# POSTER SESSION 2: TOPIC 10
# Coupled Models of Biogeochemical Cycles and Ecosystems

## PS2: 10.1
## Centre of observation of Air-Sea Interactions and fluXes (CASIX)

Jim Aiken[1], Ian Robinson[2] and members of CASIX team
[1] Plymouth Marine Laboratory, Prospect Place, Plymouth
[2] Southampton Oceanographic Centre, Southampton UK
Email: ja@pml.ac.uk

The purpose of CASIX is to exploit new-generation Earth Observation (EO) data to advance the science of air-sea interactions and reduce the errors in the prediction of climate change. The primary goal is to quantify accurately the global air-sea fluxes of $CO_2$ using state-of-the-art, error-budgeted models. New sensors in new satellites (Envisat, Aqua) will give high-precision, high-resolution data of atmosphere, ocean boundary layer properties and ocean biogeochemical variables daily, globally, and long term. Only by using and assimilating EO data in models can CASIX achieve its goals. CASIX will merge the Met Office ocean modelling team and major UK academic research groups, with Space Agency support, to accelerate the development of methods of forecasting Earth system processes.

## PS2: 10.2
## Glacial-Interglacial changes in Atmsopheric $CO_2$

Keith Alverson and Pascal Le Grand
PAGES International Project Office, Bern, Switzerland
IFREMER, Brest, France
Email: alverson@pages.unibe.ch

An inverse ocean box modeling approach is used to address the question of what may have caused decreased atmospheric $CO_2$ concentration during glacial periods. The inverse procedure seeks solutions that are consistent, within prescribed uncertainties, with both available paleodata constraints and box model conservation equations while relaxing traditional assumptions such as exact steady state and precise prescription of uncertain model parameters. Decreased ventilation of Southern Ocean deep water, decreased Southern Ocean air-sea gas exchange, and enhanced high latitude biological pumping are all shown to be individually capable of explaining available paleodata constraints provided that significant calcium carbonate compensation is allowed. The role of increased solubility of $CO_2$ associated with cooling of low and mid latitude surface waters plays only a minor contributing role in these scenarios scenarios. However, we further show exact solutions to the 7-box ocean carbon cycle model, found using the inverse procedure, which indicate that low and mid latitude sea surface temperature changes could have served as the primary driver of atmospheric $CO_2$ variability on glacial-interglacial timescales. The most substantial difference between glacial and interglacial climates is, after all, temperature. In this hypothesis, additional systematic feedbacks, such as those which have been suggested as possible primary mechanisms the scenarios listed above, play a secondary role.

## PS2: 10.3
## Modelling Predator Environment: Tropical Tuna, and Fin-Whales in the NW Mediterranean.

Andre J.-M.[1], C. Menkes[1], L. Dubroca[2], C. Guinet[2], D. Shankar[3], S. BenMustapha[1], F. Menard[4]
[1] Laboratoire d?Oceanographie Dynamique et de Climatologie (IRD/UPMC/CNRS), T26-E4 Universite P. et M. Curie, 4 Place Jussieu, 75252 Paris cedex 05, France.
[1] Centre d'Etudes Biologiques de Chizé (CNRS), 79 360 Villiers en Bois. France.
[3] National Institute of Oceanography, Dona Paula, 403 004, Goa, India.
[4] Centre de Recherche Halieutique (IFREMER/IRD), BP 171, 34203, Sète, France
Email: andre@lodyc.jussieu.fr

Predator spatio-temporal distributions result from their behaviour in the gradients of their environments. The present studies aim at understanding the role of environmental parameters; temperature, salinity, currents, dissolved oxygen and above all prey abundance. Four situations are examined: tuna in the E equatorial Atlantic, the NE tropical Pacific and the Indian ocean, and fin-whales in the NW Mediterranean, whose spatial distributions can be estimated at regional scale from field observations (catches or sightings).
Environmental fields are simulated by numerical coupled models of dynamics, biogeochemistry and trophic transfer. To predict forage abundance (pelagic micronecton, euphosiids), production transfer from primary level is parametrized in terms of an efficiency and of a characteristic recruitment time and is achieved within the moving surface layer. The currents used to force the transport are issued from previous simulations by circulation models and the primary production that feeds the trophic transfer is issued from a biogeochemical coupled model or is estimated from ocean color imagery. For the four differing examined situations, basin- to meso- scale dynamics lead to constrasted spatial redistributions of production as it is transfered to prey level. A common result: periods and areas where animals are observed to concentrate compare well to periods and areas of model-predicted forage accumulation.

## PS2: 10.4
## A compact model structure for analysis of food web data and for carbon cycle simulation

Robert A. Armstrong
Marine Sciences Research Center, Stony Brook Univ., Stony Brook, NY 11794-5000
USA
Email: rarmstrong@notes.cc.sunysb.edu

Previous size-structured models of marine food webs have proved inadequate for analyzing food web data. In particular, the use of discrete, non-overlapping "boxes" for size classes does not capture the size plasticity of individual organisms, nor does it reflect the fact that characteristic size differences among competing species may not be the same as characteristic size differences between adjacent trophic levels. Here I present a new food web model structure based on a parameterized zooplankton size spectrum. This model should enable maximal information to be extracted from food web data. A novel Steele-Henderson parameterization of phytoplankton aggregation loss has been added to the basic predator-prey model, and both models have been fit to data from IronEx II; the model with aggregative loss fits this data much better than does the model without the additional loss term. Finally I suggest an approach to fully spectral models, in which size spectra of both zooplankton and phytoplankton are represented.

## PS2: 10.5
## On the development and evaluation of a Dynamic Green Ocean Model: role of phytoplankton calcifiers for ocean biogeochemistry

Erik T. Buitenhuis, Corinne Le Quéré, Olivier Aumont
MPI-Biogeochemistry, PO Box 100164, D07745 Jena, Germany
Email: ebuit@bgc-jena.mpg.de

We discuss the impact of including specifically the biomass and activity of phytoplankton calcifiers in an oceanic biogeochemical model. This work is part of the Dynamic Green Ocean Project, which is made in collaboration with a group of scientists worldwide (http://www.bgc-jena.mpg.de/bgc_prentice/projects/green_ocean/start.html). The Dynamic Green Ocean Model builds on the PISCES model (Aumont et al., GBC in press), which already includes co-limitation by P, Si and Fe and four plankton functional types: nanophytoplankton, phytoplankton silicifiers, micro- and mesozooplankton. We show model results for 1990-2000 and discuss the impact of calcifiers on the mean and variability of biogeochemical tracers in the surface ocean. We also discuss the sensitivity of the model results to the growth and mortality parameters imposed for the various plankton functional types. We compare model results with available observations of alkalinity and other passive tracers, export of POC and of $CaCO_3$, chla and coccolithophorid blooms viewed from space, and phytoplankton succession. Finally we put this work in the larger context of the development and evaluation of a Dynamic Green Ocean Model.

## PS2: 10.6
## A multi-population size-structured model of zooplankton for studying food-web dynamics and biogeochemical fluxes

François Carlotti and Marc Sourisseau
CNRS, Université Bordeaux 1, Station Marine d'Arcachon, 2, rue du Professeur Jolyet, 33120 Arcachon, France
Email: carlotti@biocean.u-bordeaux.fr

A size-structured zooplankton community model including dominant species of the Ligurian sea pelagic ecosystem is presented. Each population is described by its demographic and bioenergetical processes, using as far as possible general common size-based physiological laws, and a limited number of necessary specific parameters. The interactions between populations are based on a general predator-prey size ratio. The model is forced by temperature, food and gelatinous predation data, compiled from several studies in this area.
A standard simulation over the year shows the mean pattern of the community dynamics. A species succession is delivered by the simulation: the smallest species are present during all the year whereas the largest species, responsible of the highest variations in term of biomass, disappear during the summer due to food limitation. Successive top-down and bottom-up controls influence the community composition and production.
Such a size-based representation of the copepod community is potentially interesting to better understand the pivotal roles of zooplankton, both for biogeochemical cycles in the ocean and for trophic matter flux up to fish. Starting from the size-structured model of the copepod community, we computed the matter fluxes through the different populations and the community as whole. The size-structure of the zooplankton community was also used to represent the prey field for early life stages of anchovy. A simple larvae fish growth model coupled with the copepod community model shows the potential impact of the copepod community dynamics on the survival and growth of anchovy larvae

## PS2: 10.7
## Characterizing the global distribution and nature of the rate of algal loss in pelagic marine ecosystems

Mark D Dowell Jeffrey Runge & Janet W. Campbell
Ocean Process Analysis Laboratory, University of New Hampshire, Durham, NH, 03824, USA
Email: mark.dowell@unh.edu

Satellite-based estimates of chlorophyll a and primary production have provided an unprecedented perspective phytoplankton dynamics at the global scale. Only a few studies have used the same satellite data to characterize the loss terms associated with biomass variability. Loss rates are a major gap in our understanding of pelagic ecosystems. The total loss rate (L) is easily obtained from the equation $dB/dt=P-L$, if the biomass (B) and primary productivity (P) are known. To date a major obstacle in using satellite data to study algal loss rates is that dt has been too large, i.e. typical cloud free global coverage ~ 30 days. With the advent of the MODIS sensor, almost perfect cloud free global coverage is obtained within an 8-day period, a more relevant time step for studying phytoplankton loss terms. Based on 8-day calculations, 12 monthly global composites of L were derived, as well as monthly composites of the parameter $M = L/P$. M has been proposed as an indicator of areas where algal production/loss rates are either dominated by physical or biological processes. This study provides the first insight into the global distribution and dynamics of these variables over a single year. The resulting distributions are in accordance with published estimates. For example, the sub-tropical gyres stand out as areas where the loss terms are relatively high and also dominated by biological processes. This approach will provide new information for studies of interactions among trophic levels and serve as an example of how an integrated IGBP-OCEANS program building on the previous expertise of both the JGOFS and GLOBEC communities.

## PS2: 10.8
## Physical validation of a North Atlantic Ocean model assimilating altimetry data prior to biogeochemical studies

M. Drevillon[1], I. Dadou[1], V. Garçon[1], G. Charria[1], P. De Mey[1], E. Greiner[2] and M. Benkiran[2]
[1] LEGOS, 14 avenue Edouard Belin, Toulouse
[2] CLS, parc Technologique du canal, Toulouse
Email: drevillo@notos.cst.cnes.fr

Ocean colour images display the link between mesoscale circulation and primary production in the ocean. A major stake is to improve our understanding of these physical/biogeochemical interactions by using these datasets to constrain oceanic circulation models. A "Mercator Ocean" reanalysis was performed by the MERCATOR project with a General Circulation Model (GCM) of the North Atlantic ocean (1/3 degree horizontal resolution, 43 vertical levels), assimilating satellite altimetry data for the years 1993 to 2001. In order to diagnose the performances of this GCM, prior to coupling it with an ecosystem model, the reanalysis is compared with upper ocean physical data in three different biogeochemical provinces (NABE,BATS and EUMELI). Over the simulation period, a pronounced drift is found at BATS and NABE towards an overcooled subsurface ocean. The EUMELI site does not experience any visible temperature drift. A marked salinity drift towards more freshwater content is produced at BATS, whereas the broad subsurface salinity maximum, typical of the tropical North East Atlantic ocean is well maintained. The model temperature fluctuations at the EUMELI site are in relation with the North Atlantic Oscillation (NAO), with cooler (warmer) surface waters following a mean winter positive (negative) NAO. 1996 is cooler at BATS, probably in response to a strong 1995/96 winter negative NAO, however this signal is difficult to deconvolve from the temperature drift. A validation of various basin scale physical diagnostics that impact on the biogeochemical variables is also performed, prior to sensitivity studies to ocean colour data.

## PS2: 10.9
## Empirical and predictive models for the particle export ratio

Dunne, J. P., R. A. Armstrong, C. A. Deutsch, A. Gnanadesikan, N. Gruber, J. L. Sarmiento and P. S. Swathi
AOS Program, Princeton University, P.O. Box CN710, Princeton, NJ 08544
Email: jdunne@princeton.edu

We utilize an expanded compilation of observations of the ratio of particulate organic matter export to primary production (the pe-ratio) in order to calibrate new empirical and predictive models of the pe-ratio. Our empirical model captures 64% of the variance with a model that is a function of the temperature and chlorophyll concentrations only. We also utilize this observational data set and other data we have compiled in order to calibrate a simple prognostic model of the allocation and recycling of new production that includes small and large phytoplankton, as well as explicit ballast driven sinking and remineralization of particulate organic matter. A key feature of this model is a representation of grazing that reproduces the observed allometric relationship in the phytoplankton community. This model is able to explain 63% of the variance in the pe-ratio when driven by primary production and temperature. The resulting model has been incorporated into the Princeton Ocean Biogeochemical Model to diagnose "new" (nitrate) production, primary production, particle export and dissolved organic matter transport through restoring of surface nitrate, phosphate, silicate and alkalinity in the MOM3 general circulation model. Model results are compared with satellite-based primary production from ocean color. The model is able to reproduce major patterns in primary production as interpreted from satellite-based estimates. However, important differences exist, pointing primarily to deficiencies in model representation of ocean circulation.

## PS2: 10.10
## Simulated physical environments and biogeochemical processes at the subarctic North Pacific time-series Station KNOT (44N, 155E)

Masahiko Fujii, Yukihiro Nojiri, Yasuhiro Yamanaka, Michio J. Kishi
National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki 305-8506 Japan
Email: fujii.masahiko@nies.go.jp

A vertically one-dimensional marine ecosystem model based on the NEMURO (North pacific Ecosystem Model Used for Regional Oceanography) was applied to Station KNOT (44°N, 155°E). This model has fifteen compartments including two categories of phytoplankton (diatoms and non-diatom small phytoplankton) and three categories of zooplankton (small, large and predatory zooplankton). Cycles of nitrogen, silicon, calcium and carbon including air-sea $CO_2$ exchange were simulated simultaneously.
The simulation successfully reproduced seasonal features in the observed physical environments and biogeochemical processes at KNOT, such as vigorous vertical mixing in late winter and strong surface stratification in summer, and large seasonal amplitudes of the temperature, nutrient, chlorophyll-a and total carbonate concentrations at the surface, and primary production. Results of the simulated carbon system suggested that the ocean released and absorbed $CO_2$ in late winter and autumn, respectively, and generally functioned as a sink of $CO_2$.
The simulated results in 1998, 1999 and 2000 were compared with one another and also with the observed ones. The simulated surface water temperature in winter was higher in El Niño year than in La Nina year, consistent with the observed. The simulated mixed layer depth maximum reached nearly 200m in each year, but the timings of vertical mixing, the following stratification and spring diatom bloom were rather different. The simulated annual-mean primary production, however, did not show clear difference in each year. Thus, the model successfully reproduced interannual variations in the physical environments but not in the biogeochemical processes. This implied that horizontal advection and/or specific biogeochemical changes, both of which were not included in the model, were also effective to the interannual variations in the biogeochemical processes.

## PS2: 10.11
## Exchange Processes and Nitrogen Cycling on the Shelf and Slope area of the Black Sea Basin

Marilaure Grégoire [1], Beckers J.-M.[1], Kostianoy A. [2], Nezlin N.2, Stanev E.[3] and Nihoul J.[1]
[1] GHER (GeoHydrodynamics and Environment Research laboratory), B5 Sart-Tilman, University of Liège, 4000 Liège, Belgium
[2] P.P. Shirshov Institute of Oceanology, Moscow, Russia
Email: mgregoire@ulg.ac.be

A 6-compartment biogeochemical model of nitrogen cycling and plankton productivity has been coupled with a 3D general circulation model in the Black Sea so as to quantify and compare, on a seasonal and annual scale, the typical internal biogeochemical functioning of the shelf and of the deep sea as well as to estimate the nitrogen (inorganic and organic) and water exchanges at the shelf break and at the continental slope-deep sea cross section. Model results indicate that, regarding the deep sea, the shelf acts, throughout the year, as a nutrient source and the total annual nitrogen export to the deep sea roughly corresponds to the annual load of nitrogen discharged by the rivers on the shelf. The model estimated vertically integrated gross annual primary production is 130 gC m-2 year-1 for the whole basin, 220 gC m-2 year-1 for the shelf and 40 gC m-2 year-1 for the central basin. In agreement with sediment trap observations, model results indicate a rapid and efficient recycling of particulate organic matter in the sub-oxic portion of the water column (60-80 m) of the open sea. More than 95% of the PON produced in the euphotic layer is recycled in the upper 100 m of the water column, 87 % in the upper 80 m and 67 % in the euphotic layer. The model estimates the annual export of POC towards the anoxic layer to 4 1010 mol year-1. This POC is definitely lost for the system and represents 2 % of the annual primary production of the open sea.
On the shelf, biological processes are in approximate balance. The primary production is mainly fuelled by the rapid in-situ recycling of nutrients as well as by the river discharges.

## PS2: 10.12
## Calibration and validation of an ecosystem model using satellite ocean colour data

John C. P. Hemmings, Meric A. Srokosz, Peter Challenor & Michael J. R. Fasham
Southampton Oceanography Centre, European Way, Southampton SO14 3ZH, UK
Email: J.Hemmings@soc.soton.ac.uk

An ability to predict the response of the plankton ecosystem to physical changes in the environment is a prerequisite for quantifying potentially important climate feedbacks. Progress in this area requires the development of ecosystem models which can reliably extrapolate biological predictions from external forcing data describing the environmental variability. Such models can be coupled with general circulation models to give global scale predictions. However, there are major regional differences in the observed annual plankton cycle, summarised by the division of the ocean into biogeochemical provinces, and is unclear to what extent these differences can be explained by the environmental forcing. Factors requiring geographical variations in the ecosystem model's parameters, such as differences in species composition, may also be important. A method is presented for calibrating an ecosystem model for a large geographic domain over which its ideal parameter set cannot be assumed to be invariant. The number and geographic scope of parameter sets are sought which allow the best fit of a given model to validation data to be obtained. These are data not used in the parameter estimation process. The results of testing the method for a simple zero-dimensional phytoplankton-zooplankton-nutrient model, using observations from 30 North Atlantic stations, are presented. The stations were divided into similarly distributed calibration and validation sets. One year of ocean colour data was used in conjunction with climatological estimates of the annual nitrate maximum. The optimal fit to the validation data is given by two regional parameter sets with an associated misfit-based cost 25% lower than that for the parameter set obtained using the full set of calibration stations.

## PS2: 10.13
## Modeling the seasonal $pCO_2$ cycle in the subarctic Pacific ocean

M. Hofmann M. A. M. Maqueda
Potsdam Institute for Climate Impcat Research (PIK), Germany
Email: hofmann@pik-potsdam.de

The subarctic Pacific is believed to play an important role in controlling the global carbon cycle. However, our understanding of the mechanisms that determine the spatial and temporal distributions of $CO_2$ sources ans sinks in this area is still incomlete. Given the enormous complexity of the oceanic $CO_2$ cycle and the lack of systematic observations, numerical models of the coupled ocean-carbonate system are about the only tools available to help gaining such understanding as well as evaluating oceanic $CO_2$ budgets and air-sea $CO_2$ fluxes. Here we present results from a simulation of the seasonal cycle of $CO_2$ with an Ocean GeneralCirculation Model (OGCM) coupled to a carbonate system and plankton dynamics model. Our simulation suggests that the combination of an aeolian iron supply to the ocean and the shoaling of the mixed layer depth during spring triggers a chain of processes that cause a pronounced drop in sea-surface p $CO_2$ during late spring in the western subarctic Pacific.

## PS2: 10.14
## Spatial Patterns of Organic Carbon in Sediment Traps: Application to the LGM Carbon Cycle.

Christine Klaas[1] and David E. Archer[2]
[1] Max Planck Institute for Biogeochemistry, Winzerlaer Strasse 10, 07745 Jena, Germany.
[2] Department of the Geophysical Sciences, The University of Chicago, 5734 S. Ellis Avenue, Chicago, IL 60637.
Email: cklaas@bgc-jena.mpg.de

Model studies have shown that possibly the most important factor driving interglacial glacial variations in atmospheric $pCO_2$ is a change in the Particulate Organic Carbon/$CaCO_3$ (POC/PIC) rain ratio to the sediments caused by shifts in the plankton community in surface water. In a study of vertical flux composition from deep-sea sediment traps we show that deep-sea fluxes of organic carbon are linearly related to mineral fluxes opal, $CaCO_3$ and lithogenic material with most of the POC export being associated to the flux of $CaCO_3$ to the deep ocean. We use the results of the sediment trap analysis to constrain variations in the Particulate Organic Carbon/$CaCO_3$ (POC/PIC) rain ratio to deep-sea sediments in a coupled circulation-carbon cycle model LSG-HAMOCC2 and simulate the effect of plankton community changes on glacial/interglacial $pCO_2$ variability.

## PS2: 10.15
## Assimilation of real time observations into regional 3D-biogeochemical models: The future is bright.

Lampitt R.S., Popova E.E., Send U. and the ANIMATE partnership.
Southampton Oceanography Centre, UK
Institut fuer Meereskunde, Kiel, Germany
Email: R.Lampitt@soc.soton.ac.uk

The ANIMATE project delivers real time data to the public domain every 2 hours on the physical properties of the upper 1000m of the water column at three contrasting deep-water sites in the Northeast Atlantic http://www.soc.soton.ac.uk/animate/. Other variables, (currently recorded *in situ*) of water currents, nutrients, $pCO_2$, fluorescence, backscatter and downward particle flux will become public immediately after instrument recovery and should be available in real time by 2004.
Upper ocean processes can be described by a variety of modelling approaches. We compare results from three approaches all of which are based on the biogeochemical model of Fasham et al (1990). The first is a simple 1D model, the second a basin scale coarse resolution coupled model and the third a regional eddy resolving coupled model.
The 1D upper ocean model was run near to the site of JGOFS NABE and now one of the ANIMATE sites (PAP). The coarse resolution coupled global model embeds biogeochemistry into a general circulation model (OCCAM) with a horizontal resolution of 1 degree. The eddy resolving model uses the Harvard Ocean Prediction System with a horizontal resolution of a few kilometres. With data assimilation this was used to reproduce and analyse ecosystem variability just south of the PAP ANIMATE observatory in April-May 1997 and at the Iceland-Faeroes Front in June 2001. In both cases the model was run in real time in conjunction with research cruises and satellite remote sensing to provide model initialisation, data assimilation and forecast verification.
The opportunity is now available to exploit and assimilate *in-situ*, satellite and historical data into a variety of 3D coupled biogeochemical models and for this to provide descriptions and forecasts of the biogeochemical system that have never been achieved to date. The linkage between data gathering and modelling is rapidly becoming stronger- the future is bright.

## PS2: 10.16

## Using the 3D coupled physical-biological model MIRO&CO to assess Phaeocystis blooms and related C, N, P and Si cycling in the Southern Bight of the North Sea and the response to short-term climatic and nutrient changes.

C. Lancelot[1], K. Ruddick[2], Y. Spitz[3], G. Lacroix[2], N. Gypens[1], V. Rousseau[1], S. Becquevort[1], J-Y. Parent[1], E. Breton[1], G. Déliat, C[1]. Leblanc[1], M-H Daro[4], S. Gasparini[4], E. Antajan[4], J.Ozer[2]
[1] Ecologie des Systemes Aquatiques, Universite Libre de Bruxelles CP-221, bd du Triomphe, B-1050, Belgium
[2] Management Unit Of North Sea Mathematical Models, Gulledelle 100, B-1200
Email: lancelot@ulb.ac.be

There is increasing evidence that the North Atlantic Oscillation (NAO) has a substantial impact on phytoplankton bloom dynamics and species dominance in the northwest European shelf seas. However mechanisms are still poorly understood and the added influence of human activity is generally overlooked. Such is the case in the Southern Bight of the North Sea, a highly dynamic system with water masses resulting from the variable mixing between the inflowing southwest Atlantic waters through the Strait of Dover and freshwater and nutrient inputs from the Scheldt and Rhine rivers.
Here we use a 3D coupled physical-biological model (MIRO&CO) to explore the dual role of short-term climate variability and nutrient loads of anthropogenic origin on the magnitude and extent of diatom-Phaeocystis blooms in the Southern Bight of the North Sea during the last decade. MIRO&CO results of the online coupling of the COHERENS 3D hydrodynamic model and the complex ecological model MIRO chosen to resolve the changing nutrients loads, the complex biology and hydrodynamics and the tight coupling between the benthic and pelagic realm that characterises the coastal shelf ecosystem. The 3D-MIRO&CO model was run to simulate the annual cycle of inorganic and organic nutrients, phytoplankton (diatoms & Phaeocytis), bacteria and zooplankton (microzooplankton & copepods) in the Southern Bight of the North Sea for the period 1990-2000. These model runs give for the first time a general view of interannual and spatial variability of blooms and nutrient cycling within the domain. Additional MIRO&CO runs are conducted to explore the ecosystem response to several nutrient reduction scenarios under contrasting climate conditions.

## PS2: 10.17
## Modelling the climate-related fluctuations of tuna populations from coupled ocean-biogeochemical-populations dynamics models

Patrick Lehodey
SPC, BP D5, 98848 Noumea cedex, NEW CALEDONIA
Email: Patrickl@spc.int

To explore the underlying mechanisms by which the environmental variability affects the pelagic ecosystem and tuna populations, a spatial environmental population dynamic model (SEPODYM) has been developed. The model is a 2D coupled physical-biological interaction model at the scale of ocean basin, combining a forage (prey) production model with an age structured population model of targeted (tuna predator) species. The model contains environmental and spatial components used to constrain the movement and the recruitment of tuna. Input data set for the model are sea surface temperature, oceanic currents, dissolved oxygen concentration and primary production predicted from coupled physical-biogechemical models. Applications to two tuna species, skipjack (*Katsuwonus pelamis*) and albacore (*Thunnus alalunga*) in the Pacific Ocean are presented. Simulations reproduce both interannual and decadal fluctuations predicted independently from a statistical population model using large fishing data sets. The impact of the climate signals appear to be opposite according to the species. El Niño event have a positive influence on the recruitment of skipjack while the effect would be negative on the albacore.

## PS2: 10.18
## Modeling Study on the Ecosystem of the Bohai Sea using a Coupled Three-dimensional Physical-chemical-biological Ocean Model

Liu Guimei, Sun Song, Wang Hui, Zhu Jang, and Han Boping
Institute of Oceanology, Chinese Academy of Sciences, Nanhai Road 7, Qingdao, 266071, China
Email: liuguimei@ms.qdio.ac.cn

Bohai Sea locates at the north of the East China Sea (37°-41°N, 117°-123°E). The source of nutrients is considered to be over one hundreds riverine inputs (Fei, 1988a). In recent years, the development of the industry has made the nutrient structure changed dramatically. The nitrogen appears increasing and the phosphate is decreasing (Yu, 2000). Meanwhile, the averaging primary production has been decreasing in the Bohai Sea (Lu, 1999). The harmful algal blooms happen frequently, which has influenced the ecosystem environment and fishery production significantly. Since the physical processes play an important role in regulating the nutrients and phytoplankton, a coupled physical and biological model is a useful tool to study the ecosystem of Bohai Sea.
The physical model is a three-dimensional coastal ocean circulation model originated by Blumberg and Mellor (1987) incorporating with the Mellor and Yamada (1974 & 1982) level 2.5 turbulent closure scheme. Physical processes include the M2 tide, winds and water discharge. The biological model is a simple, nitrate and phosphate based, lower trophic food web system basing on the NPZ model (Franks, 1996). The model results showed the wind variation lead to the changing of the residual currents, but only showed its impact on the phytoplankton distribution at Laizhou Bay where the phytoplankton density was higher. The transparence had impacts on the distribution pattern of phytoplankton. The upwelling motion was helpful to the forming of the phytoplankton patches and the downwelling motion was helpful to the aggregation of the phytoplankton in the subsurface when the turbulent mixing is not strong enough to mix the whole water column. Algal bloom may occur at the river mouth due to the nutrient riverine inputs.

## PS2: 10.19
## Modeling the relationship between climate and marine dissolved organic matter

Markus Pahlow, Alain F. Vezina, Daniel G. Wright
Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, N.S. B2Y 4A2, Canada
Email: pahlowm@mar.dfo-mpo.gc.ca

Dissolved organic matter (DOM) is the dominant form of organic carbon in the ocean and forms a significant part of the global carbon cycle. We developed a general model of plankton and DOM dynamics with a simple representation of the major biological, physical, and photochemical processes of DOM production, transport, and removal. The model was coupled to a 2D model of the global thermohaline circulation for long-term climate studies. When forced with current climatic conditions the model successfully reproduces the global DOM distribution. Experiments with different climatic forcing conditions reveal a strong negative relationship between global ocean temperature and total DOM content. This negative temporal relationship results mainly from biological processes and is not related to the positive correlation between temperature and DOM in the surface ocean, which is due to physical processes. Total oceanic DOM content changed by as much as 50GtC per Kelvin change in average ocean temperature. Modeled changes in DOM content do not require changes in nutrient conditions in the surface ocean. The negative relation between temperature and DOM implies a positive climatic feedback between temperature and $CO_2$. Because of its strength and independence from inorganic nutrients, this positive feedback could explain most of the glacial-interglacial difference in atmospheric $CO_2$. The feedback could be even stronger if changes in photochemical DOM removal owing to ice-cover variations were considered.

## PS2: 10.20
## Models of the Global Ocean Iron Cycle and Ocean Productivity

Payal Parekh, Stephanie Dutkiewicz, Mick Follows
Department of Earth, Atmosphere and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA
Email: mick@mit.edu

We use a hierarchy of ocean circulation and biogeochemistry models to examine parameterizations of the cycling of iron in the deep ocean and their influence on surface ocean biologicical productivity. We formulate a mechanistic model of iron cycling in the deep ocean, which includes representations of scavenging onto sinking particles, desorption from those particles and complexation with an organic ligand. The iron cycle is coupled to a model of the global ocean cycle of phosphorus, which includes representations of phosphate and dissolved organic phosphorus. Export production is limited by the availability of light, phosphate and iron. We examine the iron cycle model in the context of a highly idealized box model of the oceans which has prescribed volume transports and mixing rates. The Aeolian source of iron to the surface ocean is prescribed. With appropriate choice of parameter values, the model can be brought into consistency with the relatively sparse ocean observations of iron in the oceans. It captures the decrease in deep, dissolved iron concentration from North Atlantic to Southern Ocean with values somewhere in between in the Pacific basin. With a relatively low complexation coefficient and high value for the specified total amount of organic ligand, the model also indicates the prescence of significant amounts of free ligand, as has been observed. In addition, the phosphate distribution is consistent with the observed climatology. We examine the sensitivities of the iron and phosphate distributions, and export production, to variations in dust flux and model parameters. We also implement this biogeochemical scheme in a coarse resolution ocean general circulation model, guided by box model senstivity studies. This model is also able to reproduce the broad regional patterns of iron and phosphorus. In particular, the high macro-nutrient concentrations of the Southern Oceans result from iron limitation in the model. We also replace the simplified export production parameterization with an explicit ocean ecosystem model from which we will show initial results.

## PS2: 10.21

## Year-to-year variability phytoplankton bloom in southern Adriatic Sea (1998-2000): SeaWiFS observation and modelling study

R. Santoleri,V.  Banzon, S. Marullo, , E. Napolitano, F. D'Ortenzio, R. Evans
Ente per le Nuove tecnologie l'Energia e l'Ambiente - Centro Ricerche Casaccia  Roma - Italy
Email: ernesto.napolitano@casaccia.enea.it

The year-to-year variability in the timing, duration, and spatial extent of the surface phytoplankton bloom is examined in the southern Adriatic Sea using SeaWiFS-derived chlorophyll images for three years (1998, 1999, 2000) over the winter-spring period. Each year's image time series shows that blooms were intermittent and differed in onset, duration, and intensity with relative low values observed in 2000. The relation between atmospheric forcing and inter-annual variability of the bloom timing and intensity is investigated using a coupled physical-biological model. The model is used to investigate  the effect of cumulative buoyancy loss on convective depths and its implications on surface nutrient availability, chlorophyll concentrations, and other ecosystem components during the study period. In this paper we tested the hypothesis whether the South Adriatic bloom is essentially controlled by the local winter climatic conditions (as suggested by recent findings) or also depends crucially by the year-to-year variability of the nutrients budget available in the intermediate depths (200-800m). It results that the maximum convective depth is not the only factor controlling the plankton production, although it does determine nutrient availability, but in combination with particular nutrient pool. As consequence, the most probable explanation for the low SeaWiFS phytoplankton biomass observed in 2000 is the reduced nutrient pool due to the return from the Transient phase to the pre-Transient regime of the Mediterranean Sea. Our  results indicate that the South Adriatic bloom is a complex phenomenon, and cannot simply be explained by interannual changes in convective depth.

## PS2: 10.22
## Ecological modeling in coastal area: from nutrient dynamics to marine resources under different scenarios of human activity and physical forcing. Examples from a real case study

C.Solidoro, G.Cossarini, D.Melaku Canu, R.Pastres, V.Mosetti, I.Tomini
Istituto Nazionale di Oceanografia e di Geofisica Sperimentale OGS, Borgo Grotta Giagante 42c 34010 Sgonico TS Italy
Email: csolidoro@ogs.trieste.it

Models provide a framework for integration and synthesis of existing knowledge about an ecosystem, and might offer important contributions for understanding the scale of human disturbance and the potential effectiveness of restoration action. In addition they provide the quantitative knowledge which is required for evaluation, at ecological and economic levels, of consequences of the implementation of possible alternative scenarios of policy options. Coastal area, and estuaries, are particularly important sites, since they are very sensitive to antropic impact and very valuable. We present applications of a long term modeling study on the Lagoon of Venice, which is the largest Italian lagoon. A 3D fully coupled transport water quality model has been developed, validated against a substantial amount of real world data, and used to investigate nutrient cycles, primary production and water quality level. A keener interpretation of data collected in monitoring programs were derived, together with indications on ‘natural’ spatial-temporal variability, on fluxes which were not measured, and on the importance of exchanges with the sea. The model has then been used to analyze the effects of different scenarios of loading from the drainage basin, and to solve the inverse problem of the identification of Maximum Permissible Load that are compatible with predefined Water Quality Target. Other applications include the integration of the model with a model for growth and population dynamic of clams, and identification of economically efficient and ecologically sound policies for exploitation of this renewable resource.

## PS2: 10.23
## Modelling the deep ocean carbon cycle as part of the Centre for observation of Air-Sea Interactions and fluXes (CASIX)

Steve Spall[1], Rosa Barciela[1], Spencer Liddicoat[1] and Jim Aiken[2]
[1] Met Office, London Road, Bracknell, RG12 2SY, UK
[2] Plymouth Marine Laboratory, Prospect Place, The Hoe, Plymouth, PL1 3DH, UK
Email: steven.spall@metoffice.com

The Centre for observation of Air-Sea Interactions and fluXes (CASIX) is a geographically distributed research centre funded by the UK Natural Environment Research Council. Its primary goal is to quantify accurately the global air-sea fluxes of $CO_2$. One component of CASIX to help achieve this goal is the use of numerical models. The modelling aspect will include detailed air-sea interface modelling, high resolution 3-D shelf sea modelling and deep ocean carbon cycle modelling. The latter is to make use of the Hadley Centre Ocean Carbon Cycle model (HadOCC) embedded in the Met Office Forecasting Ocean Assimilation Model (FOAM).
The FOAM system is a suite of nested ocean models which assimilate various types of physical data to give a best estimate of the present physical state of the ocean, plus provide five day forecasts. By using an ocean carbon cycle model in this realistic physical context,it is envisaged that a best estimate of short time-scale variability in global air-sea fluxes of $CO_2$ can be derived. In order to improve these estimates, the assimilation of ocean biogeochemistry data into the modelling system is to be investigated, for example assimilation of satellite derived chlorophyll. Also other aspects of CASIX aim to deliver improved parameterisations for use in the hierarchy of models.
This presentation will show the aims of CASIX from the global modeling perspective, show how different aspects of CASIX will feed into this modelling effort and present some preliminary results from coupling the HadOCC model to FOAM.

## PS2: 10.24
## Modeling the aggregation of dissolved polysaccharides during a marine phytoplankton bloom

Silke Thoms and Anja Engel
Alfred Wegener Institute for Polar and Marine Research, PO Box 12 01 61, D-27515 Bremerhaven, Germany
Email: sthoms@awi-bremerhaven.de

Aggregation of dissolved polysaccharides may have important implications for the organic carbon cycle in the ocean. Especially under nutrient limitation, phytoplankton are a source for extracellular carbon, as the cells release a significant part of the fixed $CO_2$ in the form of extracellular polysaccharides. Under the hypothesis that the exopolysaccharides coagulate into transparent exopolymer particles (TEP), a simple aggregation model was developed. The model allows for a time-dependent description of concentration of exopolysaccharides and TEP during a bloom experiment with the coccolithophorid *Emiliania huxleyi*.

## PS2: 10.25
## Analysis of HPLC pigment database : Towards a climatology of phytoplankton functional groups

Julia Uitz[1], Hervé Claustre[1], André More;[1] & Stanford Hooker[2]
[1] Laboratoire d'Océanographie de Villefranche, CNRS/INSU & Université Pierre et Marie Curie, Quai de la Darse, BP 08, 06238 Villefranche sur mer cedex FRANCE
[2] NASA/GSFC/Code 970.2, Bldg 28 Room W126, Greenbelt, MD 20771
Email: uitz@obs-vlfr.fr

The objective of this study was to investigate the possible relationship between the composition of phytoplankton communities and the chlorophyll a concentration in the surface layer ($Chl_{as}$), as potentially derived from remote sensing techniques of ocean colour. We analyse a HPLC-determined pigment database, which encompasses a wide range (more than 1650 stations) of trophic and hydrodynamic conditions. From accessory pigment composition, $Chl_a$ is partitioned into three phytoplankton functional group proxies, micro-, nano- and pico- $Chl_a$ (Vidussi et al. 2001, 106, 19,939-19,956), which quantify the $Chl_a$ biomass associated with three main phytoplankton size classes. We show that the vertical distribution of these indices heavily depends on the trophic status : Micro- $Chl_a$ is mostly associated with eutrophic regimes while pico- $Chl_a$ is typical of oligotrophic ones ; nano- $Chl_a$ is distributed in a more ubiquist manner. Furthermore, we demonstrate that these distributions can be parameterised from $Chl_{as}$, which opens the perspective of mapping phytoplankton community composition at the global scale from ocean colour. The interest of such developments for the refinement of bio-optical and biogeochemical models is discussed.

## PS2: 10.26
## A model of iron cycling in the mixed layer of the ocean

Lisa Weber[1], Christoph Völker[2], Markus Schartau, Dieter Wolf-Gladrow
Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany
[1] now at: Institut fuer Meereskunde, Kiel, Germany
[2] now at: Canadian Centre for Climate Modelling and Analysis,
Victoria, Canada
Email: dwolf@awi-bremerhaven.de

The speciation of iron within the mixed layer is heavily influenced by photochemistry, organic complexation, colloid formation and aggregation, as well as uptake and release by marine biota. Here we present a comprehensive model of these processes. Our model predicts the time course of iron concentration and speciation, driven by mixed layer dynamics, dust deposition, and insolation. Parameters in the model were chosen to reproduce the small number of available speciation measurements resolving a daily cycle. We discuss whether the most important model parameters are constrained by the data and discuss the model's sensitivity to parameter uncertainties. The model is coupled to a simple ecosystem model (based on Schartau at al.2001) and applied to the site of the Bermuda Atlantic Time-series Study (BATS). The mixed layer cycle in the model strongly influences seasonality of primary production, light dependency of photoreductive processes and therefore controlling iron speciation. Our model is almost insensitive to the dominant form of dissolved iron within wet dust deposition and also to the form of iron that is taken up directly during algal growth. This may allow to simplify the model for implementation into 3-d biogeochemical models. For this reason we compare our first results to results of a simplified model version that does not explicitly resolve the fast photochemical processes. The model clearly reproduces the available Fe concentration at the BATS station. The annual balance of Fe fluxes at BATS is not very well constrained, due to uncertainties in the model parameters. Finally, we discuss which observations might help to better constrain the relevant model parameters.

## PS2: 10.27
## Predictability of the plankton ecosystem

J.D.Woods
Imperial College London
Email: j.woods@ic.ac.uk

To study how the plankton ecosystem (and its biofeedback to the environment) change in response to natural and anthopogenic forcing, it is necessary to understand the intrinsic stability of the ecosystem, and the limits to predictability of models used to simulate how it changes. Research in the 20th century revealed that simple models of predator-prey dynamics exhibit chaotic instability, as can complex simulation models based on Eulerian integration. Simulations based on the Lagrangian Ensemble integration of individual-based models are stable. They successfully to predict the change of the biological pump as the atmospheric concentration of pCO2 changes according to the IPCC Business-as-usual scenario. This makes the Lagrangian Ensemble method ideal for research in the Ocean programme.
The LE method is also effective in computing emergent mesoscale biodiversity: the consequence of mescoscale jets broadening the distribution of relative biodiversity of plankton species.
The two barriers to adopting individual-based modelling have been (1) high cost of computation, and (2) the need for software engineers to create new codes. These barriers has been broken by the advent of affordable computer clusters and development of the Virtual Ecology Workbench, which automates the production and analysis of virtual plankton ecosystems.

## PS2: 10.28
## Preliminary results from a marine ecosystem model

Yasuhiro Yamanaka, Maki N. Aita, and Michio J. Kishi
Frontier Research System for Global Change, Yokohama, 236-0001, Japan
Email: galapen@jamstec.go.jp

To predict the effects of global warming on ecosystem dynamics and the effects of those changes in ecosystem dynamics on biogeochemical cycles and oceanic $CO_2$ uptake, we need to develop Biogechemical General Circulation Models (BGCMs) which represent explicitly the dynamics of oceanic ecosystems and settling particles. During the last few years, we have been developing a one dimensional ecosystem model with Nitrogen-Silicon-Carbon cycles, which is an extension of the NEMURO model developed by PICES. We have applied this model to several Times Series Stations: HOT, Papa, KNOT, and A7 (the last two stations are in the western North Pacific and are maintained by Japanese groups). We show our results after a time integration of sixteen years for OGCM only and six years for our ecosystem coupled with OGCM. In our preliminary results, unrealistic high primary production in the equatorial regions is obtained, though the model results in the other regions agree roughly with observations. We still need to tune the biological parameters (at present, we use global constants tuned the optimal values for the subarctic Pacific for each biological parameters): introducing temperature dependence and iron-limitation. For the equatorial regions, we also need to improve physics in our model.