea level trends, paying special attention to the quantification of the sea-level response to the different forcings (atmospheric pressure and wind, heat fluxes and the mass budget); in particular, we will show that the response to the atmospheric forcing, which has a zero-trend at a global scale, has been one of the major contributions to Mediterranean sea-level trends in the last decades of the 20th century. 3) The computation of sea level from baroclinic model runs; in particular we will focus on the evaluation of the steric component of sea-level variability from long-term regional hindcasts and from future climate scenarios.

22 May, 12:10 (S3.1-4662)

Recovery of sea level fields of the last decades from altimetry and tide gauge data

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Sea-level observations spanning several decades (tide gauge series) only cover the shores, while sea-level observations covering the whole ocean extension (altimetry series) only span the last decade and a half. We have reconstructed the monthly distribution of sea-level in the Mediterranean Sea and the north-eastern sector of the Atlantic Ocean from altimetry and tide gauge data for the period between 1969 and 2000. To carry out the reconstruction two methodologies have been used, both of them based on a principal component analysis. The first methodology consists of a principal component regression of the amplitudes obtained from satellite altimetry and on the ones from tide gauges, while the second substitutes the leading amplitudes obtained from altimetry by the ones from tide gauges in its singular value decomposition. In order to characterise the goodness of the reconstruction and the sensitivity of the methodology we have used two parameters: correlation and relative root mean square error of the time series predicted by the reconstruction and the values actually observed. Results show that the reconstruction carried out by the second methodology gives better results, moreover it is less sensitive to the number of tide gauges used for the analysis. The reconstruction is accurate along the whole north coast of the Mediterranean Sea and along the Iberian Peninsula coast, with correlations higher than 0.8 and relative root mean square errors lower than 0.45. The lowest correlations were found in the Algerian Basin, the Atlantic coast of Morocco and the south-eastern region of the Mediterranean Sea, which is related to the fact that most tide gauges are located in the northern region of the Mediterranean Sea.

22 May, 12:25 (S3.1-4559)

Sea level change and extreme events in the Mediterranean Sea

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Extreme sea levels pose significant threats to the coastal environment. The occurrence of extreme events results from the combination of various factors, primarily extreme storm events coupled with high tides and increased mean sea levels. Climate models are considered as reasonably capable to project global mean sea level changes from thermal expansion and circulation changes but neither them nor the atmospheric models, whether global or regional, are considered capable of assessing the modifications caused by climate change to the upper tail of the sea level or storm surge distribution with a reliably quantified uncertainty. Thus coupling the extreme distributions of sea level with the mean sea level changes under climate change scenarios provide a reasonable assessment of risk under climate change. In this work, we first present the results of the analysis of tide gauge stations around the Mediterranean Sea spanning several decades, in combination with the output of a barotropic model of the area forced by atmospheric pressure and wind, in order to investigate the temporal and spatial distribution as well as the forcing of sea level extremes. The anticipated changes in regional mean sea level under global warming scenarios are then added to the obtained return levels from observations to obtain return periods for sea level extremes around the basin. These climate change projections are based on the Atmosphere-Ocean General Circulation Models (AOGCMs) produced for the IPCC 4AR.

22 May, 12:40 (S3.1-4573)

Sea level trend in Gulf of Thailand using satellite altimetry data

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Sea level change is an index of global change, especially global warming. Global sea level is rising at 1.8 mm/yr (IPCC, 2007), but few studies have been conducted regarding local sea level change and there is virtually no systematic study in the Gulf of Thailand. The objective of this research is to determine the rate of sea level change in the Gulf of Thailand using satellite altimetry data in proximity to three tide gauge stations of the Hydrographic Department, Royal Thai Navy, namely Sattahip station in Chonburi province, Ko Lak station in Prachubkhirikhun province and Ko Mattaphon station in Chumporn province and one station from the Port Authority of Thailand namely, Ko Sichang in Chonburi province. Analysis of satellite altimetry data yield the rising rate between 1.1 - 2.1 mm/yr which is higher than the rate calculated from tide gauge data (0.22 - 0.81 mm/yr). The results indicate the need for further investigation of local factors before actual rate of sea level change in the Gulf of Thailand can be determined.

22 May, 12:55 (S3.1-4758)

An analysis of Brazilian coastal erosion

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Recognised as critical areas as regards climate change, beaches are some the planet's most complex and vulnerable environments. Currently, one of the most frequently observed phenomena is coastal erosion, whose magnitude and importance are further stressed by the increased occupation of the seashore and its inherent relation with the Earth's climate changes. Brazil's coast, which is about 8,500 kilometres long, is a permanent management challenge, due to the diversity of existing situations. Every policy aimed at managing the seashore must take into account the understanding that, when not rocky, the coastal area is subject to spatial changes in the short term, as this dynamic environment is directly influenced by waves and currents. This powerful dynamic is also related

to anthropogenic processes which worsen erosion effects, giving the coast certain peculiarities which require permanent efforts to keep its dynamic balance. The Brazilian Ministry of the Environment has given special attention to this matter, and the first diagnostic results on the country's current situation were published in a book entitled *Erosão e Progradação do Litoral Brasileiro* (Erosion and Progradation of the Brazilian Coast), which identified risk areas (some 40% of the Brazilian shore) and aimed to create monitoring strategies and identify causes.

22 May, 14:30 (S3.1-4588)

Forecasting the seasonal to interannual variability of extreme sea levels

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In this work, an emerging methodology for quantifying time variations on extreme sea levels is developed. The proposed statistical model is able to short-term predict the probability density function of extreme sea levels. The model uses a time-dependent generalised extreme value distribution (GEV) to fit monthly maxima series and is applied to different tide gauges in the Pacific and in the Atlantic Ocean, showing different behaviour in agreement with the different dynamics that affect every basin. The model allows the identification and estimation of the effects of several time scales - such as seasonality, interdecadal variability and secular trends - on the location, scale and shape parameters of the probability distribution of extreme sea levels. These factors are parameterised as functions of time (linear, quadratic, exponential and cosine functions) or covariates (for instance, the SOI or NAO index), automatically obtaining the best model that explains the data variability sufficiently well. Significant influences with the nodal cycle, as well as with regional climate indices have been detected. Results show that the model is adequate to carry out a rigorous analysis of seasonal-to-interannual sea level extremes providing time-dependent quantiles and confidence intervals. The modelling of the different time scales helps to achieve a better understanding of recent secular trends for the extreme climate events and to predict in the short-term (for example in the next 12 months) the probability of a given sea level.

22 May, 14:45 (S3.1-4895)

Interannual variability and recent increase in the summertime significant wave heights in the western North Pacific

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We investigate the relationship among the summer (June-August) mean of the monthly 90th percentile of significant wave heights (H90) in the western North Pacific (WNP), tropical cyclone activity and climate change in the tropical Pacific. The most prevailing interannual variability of H90 is identified by applying an Empirical Orthogonal Function analysis to H90 obtained from the ERA-40 wave reanalysis as well as from the optimally interpolated TOPEX/Poseidon (OITP) wave data. It is found that the increase of H90 is correlated with cyclonic surface wind anomalies in the WNP which links with warm SST anomalies in the Nino-3.4 region during the ENSO developing years. In particular, the first principal component (PC1) of H90 is found to be closely related to the zonal anomaly averaged over the region 5°N-15°N and 130°E-160°E (U10N). The positive U10N anomaly may be associated with an eastward extension of the monsoon trough off the east coast of the Philippines, which causes an eastward shift of TC occurrence. In fact, the mean position of TC occurrence during the typical seven high wave years shifts southeastward compared to that during the typical seven low wave years, so that TCs further develop while travelling longer distances until they encounter the continent or cool mid-latitude water. We also present a recent increase in the summertime significant wave heights in the WNP by using ERA-40 wave reanalysis as well as hindcast wave data obtained by driving a wave model with surface winds of the NCEP/NCAR reanalysis.

22 May, 15:00 (S3.1-4557)

Quantification of climate change impacts on hurricane flooding

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Reliable assessment of coastal flooding risk resulting from severe weather events, such as hurricanes, is essential when designing to protect communities and infrastructure against storm damage. However, the influence of climate change on flooding prediction is not well understood at present. Climate change may influence the risk of coastal flooding by changes in sea level and storm intensity. Historical trends in sea level are well documented, and indicate a sea level rise in many coastal communities worldwide, and many hypothesize that global warming will increase the intensity of tropical storms. Thus, it is prudent to consider the risk associated with such phenomena when assessing coastal flooding and damage risk. We conducted a case study for Corpus Christi, Texas, USA to demonstrate the impacts of climate change on coastal flooding. In our analysis, both sea level rise and hurricane intensification were considered. For this site, storm surge numerical simulations were carried out for three historical storms. Subsequent surge simulations due to future hurricane intensification were conducted by modifying the historical storms according to intensification predictions based on projected sea surface temperature rise. These simulations indicate that flood levels due to hurricane intensification increase linearly at a rate of 6 to 20 percent per degree of sea surface temperature rise, depending on geographic location. Our results present a means for quantifying the added flooding risk due to climate change and have the potential for wide-reaching impact on future community planning and engineering design to protect against climate change effects.

22 May, 15:15 (S3.1-4825)

Growing intensification of landfalling typhoon at higher latitude

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Tropical cyclone (TC) best track data from the Joint Typhoon Warning Center (JTWC) and the Regional Specialized Meteorological Center (RSMC) during 1975-2005 have been analysed to investigate long-term intensity variation of typhoons making landfall over the East Asian countries. It is found that the intensity changes for landfalling TCs over 36 years are different according to country and latitude. At higher latitude, a larger intensification of TC is found during the 36 years. Korea is located at a mid latitude above 33°N and shows the most rapid intensification, while low-latitude countries in Asia show little intensification (in JTWC data) or even weakening (in RSMC). This demonstrates that higher-latitude countries in Asia are more influenced by the growing intensification of TC. Possible explanations will be suggested.

22 May, 15:30 (S3.1-4829)

Contribution of remote sensing data to ocean hazards monitoring and emergency system development

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One of the problems in creating an operational integrated space-based ocean hazards monitoring and emergency system is an absence of various pilot researches to develop methodological principles and unified algorithm of monitoring on an international level. To contribute to this need a pilot research on sea surface monitoring in the Black Seas was conducted. The objectives of the research were to: specify of the remote sensing needs for space-based monitoring of the sea surface and approbate available satellite images for marine researches in the context of climate change monitoring. ENVISAT and ERS-2 Synthetic Aperture Radar (SAR) images with a resolution of 25-12 m were selected as a basis. SAR images do not depend on cloud coverage, season or daytime;

which is important for operational use. Detecting the surface structure, SAR images can be useful for monitoring such ocean and marine phenomena, as atmospheric fronts, wind shadows, currents, calm zones, rain, topography, sewerage discharges, oil pollution, ice and internal waves. The same SAR images have crucial restrictions such as wind speed 2-14 m/s, and image operator experience. ENVISAT MERIS and AVHRR (NOAA) images together with SeaWIFS data were selected as reference data. That allowed us to study complex information, such as, temperature sea surface water, concentration of chlorophyll, marine flows and meteorological parameters. The strongest limitation of the specified data is a low spatial resolution. As a result, the recommendations for the monitoring system and Common Operative Picture development for the Ministry of Ukraine of Emergencies were conducted.

22 May, 15:45 (S3.1-4554)

The Ebro delta coastal response during 2001-2004: a proxy of the potential effects of an increase in storminess

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One of the potential effects of climate change in our coasts is the increase in wave storminess. This should produce an increase in the frequency and intensity of erosive events in sensitive coastal zones. The Ebro delta coast (NE Spanish Mediterranean) provides an excellent "test case" to learn in an anticipated manner these consequences because it is composed of an unprotected and highly dynamic wave-dominated coastline. From analysis of storm-induced processes on the Ebro coast since 1990, it has been detected that most of the reported problems (affecting the hinterland by inundation and/or impulsive coastal erosion of a very large magnitude) were clustered, with most events occurring from 2001 to 2004. From analysis of existing wave time series in the area, this period can be classified as "stormy" (storms' frequency and intensity exceed those of "normal" years). To assess the importance of the contribution of this temporal increase in storminess to the long-term deltaic evolution, the coastal response during these three years has been characterised and compared with that calculated over a period of 4 decades. The two considered storm-induced processes are shoreline retreat and overwash transport. Results show that the magnitude of these processes during this period clearly exceeds long-term rates, with contributions in some areas up to the equivalent of 2 decades under normal conditions. With the results, the deltaic evolution under an increase in storminess scenario can be assessed and, especially sensitive areas could be easily identified in space and time.

22 May, 16:00 (S3.1-4587)

A methodology to evaluate the impacts of climate change in a coastal system

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In this work, a global frame for the determination of the impacts of climate change in a certain coastal area (beach, estuary, port, etc) is developed. Usually, relative sea level rise is the only variable that is considered to affect the coast. However, recent studies have shown that the complete ocean dynamics must be considered as well. Climate change can affect wave climate and, consequently, can modify the intensity and frequency of extreme events (wave height and storm surge) and can modify the direction of wave energy. All of these likely long-term variations in coastal dynamics can produce an important impact in the coastal area. The steps of the methodology consists of (a) calibration of reanalysis databases; (b) classification of sea states; (c) deep water-to-shallow water propagation of the most representative sea states; (d) propagation of the complete series of sea states using an interpolation scheme; (e) characterisation of shallow water wave climate in the objective area; (f) determination of long-term changes in usual wave climate parameters (such as the 50-year return period wave height, the annual mean wave height, the mean energy flux direction, etc); and (g) calculation of the impacts on beaches (e.g. shoreline retreat, erosion rates, flooding risk increase), ports (e.g. changes in the operability and reliability of maritime works), and estuaries (e.g. long-term modifications of tidal flats and tidal inlet geometry). In the presentation, several examples will show the ability and generalisation of this methodology.

22 May, 16:15 (S3.1-4798)

Potential impacts of climate change on NW Portuguese coastal zones

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Coastal erosion is a common problem within Europe, which results from the dynamic nature of coastal zones, the anthropogenic influences, such as coastal interventions (defence and harbour structures), littoral occupation and river sediment supply reduction caused by dams, dredging and fluvial flow regularisation, and the effects of climate change. The present changes, which cause serious perturbations in the littoral drift system, are occurring at timescales that range from geological, like neotectonic events and sea level rise, to decadal. Climate change has possible effects on the wave climate (wave heights and directions) with direct implications for the potential alongshore transport. The likely increase of the occurrence of extreme events, the weakening of river sediment supply, and the generalised acceleration of sea level rise are also related to the coastal embayment's infilling, acting as sinks of sand, tend to aggravate the coastal erosion phenomenon in a time horizon of decades. Coastal dynamics and erosion processes may cause serious damage, especially to people and assets in urban fronts, and they therefore merit special attention. To minimise these impacts, it is necessary to understand the various processes involved and assess different scenarios for coastal evolution prediction (medium to long term), and assess how numerical models may be of some help. Maps representing vulnerability and risk to energetic environmental actions (waves, tides, winds and currents) are thought to be of high importance for coastal planning and management, rationalising decision making. In this paper, a numerical model will be used to assess potential impacts of climate change in vulnerable coastal zones from the Portuguese northwest coast.

22 May, 16:30 (S3.1-4902)

NW Iberian coastal current: a feature of extreme freshwater and wind conditions

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Buoyancy induced coastal currents are ubiquitous and recurrent, at least during part of the year, in areas where river runoff is significant. That is not the case of the western Iberian shelf where the average freshwater inflow in winter does not reach 1000 m^3/s. However, interannual variability is important and extreme situations are frequent. To help disclose the buoyancy conditions that could induce a coastal current, hydrographic (CTD) surveys were designed to cover the whole shelf area from the Douro River mouth to Cape Finisterre, in different runoff and wind forcing conditions during winter 2006 and 2007. An ADCP moored over the inner shelf north of the Douro mouth monitored the current. Tracking of drifters deployed inside the Douro estuary allowed us to evaluate the spatial coherence of the current field. The presence of estuarine induced buoyancy was evident in the hydrographic structures, but their modifications responded mainly to the wind. At a runoff level of around 600 m^3/s, a northward current was present only when southerlies blew, and buoyancy was too weak to counteract any wind reversal. Even at 1200 m^3/s, it was unclear whether or not the associated winds were playing a decisive role in sustaining the current. Drift tracks were internally consistent and compatible with the current measurements, pointing to a rather coherent current field over the inner shelf. These results suggest that very high river flow is required to sustain a coastal current, confirming the intermittent character of the current and pointing to its dependence on wind forcing.

S3.1 Posters

Poster S3.1-4550

Moving of the Togo shoreline detected by remote sensing: an example of coastal vulnerability to sea level rise

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This study on the continuous coastal erosion of Togo, especially in the 25 km coastal drift cell that is not protected by construction works, relies on the use of new shoreline measuring techniques. The methods used are basically geomatic. Two Landsat TM imageries of January 1986 and of ETM+ in April 2001 have been acquired and the data treated according to the diachronic method. The results from these analyses have been reinforced by the positioning of the shoreline carried out in 2003 through GPS FX 312. The analysis has been supported by monthly follow-ups surveying the sector situated between the port and the village of Afiadégnigba, a distance of 15 km. The results show a major retreat of the shoreline from continuing erosion at an average speed of 6 to 8 m per year. The results of these survey follow-ups proved the intensification of the sedimentary crisis, due not only to the progressive blockage towards the east of the sediment transfer in the profile by the beach-rock but, above all, to the draining of the sub-current sands deposits of the continental shelf. The construction of a series of short ridges does not reduce the problem. On the other hand, a breakwater added to the beach-rock and/or the covering of the beach by a lot of gabions associated with the beach-rock will be appropriate for the stabilisation of the shoreline and the only solution for resolving the problem of erosion.

Poster S3.1-4578

Using GIS for vulnerability assessment to climate change: a case study National Park of Banc d'Arguin (Mauritania)

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The National Park of Banc d'Arguin (PNBA) is considered as one of the main areas of reproduction and is a nursery for the west African birds and fishes. This significant biodiversity results from an exceptional wealth of waters. It comes from a combination of the submarine and emergent meadows which hide the bottom of the Gulf and a plankton biomass produced by the permanent upwelling. The coastal ecosystem of the PNBA is extremely vulnerable to many hazards both natural and artificial. Any attack to its ecological integrity should provoke an impoverishment of resources of the entire regional ecosystem. However, there is currently a gradual acceleration of environmental and human change on the marine environment. Climate change could cause a sedimentary blockage or a destabilisation of the shoreline and Gulf bottoms. It could stifle or alter the mechanisms of primary production and consequently biodiversity and resources. These changes should reinforce the agitation of the sea and induce the erosion. Climate change may lead to adverse impacts on marine mammals and sea birds, including migratory bird populations which risk losing their habitat in the islands due to the elevation of the sea level. Remote sensing and GIS are indispensable tools for risk assessment and decision support. This work is a contribution to the study of the degradation of the coastal environment of the PNBA. Satellite images are used and coupled with bathymetric and topographic maps to delimit the zones of risks in order to minimise or reduce the negative impact of this phenomenon.

Poster S3.1-4614

Torrential rains: using satellite-retrieved sea surface temperature as a forecast input data

Francisco Pastor, María J. Estrela, Javier Miró, Igor Gómez, Jose A. Valiente and Raquel **Niclòs**

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Sea surface temperature (SST) is a key factor in the development of torrential rains in the Spanish east coast and in the whole western Mediterranean Basin. It follows that information on the exact situation of SST fields can be useful in forecasting such torrential rain events. Currently, the only way to obtain an overall vision of the SST in the western Mediterranean Basin is by means of satellite images. We have thus used the longest available SST data series available obtained from satellite measurements, i.e. NOAA-AVHRR data ranging from 1985 to 2006. We have checked the CEAM climatic database for stations with daily rain values above 100 mm and then looked for the mean SST anomaly for the corresponding and previous months. In most cases, when rain measurements higher than 100 mm were recorded in at least one station in the Valencia region, the SST field showed positive anomalies with respect to the climate mean, pointing out a possible relation between the two variables.

Poster S3.1-4713

Toward future projections of wind and wave climate in the northwestern Pacific Ocean using three different regional climate models

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Nearshore areas in east Asia are threatened by high waves caused by tropical cyclones in summer and extra-tropical cyclones in winter. Projection of nearshore winds and waves under global warming conditions is crucial for structural measures such as tide walls based on the estimated high-water levels and non-structural measures such as insurance or evacuation based on high surf warning. To predict regional ocean surface waves, sea surface wind fields are required to drive wave models with the proper horizontal resolution. However, outputs of global warming experiments prepared for the Intergovernmental Panel on Climate Change (IPCC) future climate scenarios have not been systematically down-scaled with respect to the northwestern Pacific Ocean, so there are few projections for nearshore winds and waves in the basin. In 2007, the Ministry of the Environment, Japan started a new research project on a multi-model ensemble dynamical downscaling with respect to East Asia. The purpose of the research project is to describe regional future climate scenarios in East Asia (particularly Japan) using 3 different regional climate models to provide improved guidance to the policy community beyond simple global climate models. We introduce preliminary results about the regional wind and wave fields under present climate conditions using outputs of the regional climate simulations with the lateral boundary conditions of the JRA25 (Japanese Reanalysis 25-year).

Poster S3.1-4789

Predicting of coastal flooding in Latium coast (central Italy)

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Sea level rise scenarios indicate for the next decades an increasing flooding risk for many of the low-lying coastal regions. In this study, the evaluation of the coastal vulnerability was assessed along the southern Latium coast, in central Italy. The approach was based on the amount of relative sea level rise that will occur by the year 2050 and on the potential impacts of a 50-year design storm. The relative sea level rise scenarios take into account both climatic components (global eustatic response and thermal expansion; IPCC, 2007) and the geological vertical displacements (local or regional). The rates of local tectonic uplift were calculated by comparing geo-morphological field evidence with the predicted sea level rise curves obtained from the glacio-hydro-isostatic model, developed by Lambeck and co-authors for Italian coastal regions. The occurrence of flooding events

and the extension of the flooded area will be subsequently estimated considering the wave climate data and the geometry of the shoreface. A Digital Elevation Model will be used to evaluate which coastal sectors will remain at/or below the base level in relation to the occurrence of different scenarios. The results of the wave run-up and of relative sea-level rise scenarios will provide an estimation of their incidence on coastal vulnerability.

Poster S3.1-4828

Long-term variations of storm surge intensity along the Korean Coast and their connection with climate change

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There has been growing interest in how the storm surge intensity is changing due to typhoons associated with global warming. During the past 56 years, the number of typhoons affecting the Korean Peninsula (KP) was about 3.3 per year, and approximately one per year made landfalls over the KP. The intensity of the landfall typhoons over the KP is increasing continuously, which produces more severe damage in Korea. A recent typhoon leading to serious storm surge, resulted in 85 deaths and total property damage of about 5 billion US dollars. This study investigates the long-term variations of storm surge intensity along the Korean coast and their connections to climate change using the observed sea level data of the National Oceanographic Research Institute (NORI) over 50 years. The hourly surge data at the tidal stations constructed through the tide filtering and data corrections are used to investigate the long-term trend of extreme surge height. The results show that intensifying typhoons in Korea mainly contribute to increasing surge heights. The relation between storm surge trends and climate change will be discussed.

S3.2 Estuarine and wetland ecosystem functioning

23 May, 08:30 (S3.2-4742) Plenary

An assessment of the functional variability of coastal ecosystems in the context of environmental changes

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The functioning of coastal ecosystems such as estuaries, wetlands, sea grass beds, shallow embayments, is greatly dependent on a wide variety of external pulses (e.g. tides, fresh water influx, seasonal trends in temperature, nutrient input, etc.). Assessments of the impact of a selection of environmental characteristics, thought to be driven by natural and/or anthropogenic forces on ecosystem function, are given using selected ecosystem properties such as total system throughput, system organisation, productivity, recycling, and trophic efficiency, derived from ecological network analysis (ENA) of several coastal ecosystems on intra-seasonal, seasonal, and inter-decadal scales. Results from ENA revealed considerable differences of the same property(ties) resulting from physical changes (e.g. temperature, salinity, oxygen, rate of fresh water inflow) over time. Each ecosystem was modelled based on existing quantified data of standing stocks, the flows between the constituent living (species, communities) and non-living (detritus) components in the system, exports, and imports. A small temperature increase in a Florida sea grass bed, for example, resulted in substantial increases in system throughput, the daily P/B ratio, and in the rate of carbon recycling, but also in a significant decrease in system organisation. The behaviour of C, N and P as derived from ENA is discussed for selected ecosystems. The impact of a potential increase in water temperature in the coastal zone, and the potential decrease/increase in river run-off are discussed. Examples are presented illustrating the possible effect of climate change on coastal ecosystem function, including elemental (C, N, P) behaviour in recycling processes.

23 May, 10:35 (S3.2-4756) Invited

Assessing ecosystem properties and predicting responses of coastal lagoons to altered hydrology, nutrient cycling and direct anthropogenic pressures

Pierluigi **Viaroli**

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Due to their location between the continental and the marine domains, coastal lagoons present transitional conditions which could allow multiple alternate and stable states to coexist and persist. Such fragile equilibria can be altered by local anthropogenic pressures, e.g. aquaculture and tourism, associated with external organic and nutrient loadings. In turn, effects of local stressors can be amplified by climate-dependent factors, e.g. riverine discharge and sea level rise. In this contribution, the net ecosystem metabolism of a number of coastal lagoons in southern Europe is first presented, aiming at identifying the ratio of autotrophic to heterotrophic processes. Then, the recent evolution of primary producer communities is analysed considering nutrient loadings, hydrology and biogeochemical buffers. Local factors, namely aquaculture and tourism, are assessed in the light of their impacts on ecosystem processes and water quality. Impacts of aquaculture are then analysed in the Sacca di Goro lagoon, considering different riverine discharge scenarios, corresponding to wet, dry and normal conditions. Changes in river discharge are discussed as a critical factor in controlling nitrogen, phosphorus and reactive silica dynamics and inherent stoichiometry, as well as in determining the amplitude of the saline wedge. Increased perturbation intensity and abrupt changes in perturbations and stressors can induce wide variations of the transitional zone, which in turn could be responsible for the modification in biogeochemical processes and community structure.

23 May, 11:00 (S3.2-4585) Invited

Future climate and oxygen depletion in coastal oceans

Robert J. **Diaz**

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How climate change will affect coastal dead zones will depend primarily on localised changes in freshwater runoff and nutrient loadings, which control stratification and support eutrophication, respectively. Increases in water temperatures will have direct effects on oxygen solubility, organism metabolism, and remineralisation rates, and indirect effects by enhancing stratification. Covarying with climate change will be increasing population and further changes in coastal landscapes. If in the next 50 years humans continue to modify and degrade coastal systems as they have in previous years, human population pressure will be the main driving factor in the spreading of coastal dead zones, and climate change factors will be secondary. Climate forcing, however, will tend to make systems more susceptible to the development of hypoxia through direct effects on solubility of oxygen, metabolism, and mineralisation rates. Climate change may be a principal factor in expansion of naturally occurring hypoxia associated with upwelling and oxygen minimum zones (OMZ) into shallower coastal waters. Expansion of oceanic oxygen depletion into shallow coastal system will negatively impact fisheries and energy flows in a similar manner as eutrophication-driven hypoxia. Areas at greatest risk currently are the western continental shelves of Mexico, Peru, Chile, Africa, Pakistan, and India where extensive OMZ and upwelling areas already exist. The development of new upwelling related dead zones along the western coast of other countries is highly likely if wind patterns shift. A recent example may be the development of a dead zone off the coast of Oregon.

23 May, 11:25 (S3.2-4877)

Identification of important spatial and temporal scales of ecological variables: the relative contribution of climate variables on a soft bottom invertebrate assemblage

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Benthic communities have high structural variability at a multitude of scales and this variability is closely linked with physical setting. Identification of the important spatial and temporal scales helps us to unveil factors and processes generating these patterns. In this study we analysed (1) whether stability (Bray-Curtis dissimilarity) of invertebrate communities changed with geographical and temporal distance between communities, (2) whether the shape of such functional relationships varied among different invertebrate functional groups, and (3) what was the relative contribution of climate variables versus local abiotic and biotic forcing. In general the variability of invertebrate communities changed curvilinearly in space and the variability of invertebrate communities changed linearly in time. This indicates that the spatial patterns of invertebrate communities are primarily due to landscape-scale environmental variability and the temporal variability of invertebrate communities is mainly due to climate variables and eutrophication processes. This was also supported by strong links between landscape scale, eutrophication, climate and biotic variables.

23 May, 11:40 (S3.2-4852)

Changes in the benthic subtidal vegetation along the Basque coast (north Spain) and the probable relationship with climate change

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Due to recent concern about the effects of global warming and climate change, more scientific attention is being devoted to the prediction of biological changes in marine communities as well as to the evaluation of effects already attributed to climate change. The Basque coast could be especially vulnerable to the effects of climate change because of its unique biogeographical characteristics. The purpose of our work was to identify changes in the subtidal marine vegetation of a western stretch of the Basque coast during 1982-2007. A similar sampling survey carried out in 1982 was repeated in July 2007 but the increased to facilitate future comparisons. Seven

transect lines (100 to 200 m long) were systematically distributed along 1.95 km of an exposed shoreline, from Pta. Kobaron to Pta. Muzkiz. Cover for main macrophytes (Braun-Blanquet scale) and biomass by means of a stratified destructive sampling were estimated. Temporal and spatial differences in phytobenthic assemblages were explored by applying ordination and classification techniques using the PRIMER software package. The results show significant changes in the subtidal marine vegetation in the studied area during the last 25 years. *Gelidium sesquipedale*, the dominant species in 1982, experienced a significant decrease in biomass and percentage coverage. Other significant changes in the floristic composition were also recorded. Of the several hypotheses considered, a combination of irradiance and seawater temperature increase since 1978 appears as the most plausible cause at this point, but further study is necessary.

23 May, 11:55 (S3.2-4871)

Effects of climate-driven changes on coastal food webs: the role of precipitation patterns

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Climatic changes are expected to produce variations in the precipitation patterns that might substantially modify river runoff and nutrient loading to coastal areas. Modifications of the amount and timing of nutrient loads should affect biogeochemical processes and water quality with unknown effects on the coastal food webs. In this work, we analyse the potential cascading effects of changes in precipitation patterns on the higher trophic levels of the Venice Lagoon ecosystem (Italy) by using a hierarchy of linked models. An Ecopath with Ecosim model representing the estuarine food web was linked with a 3D transport-biogeochemical dynamic model (TDM) of the lagoon which, in turn, is forced with highly resolved meteorological outputs obtained from a Regional Climate model (RegCM). A scenario analysis is presented by comparing results for a reference situation (RF, 1961-1990) with results for two future IPCC scenarios (2071-2100), representing market oriented and local sustainability policies (scenarios A2 and B2, respectively). The local strengthening of seasonal dynamics and the decrease of summer precipitation in future scenarios are predicted to further affect biogeochemical properties. The effects of these changes on higher trophic levels are analysed by comparing the mean seasonal evolution of biomass for different trophic groups simulated under the different scenarios.

23 May, 12:10 (S3.2-4751)

Benthic diatom response to changing environmental conditions

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In the Gulf of Trieste (northern Adriatic Sea, Italy) the benthic diatom community dynamics were studied for seven years at two sublittoral stations and related to variations of temperature, salinity, freshwater inflow and nutrient concentrations. Bin-averaged temperature *versus* abundance of the main genera revealed that *Nitzschia* and *Navicula* increased with temperature (ca. 800 *Navicula* cells per °C and from 540 to 670 *Nitzschia* cells per °C), while *Paralia* and *Diploneis* decreased with increasing temperature. The more thermosensitive *Diploneis* seemed to be substituted by the more thermotolerant *Gyrosigma*. *Cylindrotheca* increased in correspondence with higher salinity. *Pleurosigma* revealed a positive and a negative relationship with salinity and temperature, respectively. With a further rise in temperature and salinity, following the increasing trend recorded during the last decades, the benthic diatom community is expected to shift. *Diploneis* could be replaced by *Gyrosigma*. *Navicula* and *Nitzschia* could markedly increase. In high salinity conditions a rise of *Pleurosigma* abundances is expected. Also the biodiversity of benthic diatoms is likely to decrease. The progressive lowering of the trophic state of the Gulf of Trieste will supposedly cause a decrease of all benthic diatom abundances. Because the Gulf of Trieste can be considered a natural megacosm due to its geomorphologic characteristics, the benthic diatom response to changing environmental conditions observed there could be extended beyond the geographic limits of this particular ecosystem. In the future, similar changes in the benthic diatom community are likely to occur in deeper basins.

23 May, 12:25 (S3.2-4732)

Conservation of the Goaso watersheds in Ghana, a participatory approach to sustainability

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Watersheds provide the main source of livelihood for most rural communities in Ghana. As a result, this research was conducted with the aim of contributing to the knowledge on the status of the watersheds and to identify existing strategies, opportunities and constraints to sustainable management. It focused on the watersheds in the Goaso Forest District in collaboration with the key stakeholders. Data were obtained using various research methods such as questionnaires, focus group discussions, observations and desk studies. The findings of the team include the following: two main watersheds were identified in the forest district, namely, the Bia and Tano watersheds, the main human activities that take place are farming, fishing, logging and charcoal production, the quantity and size of fish had reduced, and the quantity of the Tano watershed has reduced and the quality (in terms of smell, taste and colour) of the Bia watershed has degraded as compared to some time past. Several watershed management strategies were identified in the district, with the main ones being the maintenance of buffer zones between farms and rivers, planting of trees around the water bodies and educational programmes for the sensitisation of the community on the need to protect the water bodies. Several recommendations including the following were proposed: education on management, strengthening of the collaborative management linkages and enactment of specific laws to protect the watersheds.

23 May, 12:40 (S3.2-4604)

Decadal change in soft-bottom community structure in high arctic fjord (Kongsfjorden, Svalbard)

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In 1997 and 1998 soft-bottom fauna of an arctic glacial fjord Kongsfjorden was extensively sampled. Four major communities were identified along the fjord axis which should be related to the diminishing influence of the glacial activity. The sampling was repeated after 10 years, in 2006, in search for natural or climate driven community change. Spatial patterns in community structure and species diversity are significantly different in the central basin of Kongsfjorden while there is no change in the inner part of the fjord. In 1997-98 three faunal associations were distinguished in the inner and central part of the fjord, while in 2006 only two faunal associations were identified. After a decade there were no significant differences between two previously identified central basin faunal associations. Only the inner glacial association remained unchanged. The increased input of Atlantic water carried with an increasingly stronger West Spitsbergen Current can be the reason for unification of previous clear faunal division. Well separated from the central part of the fjord, with strong glacier influence, the faunal association in the inner glacial part of the fjord may be more isolated from the increased amount of warm Atlantic water. Therefore, no significant change was observed there.

23 May, 12:55 (S3.2-4734)

Temperature methanogenesis regulation in shallow temperate estuaries

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The dynamics of methane production at different temperatures (15, 25, 30 and 35ºC) and the main factors that control this process were investigated in fresh water and marine habitats (intertidal sediment and salt marsh) of a Mediterranean temperate estuary in southern Spain. The results indicated that methanogenesis is strongly influenced by temperature, observing activity above at 35ºC. The fresh water site showed the highest rate of methanogenesis, being one order of magnitude higher than in intertidal sediment. The factors that regulate methanogenesis were different depending on the site. In the fresh water site, the available substrate *in situ* (acetate)

was the limiting factor of methanogenesis. The control factors were different in intertidal sediment and salt marsh. In the latter, the high sulphur load with the tidal movement is the most important methanogenesis control factor. Under this condition, sulphate-reducting bacteria activity is higher than methanogenesis, competing more efficiently for the same substrate. In the former, vascular plants and tidal oscillations have a key role in the sediment biogeochemical properties. Oxygenated sediment with positive oxido-reduction potential and acid pH are not a suitable environment for methanogenic bacteria activity.

23 May, 14:30 (S3.2-4683)

Changes in coastal upwelling conditions along the western coast of the Iberian Peninsula for the last 40 years

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The spatial and temporal variability of the upwelling regime along the western coast of the Iberian Peninsula (IP) has been analysed by means of two different, but complementary databases: QuikSCAT satellite database, available from mid-1999 with a high spatial resolution (0.25º x 0.25º); and the Pacific Fisheries Environmental Laboratory (PFEL) database, with a coarser spatial resolution (1º x 1º) extending back to 1967. Apart from the well known seasonality on the upwelling regime along the western IP, in which upwelling favourable conditions are observed during spring and summer, other features have been identified. (i) The coastal upwelling pattern is homogeneous along the entire western coast of the IP; (ii) Positive Ekman pumping has been observed near Capes Sao Vicente and Rocha during spring-summer and near Cape Finisterre all year; (iii) More favourable upwelling conditions have been observed in February and November during the last decade. This result is corroborated by sea level pressure composites, which show the existence of abnormally high pressures close to the IP during the last decade compared to historical records (1948-2006); (iv) A decadal analysis of upwelling index evolution from 1967 to 2006 showed that the upwelling conditions were highly variable during autumn-winter without a clear seasonal trend, while the variability was considerably lower during spring-summer; (v) Monthly upwelling trends indicate a weakening in upwelling intensity during most of the year with the exception of February, June and July.

23 May, 14:45 (S3.2-4892)

Response of structure and distribution pattern of benthic littoral communities to climatic variation and eutrophication

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Benthic littoral communities are widely used in assessment schemes for water quality in coastal ecosystems. These schemes are based on the assumption that different parameters of biological communities are able to react to changes in physical conditions, e.g. water turbidity, salinity, oxygen, etc. Widely used metrics for water quality are maximum depth penetration of aquatic vegetation, proportion of perennial and opportunistic species, and other parameters. In our study we analysed the pattern of different parameters of benthic littoral communities in relation to long-term variability in nutrient loading (eutrophication) to coastal ecosystem and variability of climatic conditions. Quantitative and qualitative data on the distribution of phytobenthic communities in the northern part of Gulf of Riga, northeastern Baltic Sea from three periods (1959-1961, 1986-1990 and 1995-2007) were analysed. Using different uni- and multivariate statistical methods, we were able to distinguish the effects of climatic variation from the signal related directly to eutrophication. Based on this information, corrections to the existing water quality classification scheme were proposed.

23 May, 15:00 (S3.2-4555)

Compositional changes in aquatic macrophytes propagate through detrital food webs

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The cumulative effects of climate change, catchment development and bioinvasion are causing worldwide changes to the diversity and abundance of estuarine primary producers. Among other important impacts, these changes are altering the quality and quantity of vegetative detritus entering benthic systems. We manipulated the availability of three detrital sources, *Avicennia marina* leaves, *Posidonia australis* blades and *Sargassum* sp. thalli, on an Australian mudflat to test hypotheses about how changes in the type and number of macrophytes contributing to detrital resources might impact benthic invertebrate assemblages of estuarine soft sediments. By controlling for changes in total detrital biomass and ensuring that each detrital source was present in two- and three-species mixes as well as monocultures, our experimental design was able to distinguish among effects of mixing, identity and biomass. Three months after detrital manipulation, macroinvertebrate abundance and species richness differed among treatments according to the biomass of detritus added and the non-additive effects of detrital species mixing. Whereas the mixing of two detrital species generally had an antagonistic effect on macroinvertebrate abundance and richness, faunal assemblages did not appreciably differ between three-species mixes and monocultures. Generally negative effects of two-species mixes on macroinvertebrates were opposed by positive effects on microphytobenthos. Non-additive effects on sediment communities were particularly apparent when *Sargassum* sp., the most labile of the three detrital sources considered, was included in two-species mixes. These results indicate that compositional changes to aquatic macrophyte communities, resulting from climate change and coastal development, will subsequently affect other components of the estuarine food web.

23 May, 15:15 (S3.2-4707)

Effects of land use, urbanisation, and climate change on coastal eutrophication in the Baltic Sea

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Coastal eutrophication is recognised as one of the foremost threats to ecosystem functioning. However, there is a lack of knowledge on the unique effects of point and diffuse sources of nutrients in degrading water quality and ecosystem function, or how these factors interact with climate variability to regulate coastal productivity. Sedimentary records of stable nitrogen and carbon isotope ratios and pigments were used to reconstruct the history of coastal eutrophication in Himmerfjärden, a mesohaline Baltic Sea bay in Sweden, and to evaluate the unique and interactive effects of land use, urbanisation and climate change on coastal eutrophication. Evidence indicates that changes in nutrient sources and cycling began in the 19th century, but eutrophication intensified only after the 1950s, coincident with increased population density and changes in land use. Specifically, sedimentary N and C content doubled, $\delta^{13}C$ increased ~2‰, and concentrations of pigments indicative of total algal biomass (β-carotene, Chl *a*), diatoms (fucoxanthin, diatoxanthin), chlorophytes (lutein-zeaxanthin, Chl *b*) and cyanobacteria (canthaxanthin) increased fourfold after 1950. However, the most drastic changes in N sources occurred following initiation of treated wastewater discharge. Independent Variance Partitioning Analysis revealed that historical changes in both sediment geochemistry and algal communities were strongly related to changes in nutrient flux from land, specifically increased fertiliser use and wetlands drainage, and more recently also urban wastewater discharge. These results confirm that management strategies to restore degraded coastal habitats require cooperation between stakeholders at regional and national levels to both improve wastewater treatment and alter land use practices.

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Challenges and issues in managing marine ecosystems in Sri Lanka

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Sri Lanka is an island with a land area of 6,570,134 ha and a coastline of 1,600 km, which supports a highly productive marine ecosystem including fringing coral reefs and shallow beds of sea grasses. The island consists of a broad coastal plain and a central mountainous area rising to elevations of 2,500 m. Coastal ecosystems include a variety of tropical habitats including wetlands, lagoons, estuaries, mangroves, salt marshes, seagrass beds, coral reefs, coastal sand dunes, barrier beaches and spits. Sri Lanka has a very high biodiversity and is one of the 18 hot spots in the world. Sri Lanka derives nearly 20 percent of its gross domestic product from agriculture and fisheries. The coastal and marine ecosystems provide over 65 percent of the animal protein requirement of the country and accounts for nearly 80 percent of the fish production and 70 percent of industrial output. The eroding coastline especially threatens economic activity on the densely-populated western and southwestern coast. Between 200,000 and 300,000 square metres of beach are lost in a year to storms and high waves. This paper synthesizes the present challenges and issues in aquatic ecosystems in Sri Lanka as a small island country and gives recommendations for the policy makers for sustainable ecosystem management.

S3.2 Posters

Poster S3.2-4577

Anthropic and natural impacts upon the coastal lagoons in the SW of Spain (Doñana National Park)

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The Doñana peridunar lagoons, located in the SW of Spain (Doñana Biosphere Reserve), have been thoroughly studied from limnological and hydrogeological viewpoints because their conservation is of great interest. However, the impact exerted by human actions upon them and the most recent climatic changes in those lagoons are unknown. Our study reveals that anthropic activities have affected these lagoons for centuries in the form of fires. Besides, since 1965, they have also been affected by the drawing of underground water in connection with local coastal tourist resorts. A reconstruction of the evolution of these coastal lagoons reveals that, along with the anthropic impact, there is a natural impact due to the reactivation of mobile dunes that have cut and filled the initial lagoon complex. Thus, for the 1920-1987 period, this series of coastal lagoons has suffered a 70.7% reduction, although this process has lasted for centuries. The natural causes appear to be related to an advance of the active dune fronts in the coastal area. These fronts might be fed by the deposits of marine sand during the driest climatic phases of the Little Ice Age in Andalusia (Spain). Consequently, if the driest periods increase, as well as droughts as a whole, due to global warming in the SW of Europe, the drying up and disappearance of the lagoons under study could be prompted (as well as those of the lagoons in a similar situation located in the coastal strip of the south of Europe).

Poster S3.2-4584

Coastal hypoxia will be aggravated by climate change

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The occurrence of hypoxia in coastal areas is increasing, and the trend is consistent with the increase in human activities that result in increased fluxes of nutrients to coastal waters. More and more coastal systems, especially in areas of increased industrialisation and mechanised farming, where the physical conditions are appropriate and where nutrient loads are predicted to increase, will likely become eutrophic with accompanying hypoxia. The continued and accelerated export of nitrogen and phosphorus to the coastal ocean is the trajectory to be expected unless societal interventions are pursued. Increased production of biofuels will further amplify nutrient delivery from the land to the sea. Another source of future change in nutrient loadings leading to increased organic production and water column stratification is climate. Global climate changes within the range predicted to occur in the 21st century could have profound consequences to hypoxia in the northern Gulf of Mexico and globally. The annual discharge of several rivers would increase if the concentration of atmospheric CO_2 doubles, nutrient loads would increase, stratification would strengthen from increased freshwater inflow, and hypoxia would intensify and expand. Increases in surface water temperature would strengthen the summer pycnocline and perhaps worsen hypoxia. On the other hand, warmer Atlantic Ocean temperatures could also increase tropical storm activity and severity resulting in more mixing and reaeration events. Whichever occurs, the increase or decrease in flow, flux of nutrients and changes in water temperature are likely to have important, but as yet not clearly identifiable, influences on hypoxia.

Poster S3.2-4617

Changes in coastal wetland function with sea-level rise

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Landscape alterations associated with sea-level rise and climate change are most obviously exemplified through changes in wetland class position and area. As change occurs in these aspects of wetlands, so does the extent of the various ecosystem functions. We have evaluated these relationships for the coastal wetlands of the southern Pamlico Sound, North Carolina, USA. The five major wetland classes within the system are freshwater riverine swamp forest; sea-level controlled swamp forest; irregularly flooded, oligohaline and meso-polyhaline marshes; and regularly flooded, tidal salt marshes. Attributes of each were estimated from decades of field work and were considered in assigning functions to each class and their vulnerabilities to disturbance and sea-level rise. Hydrologic and geomorphic, biogeochemical, and habitat functionality differed among wetland classes. For example biogeochemical functioning includes the manner and extent of organic matter accumulation and availability. The production of organic matter as wood or peat compared to readily recyclable leafy material changes across the landscape and wetland class. Similarly water storage and wildlife habitat features change across the landscape. Information about the attributes of the wetland classes was then associated with the results of a landscape model forecasting decades of effects of sea-level rise and disturbance. This exercise provides a qualitative view of how ecosystem functionality would be expected to change under different scenarios of sea level and geomorphic change.

Poster S3.2-4735

A series of data in water and sediment conditions (from 1980s to present) in a shallow temperate estuary (Palmones, Spain)

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In this study the fluctuations suffered in the Palmones river estuary from the end of the 1980s to the present day have been analysed in water and sediment. Our aims are to continue the previous studies to determine if the estuary has been gradually eutrophicated and to identify the reasons for it. Phosphorous and nitrogen forms have been analysed as organic matter and C:N ratio determined. They have been related to rainfall pattern. Results show that the relation between the total inorganic phosphorous and the total organic phosphorous increased from the end of the 1980s to 2005, suggesting that inorganic processes dominated over biological processes. However, in the last two years there has been an increase in the organic fraction, so the biological control prevailed in this last period, as it was 15 years ago. Total phosphorous and organic matter values presented fluctuations, although the concentration increased in the sediment mainly related to drought periods. On the other hand, the C:N ratio kept constant with values between 12 and 15, which can be useful to identify the possible origin of the organic matter. The values of the different variables show that the eutrophication is progressive and mediated by a positive feedback of internal fertilisation (endofertilisation). The input of allochtonous organic matter coming from anthropogenic activities is mainly responsible of this effect.

Poster S3.2-4775

Influence of different North Atlantic Oscillation indices on climatic factors and water temperature in Basque estuaries (Gulf of Biscay)

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The effect of the North Atlantic Oscillation (NAO) indices on climatic conditions and their subsequent influence on water temperature of two Basque estuaries (estuaries of Bilbao and Urdaibai) were assessed by transfer function (TF) models for the period 1997-2006. We observed that air temperature showed an immediate (lag

= 0) and significant negative response to the NAO but that neither rainfall nor the amount of cloudless hours were correlated with this climate index. This inverse relationship between surface air temperature and NAO is consistent with the response observed in northwest Africa and the Mediterranean region. TF models revealed that negative correlations between the NAO and air temperature seem to be stronger with seasonal NAO indices calculated taken Ponta Delgada (Azores) as the southern station of the dipole. Surface air temperature and water temperature were positively correlated. A cold summer registered in 2002 was strongly consistent with our TF results, where the positive phase of NAO was concurrent with a remarkable decrease of surface air temperature and water temperature. The effect of air temperature on water temperature had lags of 0 and 1.

Poster S3.2-4896

Prediction of variation in structure of benthic littoral communities on offshore hardbottom banks in the NE Baltic Sea related to changes in climatic conditions

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The study on possible effects of construction of an offshore windfarm on benthic littoral communities in the NE Baltic Sea was carried out during the vegetation season in 2007. The investigated area included offshore, hard substrate shallow with a surface area of approximately 20 km^2 surrounded by deep waters. The structure and distribution of the benthic littoral communities was studied in relation to the benthic morphology and topography. Distribution of most species was significantly related to the topographic features of the bottom as well as wind and wave exposure directions. Ice scarping and mechanical stress caused by wind induced wave action are supposed to be the main environmental factors structuring the benthic littoral communities in exposed offshore environments in the NE Baltic. It is also known from the previous studies in the same area that the structure of the pioneer community of the seasonal succession on exposed hard substrates is related to temperature and wave conditions. In the current study we have compared the different scenarios of environmental conditions including change in wind-driven wave activity as well as changes in ice scraping regimes on the quantitative and qualitative structure of benthic communities in the extremely exposed conditions of the NE Baltic Sea. The decrease of the ice cover period together with decreased thickness of ice cover may favour the development of perennial macroalgal communities in the shallow (up to 4 m) hard-substrate conditions, while increased wave activity may prevent algae with large thalli from establishing viable communities.

Poster S3.2-4943

Responses to thermal stress in the intertidal: utilisation of refuge by a predatory whelk

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Rocky intertidal regions are model systems for examining the role of climate on communities as the ecology of intertidal organisms is closely linked to physical factors along vertical and horizontal gradients of the shore. We characterised the microclimates experienced by the predatory whelk, *Morula marginalba*, and used an integrated ecological and physiological approach to determine how their: (1) distribution and abundance, (2) utilisation of refuges (crevices and rock pools), and (3) thermal sensitivity (measured by metabolic response and tenacity) varies along gradients of thermal stress. In all microhabitats, substratum temperatures were more variable and maximal temperatures were greater higher on the shore than further down. Crevices and pools provided less thermally variable microhabitats to the whelks, and maximal temperatures were 5-10°C less within refuges than on exposed rock. Utilisation of refuges increased and abundance declined where thermal stress was greater higher on the shore and in locations sheltered from wave splash. Although whelks were able to lower their level of metabolism to cope with long-term increases in temperature, physiological function was severely compromised when body temperature exceeded 40°C. Refuges were thus essential to *M. marginalba* to avoid sublethal or lethal thermal stress where temperatures on exposed surfaces exceeded 50°C high on the shore. Refuges play an important role in the ecology and thermal physiology of organisms living on rocky shores and may act as buffers against climate-related stress as extremes in temperatures and storms become more frequent in the future.

Poster S3.2-4950

Estimation of seaweed carbon uptake as a CO_2 removal mechanism

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Aquatic primary production removes dissolved inorganic carbon (DIC, CO_2+HCO_3^-) which facilitates further dissolution of atmospheric CO_2. Seaweeds, being immensely abundant in coastal waters, are considered by ocean-CO_2-removal researchers to be model photosynthetic organisms. Measurements of seaweed production are difficult to predict by ordinary techniques (e.g. bottle incubation). Thus, an alternative, simple box model to estimate the net primary production of the brown seaweed *Sargassum horneri* was considered. The choices of states variables and model structure were made on the basis of experimental knowledge of the studied site. The primary production was calculated from the monthly variation of seaweed biomass and its carbon uptake over the period of the model simulation, and was compared with the former experimental results (i.e. for the ^{13}C method and the light/dark oxygen technique). The model simulation results confirmed the importance of considering the effect of increased temperature on seaweed production in order to account for their contribution on climate change. Our model-derived estimation of seaweed carbon uptake points to the need for additional research on the impact of global CO_2 removal by seaweeds.