2009 ROMS/TOMS Asia-Pacific Workshop

Sydney Institute of Marine Science
Sydney, Australia
March 31 - April 2, 2009

Organized by: H. G. Arango, J. L. Wilkin, C. R. Sherwood, M. Roughan, and D. Cox

In Memory of Robert Osborne Reid (1921 - 2009)

Getting to the Workshop W

From Sydney Airport:

Via Car/Taxi:

SIMS is approximately **22km** by road from Sydney Airport. It is located near the end of Chowder Bay Road, where a limited amount of free parking is available. Additional parking is available in the nearby Clifton Gardens Reserve parking area, which is accessible via Morella Road, Clifton Gardens. Council parking fees apply here and you will need to walk across the park and beach to get to SIMS.

Via Train/Bus:

The Workshop venue can be reached from Sydney Airport using a combination of train and bus. Take the train from Sydney Airport to Wynyard station. At **Wynyard station**, take the lift up to street level (Carrington Street) where you can catch the **244** bus from Stand A directly to SIMS. Allow approximately **90 minutes** total travel time from the airport.

From the recommended North Sydney hotels:

Via Car/Taxi:

SIMS is located near the end of Chowder Bay Road, Georges Heights. Limited free parking is available at SIMS.

Additional parking is available in the nearby Clifton Gardens Reserve parking area, which is accessible via Morella Road, Clifton Gardens. Council parking fees apply here and you will need to walk across the park and beach to get to SIMS.

Via Bus:

Full information about the Sydney Bus service, including timetables, can be found at:

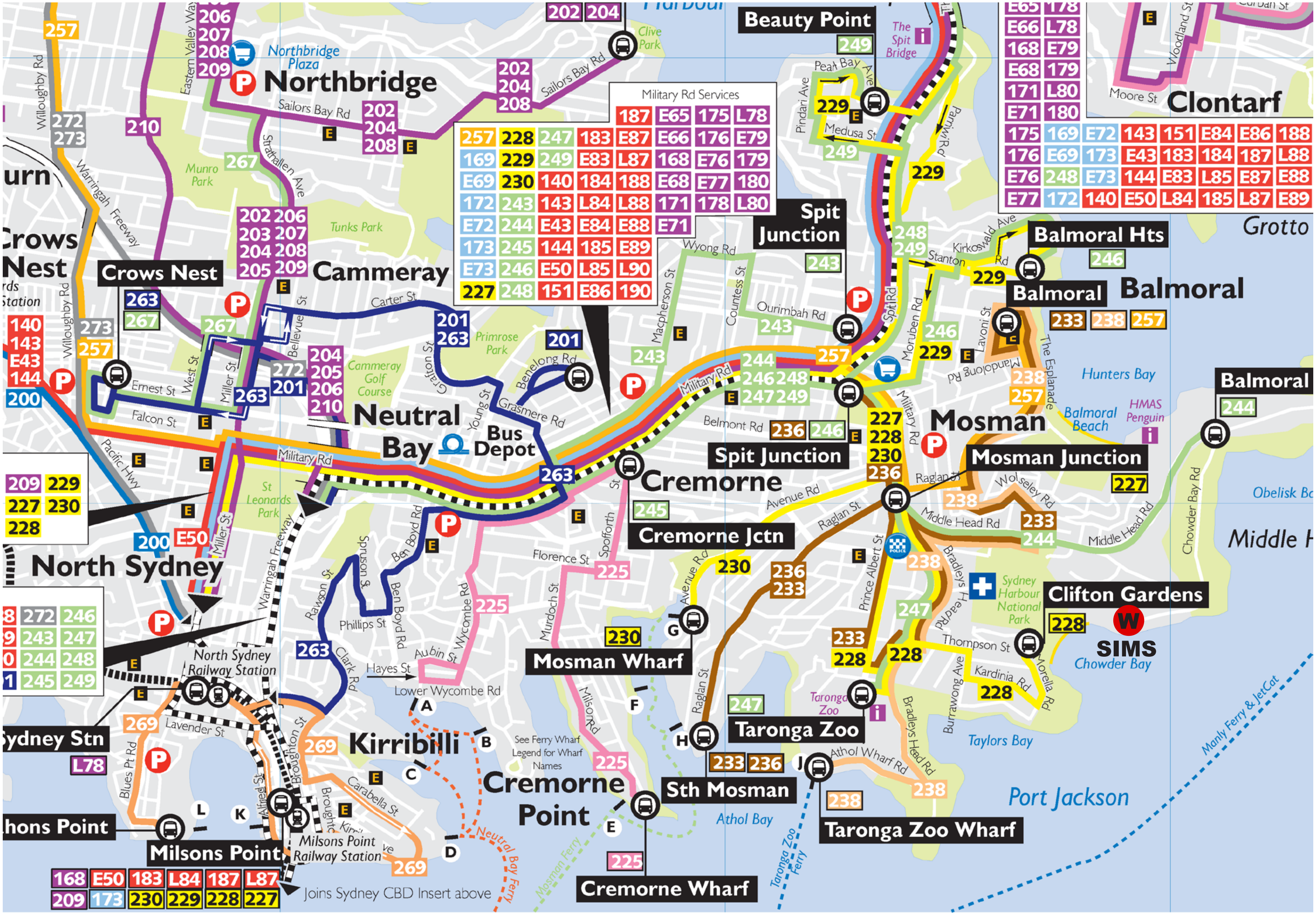
http://www.sydneybuses.info/

A map of all North Sydney bus routes can be found on page 4. There are two bus routes available Monday - Friday:

1. **Route 244:** This service is available from Wynyard Station and operates via Military Road terminating at Chowder Bay. **NOTE:** Available timetable states that service terminates at Balmoral Naval Depot, this is incorrect service now runs to and terminates at Chowder Bay.
2. **Route 228:** This service is available from Milson Point Station and runs via North Sydney Station and Military Road, terminating at Clifton Gardens Reserve. **NOTE:** This service does terminate at the reserve opposite Chowder Bay and you are required to walk across the beach to access SIMS.

- From **hotel 1**, take either the **244** or **228** buses from Military Road.
- From **hotel 2**, take the **225** bus from Milson Road up the hill to the intersection of Spofforth Street and Military Road, cross to the opposite side of Military Road and then take either the **244** or **228** bus.
- From **hotel 3**, take either the **244** bus along Middle Head Road or the **228** bus along Bradleys Head Road. Alternatively, it is only a 20-25 minute walk from Hotel 3 to SIMS via Bradleys Head Road, Thompson Street, David Street and Morella Road.
- From **hotels 4, 5, 6 and 7** in the North Sydney area use the **228** bus.

Map 1: North Sydney Bus Routes

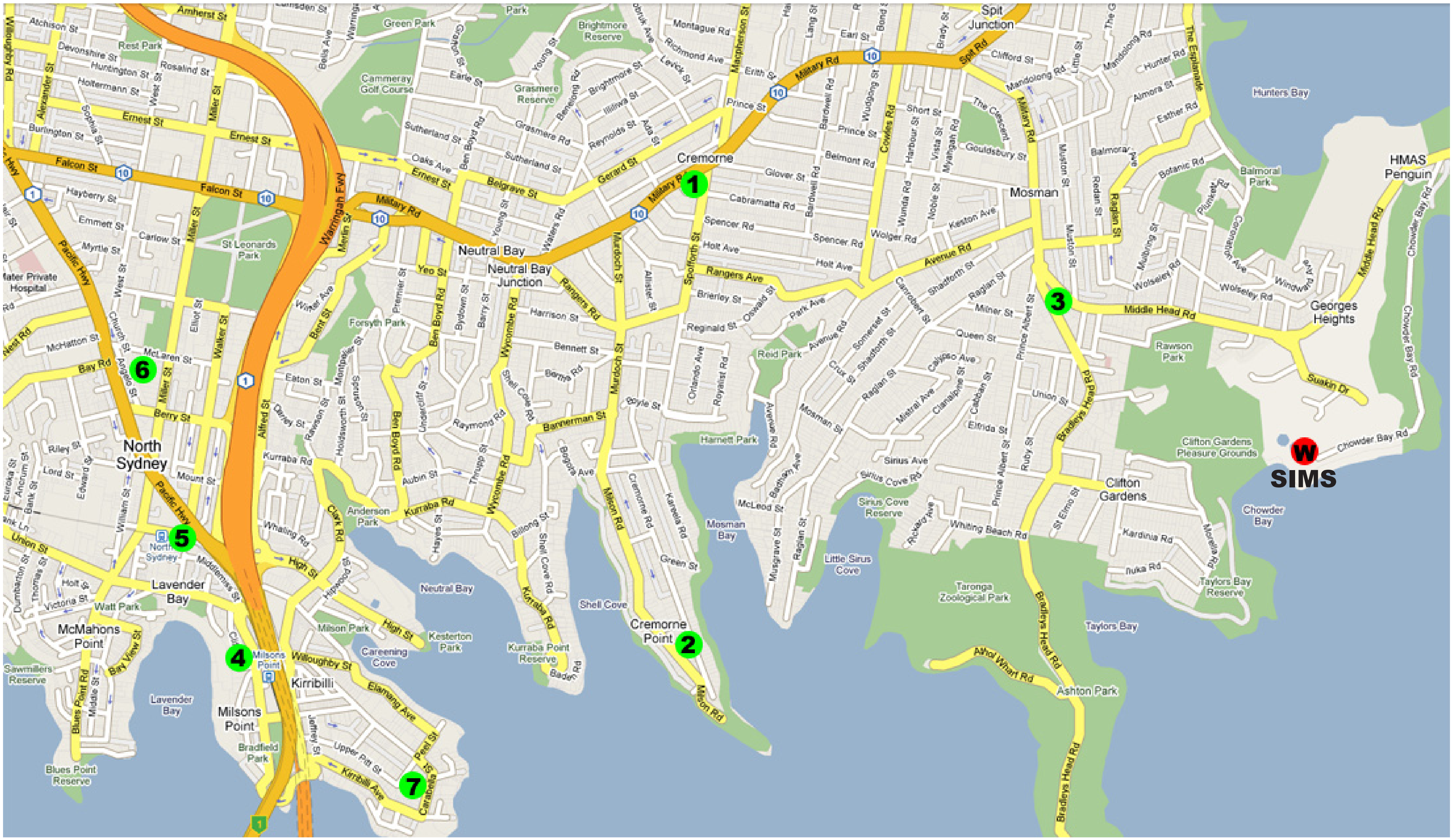


Map2: Parking (yellow) and Meeting location (blue circle)

Map 3: North Sydney Hotels and Workshop Location

1. Park Regis Concierge Apartments
2. Cremorne Point Manor
3. Buena Vista Hotel
4. Vibe Hotel, North Sydney
5. North Sydney Harbourview Hotel
6. McLaren Hotel
7. Glenferrie Lodge

W. Sydney Institute of Marine Science (SIMS)



Sydney Tourist Information

Whether you're looking for outdoor adventure or cosmopolitan culture, Sydney's got it. Climb to the top of the Harbour Bridge or take a skywalk on Sydney Tower for a 360-degree view of the city. Stroll through the Botanical Gardens or take a tour of the Opera House. Cuddle koalas in the Taronga Park Zoo or learn to surf at Bondi Beach. For quaint cafés and shopping, visit The Rocks, Sydney's historic district. For everything from beaches to ballet, you're bound to enjoy your Harbour City stay.

Some of the more popular tourist attractions are:

1. **Taronga Zoo:** Open 9am to 5pm every day and situated on the north side of Sydney Harbour, Taronga Zoo is an experience not to be missed. Located just 12 minutes from the city by ferry, Taronga Zoo offers free keeper talks, animal shows and feedings throughout the day. Taronga Zoo is home to over 2900 exotic and native species.

2. **BridgeClimb:** The Bridge Climb takes you along the upper span of the Sydney Harbour Bridge on catwalks and ladders all the way to the summit, 134 meters above Sydney Harbour. The Discovery Climb is a new experience that takes you inside the workings of the Sydney Harbour Bridge for a behind-the-scenes look at this Australian icon. You will be led to the summit upon the suspension arch of the Bridge, winding around structural elements and climbing steep staircases that join the two arches.

3. **Sydney Opera House:** One of the worlds most recognisable buildings. The Sydney Opera House (build from 1957 to 1973) is a masterpiece of late modern architecture. It is admired internationally and proudly treasured by the people of Australia.

4. **Museum of Contemporary Art (MCA):** The Museum of Contemporary Art is Australia's only museum dedicated to exhibiting, interpreting and collecting contemporary art from across Australia and around the world. With a continually changing program of exhibitions there's always something new, exciting and inspiring to see at the MCA.

5. **Lady MacQuarie's Chair:** Mrs. Macquairie's Chair, otherwise known as Lady Macquarie's Chair, provides one of the best vantage points in Sydney. The historic chair was carved out of a rock ledge for Governor Lachlan Macquarie's wife, Elizabeth, as she was known to visit the area and sit enjoying the panoramic views of the harbour.

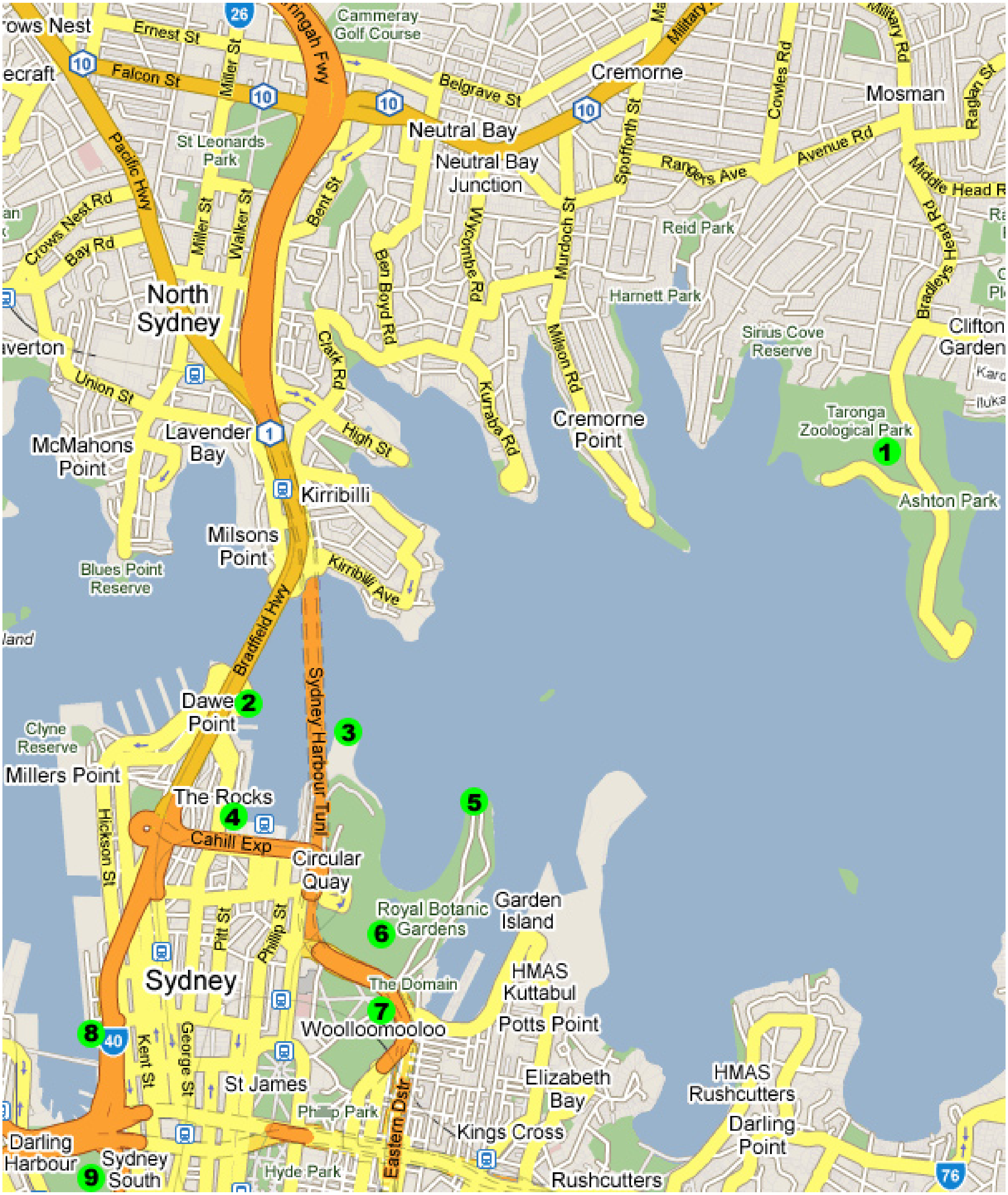
6. **Royal Botanical Gardens:** The Royal Botanic Gardens is a place of natural beauty, where people come for peace, relaxation, education, and to learn more about plants and horticulture. The surrounding parkland of the Domain is a place for sport, entertainment and recreation.

7. **Art Gallery of New South Wales:** The Art Gallery of New South Wales is the leading museum of art in New South Wales and Sydney, and one of Australia's foremost cultural institutions. It holds significant collections of Australian, European and Asian art, and presents nearly forty exhibitions annually.

8. **Sydney Aquarium:** Sydney Aquarium is a must-see, and one of the best things to do in Sydney. Walk under water and explore Australia's rich and diverse aquatic life and habitats.

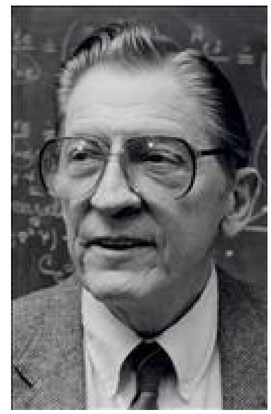
9. **Chinese Friendship Garden:** Initiated by the local Chinese community to share their rich cultural heritage and celebrate Australia's 1988 Bicentenary, the Chinese Garden is the result of a close bond of friendship and cooperation between the sister cities of Sydney and Guangzhou in Guangdong Province, China.

Map 4: Sydney Tourist Attractions



In Memoriam

Robert Osborne Reid
(1921-2009)



On January 23, 2009 the physical oceanography community lost one of its greatest professors, graduate student advisors, and pioneer modelers. Robert Osborne Reid studied at UCLA and later engineering at USC. At UCLA he participated in special Army training in Meteorology and went on to be commissioned as a Second Lieutenant in the Army Air Corps as a weather officer. He was sent to England and was eventually assigned to Project Overlord, where he was a member of a team that predicted weather and tides for the Allied Invasion of France on D-Day.

It was in these wartime experiences that he found his interest in oceanography and developed some lifetime bonds with fellow scientists that became lifelong colleagues. At the end of the War he completed his education at the Scripps Institution of Oceanography in La Jolla, California under the guidance of Harold U. Sverdrup and Carl Eckart. He sited Sverdrup and Eckart as the two men who have had the greatest impact on his professional outlook.

Bob Reid went to Texas A&M University, College Station, TX, in 1948 as an assistant professor at the newly formed department of Oceanography and Meteorology. During his distinguished career of research, teaching and advising, he received many honors including four Distinguished Teaching Awards and a Distinguished Research Award. In 1978 he received the Medal of the University of Liege, Belgium. He was elected to the National Academy of Engineering in 1985 for his pioneering contributions to hydrodynamical theory/ applications, wave force analysis, storm tide prediction, tsunami flooding estimation, and for superlative teaching. He was also a member of the National Academy of Sciences, a Fellow of the American Geophysical Union and the American Meteorological Society, and has an Honorary Doctor of Science degree from Old Dominion University. He was the founding editor of the Journal of Physical Oceanography from 1970 to 1980. He wrote a very insightful editorial commentary for the Journal's twenty-fifth anniversary. He served as Head of the Department of Oceanography at Texas A&M University from 1981 to 1987. Upon his retirement in 1987, he was named Distinguished Professor Emeritus in Oceanography and a Symposium was held to celebrate his illustrious career. During his tenure, he chaired or co-chaired over 70 PhD and MS students. The dedication page of the symposium program reads:

> We, his M.S. and Ph.D. Students, believe that Professor Reid's greatest academic achievement has been in the guidance of graduate students. His scientific competence and interest combined with his kindness and patience make him uniquely qualified to guide graduate research.... We consider ourselves most fortunate in both the personal and professional sense to have had Professor Reid as a major professor - for we had the best. To honor his exceptional guidance of graduate students we dedicate this Symposium on the Practice of Physical Oceanography to Professor Robert O. Reid.

Professor Reid was graduate advisor to Hernan Arango at Texas A&M.

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PROGRAM

---------- Tuesday, March 31, 2009 ----------

08:00-08:50 Registration

08:50-09:00 Welcome and Logistics

Chairperson: Moninya Roughan

09:00-09:30 (30 min) Charitha Pattiaratchi, UWA, Australia
Applications of ROMS along the west and south coasts of Western Australia

09:30-10:00 (30 min) Robin Robertson, UNSW at ADFA, Australia
Vertical Mixing from ROMS

10:00-10:30 Break (30 min)

Chairperson: John Wilkin

10:30-11:00 (30 min) Ben Galton-Fenzi, CSIRO, UTas, Australia
Modelling marine ice accretion beneath ice shelves

11:00-11:30 (30 min) Mark Hadfield, NIWA, New Zealand
Nested simulations of coastal currents for larval dispersal

11:30-12:00 (30 min) Charles Dong, UC Los Angeles, USA
Simulation of an Upwelling Event in the Southern California Bight

12:00-14:00 Catered Lunch, Posters, and Discussion

Chairperson: Deborah Cox

14:00-14:30 (30 min) Philippe Estrade, UNSW, Australia
A numerical study of island wake generated by an elliptical tidal flow

14:30-15:00 (30 min) Madeleine Cahill, CSIRO, Australia
Modeling Tropical Cyclones on the Northwest Shelf of Australia

15:00-15:30 (30 min) Francis Pavanathara, INCOIS, India
Contrasting summer monsoon cold pool south of the Indian Peninsula

15:30-16:00 Afternoon Tea (30 min)

---------- Wednesday, April 1, 2009 ----------

Chairperson: Hernan G. Arango

09:00-10:00 (60 min) Andrew M. Moore, UC Santa Cruz, USA
ROMS 4D-Var: The Complete Picture

10:00-10:30 (30 min) Jerome Fiechter, UC Santa Cruz, USA
Improving ecosystem model prediction through data assimilation

10:30-11:00 Break (30 min)

Chairperson: Andrew M. Moore

11:00-11:30 (30 min) John Wilkin, IMCS, Rutgers University, USA
Predictability of Mesoscale Variability in the East Australia Current System given Strong Constraint Data Assimilation

11:30-12:00 (30 min) Byoung-Ju, Choi, Kunsan National U., Korea
Assimilation of Sea Surface Temperature into a Northwest Pacific Ocean Model using an Ensemble Kalman Filter

12:00-12:30 (30 min) Hernan G. Arango, IMCS, Rutgers U., USA
ROMS Framework and Algorithms

12:30-14:30 Catered Lunch, Posters, and Discussion

Chairperson: Mark Hadfield

14:30-15:00 (30 min) Uwe Rosebrock, CSIRO, Australia
Relocatable Ocean and Atmosphere Model Control System

15:00-15:30 (30 min) Richard P. Signell, USGS - Woods Hole, USA
Web service tools and techniques for ROMS users

15:30-16:00 (30 min) David Robertson, IMCS, Rutgers U., USA
ROMS: NetCDF and Matlab

16:00-16:30 Afternoon Tea (30 min)

16:30-20:00 Group Pictures
Harbour Cruise and Reception
Departure from SIMS Wharf

PROGRAM

---------- Thursday, April 2, 2009 ----------

Chairperson: Richard P. Signell

09:00-09:30 (30 min) Christopher R Sherwood, USGS, USA
Wayne Geyer, WHOI, USA
Update on the NOPP-CSTM Project

09:30-10:00 (30 min) Christopher R. Sherwood, USGS, USA
Coupled modeling of waves, currents, bedforms, and suspended sediment on the inner shelf

10:00-10:30 Break (30 min)

Chairperson: Christopher R. Sherwood

10:30-11:00 (30 min) Courtney Harris, VIMS, USA
Linking Sediment and Biological Processes within the Regional Ocean Modeling System (ROMS)

11:00-11:30 (30 min) Yusuke Uchiyama, UC, Los Angeles, USA
Wave-current interaction in ROMS: A vortex-force formalism

11:30-12:00 (30 min) Liejun Zhong, CSIRO, Australia
Wave-driven circulation in a complex reef dominated coastal environment off South West Western Australia

12:00-14:00 Catered Lunch, Posters, and Discussion

Chairperson: Madeleine Cahill

14:00-14:30 (30 min) Carlos Teixeira, UNSW/ SARDI, Australia
Application of ROMS for the Spencer Gulf and on the adjacent shelf of South Australia

14:30-15:00 (30 min) David Correa, IMARPE, Peru
Impact of high resolution wind forcing on the mesoscale circulation and surface productivity off south Peru in relation with the VOCALS-Regional-Experiment

15:00-15:30 (30 min) Mark Baird, CSIRO, Australia
Coupled physical-biological modelling of the waters off southeast Australia

15:30-16:00 Afternoon Tea (30 min)

Posters

1. Harris, Courtney, VIMS, USA
Integrating space- and time-scales of sediment transport for Poverty Bay, New Zealand, and the nearfield continental shelf

2. Jaffrés, Jasmine, James Cook University, Australia
Long-term changes in pCO_2 within the Coral Sea

3. Kim, Chang-Sin, Chonnam National University, Korea
Interannual Variation of Freshwater Transport in the Korea Strait

4. Kuroda, Hiroshi, NRIFS, Japan
Development of Coastal Ocean Modeling System around Japan for Fisheries Science with the ROMS

5. Lim, Hak Soo, Korea Ocean R&D Institute, South Korea
Change in residual circulation due to 33km-long Saemangeum coastal dyke of Korea

6. Myksvoll, Mari S., Institute of Marine Research, Norway
Physical mechanisms causing retention of cod eggs in a fjord system

7. Park, Hee Yoon, University of Melbourne, Australia
Modelling the dispersive and retentive oceanographic features affecting larval dispersal around the Wilsons Promontory Marine National Park, Australia

8. Proctor, Roger, University of Tasmania, Australia
The Integrated Marine Observing System (IMOS)

9. Rayson, Matt, University of Western Australia, Australia
Field and numerical study of internal tide dynamics in the Browse Basin, Western Australia

10. Rosebrock, Uwe, CSIRO, Australia
Data Interrogation and Visualisation Environment

11. Steinberg, Craig, AIMS, Australia
The Great Barrier Reef Ocean Observing System: Monitoring the Western Boundary Currents of the Coral Sea and Impacts on the Great Barrier Reef

Talk Abstracts

ROMS Framework and Algorithms

Hernan G. Arango
IMCS, Rutgers University, USA

An overview of ROMS framework in terms of new algorithms and developments. The entire I/O interface was redesigned to allow parallel I/O via the NetCDF-4/HDF5 libraries. Additional fine tuning is need to improve the efficiency of parallel I/O; serial I/O is still faster. The vertical, terrain-following coordinate transformation was revisited to allow an additional equation and numerous vertical stretching functions. The transformation is generic and the new **formula_terms**, which are independent of the stretching functions, were registered with the CF Conventions Committee and the NetCDF-Java group.

The full suite of 4D-Var data assimilation algorithms were revised to include sophisticated conjugate gradient solvers, spectral and Ritz preconditioning, additional state variables to adjust, and observation sensitivity drivers. This driver can help us to determine the type of measurements that need to be made, where to observe, and when. Many improvements were made to the weak constraint data assimilation algorithms that are fully working in realistic applications. The theory and technical considerations behind these algorithms will presented in Andrew M. Moore's lecture.

Coupled physical-biological modelling of the waters off southeast Australia

Mark Baird and **Helen Macdonald**
CSIRO Marine and Atmospheric Research, Australia

The biogeochemical response to wind forcing in the waters off southeast Australia have been investigated with a coupled physical-carbon chemistry-NPZD model. The model shows that upwelling favourable winds bring DIC rich slope waters to the surface causing an outgassing. As the water is advected, downstream phytoplankton production consumes carbon resulting in absorption of CO_2. The net effect of upwelling, in a region of the global ocean that is generally absorbing, is reduced absorption. This result is further investigated using a biogeochemical shelf budget, analysis of terms, and the use of an age tracer. In the talk I will concentrate as much on general analysis techniques (*i.e.*, using the age tracer) as the scientific conclusions themselves.

Modeling Tropical Cyclones on the Northwest Shelf of Australia

Madeleine Cahill and **Peter Craig**
CSIRO Marine and Atmospheric Research, Australia

Tropical Cyclones play an important role in the oceanography of Australia's Northwest Shelf. On average, three cyclones occur in the region each year. Both ROMS and the CSIRO z-level model, SHOC, have been configured to model the ocean's response to a particular cyclone, TC Bobby, which passed directly over a shelf array of current meters and an ADCP. The temperature and velocity observations are used to assess the simulations of ROMS and SHOC, and to evaluate different vertical mixing schemes.

Assimilation of Sea Surface Temperature into a Northwest Pacific Ocean Model using an Ensemble Kalman Filter

Byoung-Ju Choi
Department of Oceanography, Kunsan National University, Korea

Gwang-Ho Seo, **Yang-Ki Cho** and **Chang-Sin Kim**
Department of Oceanography, Chonnam National University, Gwang-Ju, Korea

Sangil Kim
COAS, Oregon State University, Corvallis, Oregon, USA

Young-Ho Kim
Korea Ocean Research & Development Institute, Ansan, Korea

Sea surface temperature (SST) data is assimilated into a Northwest Pacific Ocean model from October 2003 to June 2004 in order to investigate the performance of SST assimilation with an Ensemble Kalman Filter (EnKF). ROMS is used to simulate the ocean circulation with the horizontal resolution of 0.25° and 20 vertical levels. The model results of a global ocean model, Estimating the Circulation and Climate of the Ocean (ECCO), is used for the open boundary data. The surface forcing is provided from the European Center of Medium Range Weather Forecasting (ECMWF) reanalysis data. EnKF needs to calculate background error covariance to update the background field in each step. Localization of the background error covariance is adapted to prevent ensemble collapse. Empirical Orthogonal Functions (EOF) analysis is performed on 10 year model simulation results to perturb the initial state of the ensemble. The performance of data assimilation is evaluated by comparing the data assimilative model results with observed data such as satellite sea surface temperature, sea surface height and in-situ observation data from Japan Oceanographic Data Center (JODC), Korean Oceanographic Data Center (KODC), and Global Temperature-Salinity Profile Program (GTSPP). Assimilation of SST improves SSH distribution and subsurface temperature profiles in the Kuroshio Extension region by restraining overshooting of Kuroshio. This preliminary work shows promising results indicating this assimilation scheme can be used for an operational ocean prediction system for the Kuroshio region and Northwest Pacific marginal seas.

Impact of high resolution wind forcing on the mesoscale circulation and surface productivity off south Peru in relation with the VOCALS-Regional-Experiment

David Correa and **Jorge Tam**
Centro de Investigaciones en Modelado Oceanografico y Biologico Pesquero, Instituto del Mar del Perú, Peru

Vincent Echevin
LOCEAN, UPMC, Paris, France

Francis Codron
LMD, UPMC, Paris, France

We aim to study how dynamical and biogeochemical processes, and their coupling, are affected by wind forcing in the south of Peru using the ROMS/PISCES model. This region is characterized by strong mesoscale activity and intense upwelling/filament events, which are the result of an intensified and permanent coastal wind forcing. Here we study the impact of wind forcing on the surface dynamics and biological productivity for 2001. Two wind forcing were used: Quikscat winds and a high resolution winds from the LMDZ atmospheric model. The simulations are contrasted in terms of nearshore wind stress curl, surface and subsurface circulation, mesoscale activity, and biogeochemical response. To highlight the characteristics of these mesoscale filaments, results are compared against glider data and the VOCALS-Rex cruise measurements carried out in October 2008.

Simulation of an Upwelling Event in the Southern California Bight

Changming Dong, **Jim McWilliams**, **Mimi Hughes** and **Alex Hall**
IGPP, University of California, Los Angeles, USA

In March, 2002, a big upwelling event occurred in the Southern California Bight with a 4-5 degree decrease in sea surface temperature within 2-3 days. ROMS is applied to simulate the local event. With the forward mode, ROMS can reproduce the event fairly well when forced by a high resolution MM5 wind. The simulation is validated with the observational data available. The sensitivity of the synoptic-scale event simulation to the external forcing and model parameters are examined in detail, such as, the wind forcing, heat flux function, tides, lateral boundary forcing, model resolutions, and so on.

A numerical study of island wake generated by an elliptical tidal flow

Philippe Estrade and **Jason Middleton**
University of New South Wales, Australia

An idealized numerical study of the influence of a tidal flow around an island has been undertaken with ROMS. The study focusses on coastal island wakes which are mainly controlled by elliptical tidal current flows on shallow shelves. This model is typical of some isolated continental shelf islands. The model is forced by a semi-diurnal barotropic inertia gravity wave imposed on the 4 open boundaries of a rectangular domain. Its propagation results in an elliptical tidal flow within the domain in which the circular island lies. The influence of the surrounding island bathymetry and the ellipse shape have been studied both in two and three dimensions. In the island's vicinity, the residual circulation patterns over a tidal period show flow divergence along the major axis and convergence along the minor axis. A thin tidal ellipse (*i.e.,* with a large ratio between major and minor axis) leads to strong eddy activity periods in the lee of the island during the flood and ebb phases, with eddy dissipation phases in between. By contrast, an almost round ellipse (axis ratio nearly 1) leads to vorticity filaments which continuously progress around the island without eddy shedding. The presence of a topographic slope in the vicinity of the island strengthens the eddy activity. This study suggests that the tidal current rotation favors the development of the eddy rotating in the same direction and weakens the development of the second eddy. In three dimensions with a surrounding bathymetry, an intense upwelling occurs in a large area in the lee of the island and the vertical velocities are stronger with thinner ellipses. With a flat bottom the vertical motions are almost fully generated by convergence/divergence of the secondary flow. With a varying bottom topography, the vertical motions come from a combination of this mechanism with convergence/divergence of the depth averaged flow.

Improving ecosystem model prediction through data assimilation

Jerome Fiechter, **Andrew M. Moore** and **Gregoire Broquet**
University of California, Santa Cruz, USA

As part of an ongoing effort to improve ecosystem prediction in the Coastal Gulf of Alaska, satellite altimetry (AVISO), sea surface temperature (Pathfinder), and chlorophyll (SeaWiFS) are used for data assimilation purposes within the ROMS/IS4DVAR framework. The primary objective is to improve the representation of mesoscale processes at the shelfbreak as they are known to impact biological activity in that region. Numerical experiments are conducted with two lower trophic level ecosystem models (NPZD and NEMURO) of different complexity to assess the benefits of assimilating physical data only, biological data only, or both. The ROMS/IS4DVAR framework is also used to investigate the benefits of using a full adjoint for the ecosystem model versus assimilating chlorophyll simply as a passive tracer.

Modelling marine ice accretion beneath ice shelves

Ben Galton-Fenzi[1,2,3], **John Hunter**[1,2], **Simon Marsland**[3], and **Roland Warner**[2,4]

1. University of Tasmania
2. Antarctic Climate and Ecosystems CRC
3. CSIRO Marine and Atmospheric Research
4. Australian Antarctic Division

The Rutgers version of ROMS was modified to investigate the effect of a changing climate on the mass balance of ice shelves and dense water formation. Most of the snow falling on Antarctica drains to the ocean where it floats seaward of the grounding line forming ice shelves. The mass balance of ice shelves involves glacier flow, snowfall and ablation on the upper surface, melting and accretion of marine ice on the lower surface and the calving of icebergs. Marine ice is formed by seawater that freezes directly onto the base of the ice shelf and by the precipitation of frazil ice crystals. ROMS was modified to include the thermodynamic processes beneath ice shelves, including direct basal processes and frazil ice dynamics. The model is applied to the Amery Ice Shelf ocean region in East Antarctica and is forced with tides, winds and relaxation to lateral boundary climatology. The open ocean surface fluxes are modified by an imposed climatological sea-ice cover that includes the effect of polynyas. Frazil ice was implemented in ROMS by modifying the existing sediment code. As such, frazil ice crystals suspended in the water column are transported by solving the advection-diffusion equation with additional terms for buoyant vertical rising, and source/sinks due to freezing/melting, nucleation and precipitation. Results show that, under the ice shelf, frazil ice forms in a supercooled water layer adjacent to the ice shelf base. The supercooled water is formed when buoyant water that is created by basal melting begins to rise. Comparison with glaciological observations shows that the inclusion of frazil ice processes in the model improves the simulated pattern of marine ice accretion. Further simulations will involve determining the sensitivity of the ice shelf to a warming ocean and the application of the model to the cavities of other ice shelves.

Nested simulations of coastal currents for larval dispersal

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A series of three nested ROMS models have been set up for the southeast coast of New Zealand with the ultimate aim of estimating larval connectivity patterns along the coast. All nesting is one-way and off-line, using the Rutgers ROMS code. The outer model is a non-assimilating, climatological model for the New Zealand region at 10 km resolution. This model has been shown to generate a realistic Southland Current along the continental shelf edge. The intermediate model is at 2.5 km resolution and covers the continental shelf for a distance of 830 km, in order to represent the effect of fluctuating winds on the flow. Validation at this scale is available from historical current meter data. The inner model is at 0.625 km resolution.

The interface between the outer and intermediate models was problematic because the outer model is forced by steady winds, whereas the intermediate model uses fluctuating winds (as does the inner model). Since, none of the existing open boundary condition options for the M3 mode were satisfactory, we developed a novel one combining zero-gradient extrapolation and nudging.

Results from the model will be presented, concentrating on the first-order effects of fluctuating wind forcing on the variability in the current.

Linking Sediment and Biological Processes within the Regional Ocean Modeling System (ROMS).

Courtney K. Harris
Virginia Institute of Marine Sciences, USA

Katja Fennel
Dalhousie University, Canada

Kevin Xu
Coastal Carolina University, USA

Rob Hetland and **James Kaihatu**
Texas A&M University, USA

Hypoxic conditions, whereby dissolved oxygen concentrations fall to dangerous levels, are a leading concern for water quality throughout the world. Within the U.S., management practices have been enacted to reduce nutrient inputs into the Gulf of Mexico with the belief that this will mitigate the extent and frequency of hypoxia there. Our understanding of the conditions that trigger hypoxia, however, is weak. For the northern Gulf of Mexico, U.S., it is thought that sedimentary processes, including burial, diagenesis, and resuspension, impact the cycling of nutrients pertinent to hypoxia. Our efforts, part of the "Mechanisms Controlling Hypoxia (MCH)" experiment, include development of a three-dimensional, realistic model of the northern Gulf of Mexico using the Regional Ocean Modeling System (ROMS). Within this model, we have previously included physical oceanography, sediment transport using the Community Sediment Transport Modeling System (CSTMS), and a biogeochemical model (Fennel *et al.* 2006, 2008). To date, the sediment and biological models have been run separately.

The three-dimensional sediment model has been applied to calendar year 1993 because (1) there was a very large storm during this year, (2) the extent of the hypoxic zone was one of the largest measured, and (3) limited data was collected by the LATEX experiment. Because wave energy is important for sediment resuspension, bed shear stresses are impacted using waves as estimated by SWAN (Shallow WAves Nearshore). Preliminary results from this model indicate that material from both the Mississippi and Atchafalaya River systems affect the area particularly impacted by hypoxia, called the "dead zone". Additionally, our calculations indicate that the passage of frontal systems can trigger shoreward sediment transport, which may provide additional nutrients to the inner shelf where hypoxic conditions occur.

The biogeochemical model provides encouragingly realistic estimates of hypoxic extent when run for a ten year period even though it includes a very simple treatment of benthic nutrient cycling. Current efforts are therefore aimed at developing a simple, but more realistic treatment of diagenesis. We are pursuing this by coupling the sediment bed and biogeochemical models. This coupled model is being developed within a one-dimensional test case ("SED-BIO-TOY"), and will later be included in the full three-dimensional model of the northern Gulf of Mexico.

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ROMS 4D-Var: The Complete Picture

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ROMS is one of the few community ocean models for which a 4-dimensional variational (4D-Var) data assimilation capability has been developed. The ROMS 4D-Var system, however, is by far the most comprehensive of all those currently available. ROMS 4D-Var comprises three different 4D-Var platforms: one that searches for the best linear unbiased estimate (BLUE) of the ocean circulation in the full space spanned by the model, and two that search for the BLUE in the sub-space spanned by the observations. In all cases, the BLUE can be identified by adjusting the model initial conditions, surface forcing, and open boundary conditions. In the case of 4D-Var in observation space, model errors can also be admitted leading to the so-called weak-constraint problem. Several powerful 4D-Var post-processing algorithms have also been develop for ROMS including an observation sensitivity driver. In this talk I will present a review of the entire 4D-Var package for ROMS, including the underlying fundamental ideas and methods used. Illustrative examples will also be presented.

Applications of ROMS along the west and south coasts of Western Australia

Charitha Pattiaratchi, **Michael Meuleners, Susan Rennie**, **Mohd Akhir** and **Gregory N. Ivey**
University of Western Australia, School of Environmental Systems Engineering, Australia

It is often claimed that Australia is 'upside-down' referring to the northern hemisphere view of our island continent. However, when we examine the marine environment of Western Australia this is absolutely true. The resource rich marine environment is truly unique - covering tropical to temperate climate regions with rich species diversity, ocean current systems and geological formations. These features make the continental shelf and offshore region of Western Australia an ideal natural laboratory as it consist of contrasting physical environments as well as strong connectivity. The circulation is dominated by the presence of the anomalous Leeuwin Current, which transports warm, nutrient poor water poleward and has a strong influence on the local climate and biology. Mesoscale eddies, generated by the instabilities in the current, have a distinct alongshore length scale and thus interact with the same region of the coastline at regular intervals. In the summer months, strong sea-breezes, unique to the region, force water northward along the shelf. The Capes Current is generated by the strong southerly winds as an upwelling current. There is localised upwelling due to the southerly winds and flow interaction with topographic features such as the Perth canyon. In this presentation several applications of ROMS will be presented and will include the eddy structure of the Leeuwin Current, Circulation along the Perth canyon and the shelf/slope processes along the south coast of Western Australia.

Contrasting summer monsoon cold pool south of the Indian Peninsula

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The recently discovered summer monsoon cold pool (SMC), south of the Indian Peninsula, has become an active topic of research as it is considered to be important for the active and break spells of the Indian summer monsoon rainfall. The cold pool is associated with the enhanced upwelling. It exhibits variations in different time scales. In the present study, we focus on the contrasting years of 2002 and 2003. The observations show that the SMC was strong in 2002 and weak in 2003. The regional ocean modeling system (ROMS) setup for the tropical Indian Ocean is used to simulate this realistically. We analyze various ocean parameters from the model to understand the reasons for this contrast in the intensity of the cold pools. We find that in addition to the difference in the strength of the local wind forcing, the difference in the equatorial dynamics between these two years also plays an important role in generating the contrasting SMCs in 2002 and 2003.

ROMS: NetCDF and Matlab

David Robertson and **Hernan G. Arango**
IMCS, Rutgers University, USA

A quick review of the tools and information available on the ROMS web sites will be presented.

Nowadays, almost all the pre- and post-processing of ROMS NetCDF files is done with Matlab. There is an increasing number of scripts out there, some accurate some not, that users employ to perform such processing. This is complicated by the fact that several NetCDF interfaces are available for Matlab. Furthermore, we need to consider issues like: the NetCDF library version (NetCDF-3, NetCDF-4), file type (classic, HDF5), compression, and OpenDAP. Matlab's native NetCDF interface (starting with R2008b) adds yet another layer of complexity. Currently, we have mexcdf, mexnc, snctools, NetCDF-java, and native Matlab potentially available and interacting with each other. We will attempt to explain the hierarchy of these interactions.

In view of this, we have started releasing our official versions of Matlab processing scripts in the ROMS svn repository. We are trying to set a few guidelines on how to write such scripts in a modular and generic way, allowing users to employ them in their own applications. For example, users need to compute the ROMS vertical grid correctly when preparing initial conditions, boundary conditions and climatology. Since this important computation is hard-wired in many of the 3rd-party scripts available, the new vertical grid transformations render such scripts obsolete time consuming to repair.

Vertical Mixing from ROMS

Robin Robertson
University of New South Wales at AFDA, Australia

Recently, efforts have been made to include vertical mixing in GCM's to improve ocean circulation simulations. Mixing occurs at a wide variety of spatial and temporal scales making it difficult, if not impossible, to specify exactly in the models. The solution has been to parameterize the vertical mixing, for which a variety of schemes have been developed. But the mixing estimates from the models will only be as good as the performance of the mixing parameterization and with a wide variety of mixing parameterizations, it is desirable to know which one performs best or at least which ones perform adequately. In this study, the performances of ten different vertical mixing schemes were evaluated against observational data. Since much of the vertical mixing in the ocean is believed to be tidal and tidal motions are relatively easy to simulate, the study focused on tidally-driven mixing. Terrain-following ocean models have been used to simulate internal tides and provide estimates of the tidal mixing.

In order to evaluate the capability of the Regional Ocean Model System (ROMS) to simulate tidal mixing, the combined tides for four constituents, M2, S2, K1, and O1, were modeled over Fieberling Guyot using different vertical mixing parameterizations. Although estimates for the major axes of the tidal ellipses were similar between all vertical mixing schemes, the diffusivities varied widely between parameterizations. The most significant effects occurred over the crown of guyot and in the lower water column. In the velocity fields, the greatest differences between the parameterizations occurred at high frequencies. There was a strong correlation between schemes with high diffusivities and less energy in the velocities at high frequencies. Although there was no definitive best performer for the vertical mixing parameterization, several parameterizations could be eliminated based on comparison of the vertical diffusivity estimates with observations. The best performers were Mellor-Yamada, and three generic length scale schemes.

Relocatable Ocean and Atmosphere Model Control System

Uwe Rosebrock
CSIRO Marine and Atmospheric Research, Australia

The Relocatable Ocean and Atmosphere Model (ROAM) control system is a software package for running coupled ocean and atmospheric models. The ROAM software is largely automated, allowing the user to graphically set up the model domain and control the execution of the models. One of the main features of ROAM is its tight integration and management of the data streams which provide forcing and domain information (*e.g.,* bathymetry and coastline) for the various models. This aspect is fully automated, requiring no user interaction.

ROAM currently incorporates three models, the hydrodynamic model SHOC, the atmospheric model RAMS and the wave model SWAN, but has the potential to run different models. A further development of ROAM targets a stand-alone application running a littoral ocean and wave model. ROAM has been developed by CSIRO Marine and Atmospheric Research, for the Royal Australian Navy under the BLUElink project.

Coupled modeling of waves, currents, bedforms, and suspended sediment on the inner shelf

Christopher R. Sherwood and **Neil K. Ganju**
U.S. Geological Survey, Woods Hole Science Center, Woods Hole, MA, USA

We are using the two-way (wave-current) coupled version of ROMS with the Community Sediment-Transport Modeling System (CSDMS) algorithms to model conditions during experiments at the Martha's Vineyard Coastal Observatory in Autumn 2007. The inner shelf at MVCO is characterized by a generally smooth bed of fine (0.14 - 0.17 mm) sand with small ripples (height of 1 - 2 mm, wavelength of ~10 mm) and large patches of coarse (0.4 - 0.6 mm) sand with larger ripples (height 0.08-0.15 m, wavelength 0.6 to 0.8 m). Our objective is to evaluate model performance in reproducing observed ripple geometries and suspended particle-size characteristics.

Web service tools and techniques for ROMS users

Rich Signell
U.S. Geological Survey, Woods Hole Science Center, Woods Hole, MA, USA

We will describe how the NetCDF Markup Language, the THREDDS Data Server, NetCDF-Java and Matlab can be used with web served data to make a ROMS user's life easier and distribution of results more effective.

Application of ROMS for the Spencer Gulf and on the adjacent shelf of South Australia

Carlos Teixeira and **SARDI Oceanographic Team**
SARDI Aquatic Sciences / University of New South Wales, Australia

The ROMS model will be used by the SARDI Oceanography Program to build a hydrodynamic/bio-geochemical modelling facility. This facility will elucidate the important components of circulation within Spencer Gulf and on the adjacent shelf of South Australia, including tides, cross-shelf exchange, thermohaline and wind-forced circulation. A second aim of this facility will include development of bio-geochemical models of the ecosystems for the upwelling region of South Australia and within Spencer Gulf. Ultimately, these models will be validated against the data from the Southern Australian Integrated Marine Observing System. In this talk we discuss some preliminary results associated with idealized wind forcing. The net transports in different sections along the gulfs are used to examine the re-circulation within the gulfs and exchange with shelf. Passive tracers and particles are used to elucidate the possible connections between the gulfs.

Wave-current interaction in ROMS: A vortex-force formalism

Yusuke Uchiyama, **James C. McWilliams**, **Maarten Buijsman**, and **Alexander Shchepetkin**
University of California, Los Angeles, USA

The multi-scale asymptotic theory by McWilliams et al. (2004) with a vortex-force formalism is extended appropriate for strong current regimes applicable to wave-driven nearshore currents around surf zones. The wave-averaged, three-dimensional primitive equations for current and tracers are derived and implemented into ROMS with appending non-conservative parameterization that accounts for momentum exchange due to wave breaking and bottom friction. A set of WKB wave ray refraction equation and wave action balance equation, and roller energy conservation equation for onshore-traveling bore of broken waves (Svendsen, 1984) are used to provide wave-induced forcing for a current field. The KPP model (Large *et al.*, 1994) has also been modified to incorporate effects of breaking waves. The model is then applied to a standard shoreface test (Haas and Warner, 2009), Duck94 Experiment (Garcez Faria *et al.*, 1998, 2000), and a regional circulation in the Southern California Bight (*e.g.*, Dong et al., 2009) by being coupled with SWAN (Booij *et al.*, 1999) to demonstrate its performance.

Predictability of Mesoscale Variability in the East Australia Current System given Strong Constraint Data Assimilation

John Wilkin, **Javier Zavala-Garay**
and **Hernan G. Arango**
IMCS, Rutgers University, USA

The objectives of data assimilation in oceanography are typically the reanalysis of a suite of observations for the purposes of hindcast state estimation, and determining initial conditions for model forecasting. In this project we focus on the latter objective and evaluate the Incremental, Strong constraint, 4-Dimensional Variational (IS4DVAR) data assimilation method implemented in the Regional Ocean Modeling System (ROMS) for predictions of mesoscale variability in the East Australia Current (EAC) System. The observations assimilated are daily composites of AVHRR SST, 7-day reanalysis of AVISO SSH anomalies, and high resolution expendable bathythermograph (XBT) temperature profiles from Volunteer Observing Ship (VOS) transects of the Tasman Sea. Considering a 2-year data set for 2001 and 2002, ROMS forecast initial conditions are generated every week by assimilating observations from the 7 days preceding the forecast initial time. Forecast ensembles are produced by adding to the forecast initial conditions so-called optimal perturbations computed from singular vectors of the ROMS Tangent Linear model.

Assimilation of satellite data only (SST and SSH) results in relatively poor estimates of the true subsurface ocean state observed by XBTs, and consequently a poor subsurface forecast skill. Furthermore, the modeled circulation shows significant sensitivity to errors in the initial conditions and therefore the uncertainty, or spread, in the forecast ensemble is high. Including the XBTs in the assimilation experiments improves the ocean state estimation in the vicinity of the XBT transects and reduces the sensitivity to errors in the initial conditions resulting in a more skillful ensemble forecast. Motivated by this finding we explore the utility of including subsurface pseudo-observations based on an empirical relationship between subsurface information and satellite observed surface conditions (CSIRO's "Synthetic XBT" analysis). The preliminary results show that better ocean state estimates and more skillful forecasts are obtained in all the domain considered.

Wave-driven circulation in a complex reef dominated coastal environment off South West Western Australia

Liejun Zhong and **Graham Symonds**
CSIRO Marine and Atmospheric Research, Australia

Coastal waters off South West Western Australia are exposed to long period southern ocean swell and a strong sea breeze cycle during summer months. Shallow limestone reefs within a few kilometers of shore are common and exposure to waves is considered to have a significant affect on benthic communities. Wave breaking over these reefs forces cross-shore and alongshore flows in addition to the wind and tidally forced components of the circulation. Between July 2007 and May 2008 *in situ* measurements of waves, currents and water properties were made on and around a series of reefs off Perth, Western Australia. Elevated nutrients are observed over the reefs with maximum in winter and minimum in summer. Offshore wave height was also a maximum in winter, Hs >3.5m, and minimum in summer, Hs <1m. The top of the reefs are typically 1-2m below the sea surface, and between the reefs and shore the average depth is about 10m. At most of the reef sites waves begin to break when the significant wave height exceeds about 1.5m resulting in spatially complex mean flows, with onshore flow over the reefs, offshore flow through some of the gaps between the reefs, and strong southward flow between the reef line and the shore. Strong winds often accompany the high wave events and it is difficult to separate currents driven by wave and wind in the observations. We have used the 3D wave-current coupled version of ROMS to simulate wave and wind driven currents in a domain approximately 5km cross shore and 20km alongshore. The model is forced by tides at the open boundaries, wind stress, heat and fresh water fluxes at the sea surface, and wave breaking over the shallow reefs using a depth dependent formulation of the radiation stresses representing the excess momentum due to the presence of the waves. During periods of high waves the model captures at least some of the wave driven flow seen in the observations, and during periods of low waves diurnal variation of currents associated with the sea breeze cycle is reproduced.

Poster Abstracts

Integrating space- and time-scales of sediment transport for Poverty Bay, New Zealand, and the nearfield continental shelf

Aaron J. Bever and **Courtney K. Harris**
Virginia Institute of Marine Sciences, USA

Poverty Bay, located on the eastern shore of the North Island of New Zealand, is an integral part of the Waipaoa River dispersal system. The sediment transport pathways within Poverty Bay and the time-scales of sediment preservation within the bay, or export to the continental shelf, have yet to be fully understood. Additionally, the configuration of the bay has changed dramatically during the last 7000 years, and the degree to which these basin changes have influenced sediment export remains unknown.

To study the modern WSS, sediment transport processes within Poverty Bay were investigated using field observations and numerical experiments. Five months of data were collected in the near-shore region of Poverty Bay during winter (April - September) 2006. Instrumentation included S4, OBS, ADCP, and ADV sensors. A three dimensional hydrodynamic and sediment transport numerical model (ROMS) was also used to model sediment transport from January through September 2006. Realistic forcing was used, including observed winds, tides, modeled waves from the Simulated WAves Nearshore (SWAN) model, observed Waipaoa River freshwater discharge, and Waipaoa River sediment concentrations from a rating curve.

Average currents were consistent with counterclockwise circulation within the bay. Nearly identical wind, river discharge, wave, current, and turbidity patterns were seen for three wet storms. At the beginning of each storm the winds blew shoreward, producing large wave heights within Poverty Bay. As the cyclonic storms moved through the system, winds reversed direction to be offshore and reduced the local wave energy within Poverty Bay, even though river discharge remained elevated. High river discharge and relatively small waves enabled significant sediment deposition in shallow water (12 m). However, turbidity and seabed observations show that this sediment was removed from the nearshore within 3 weeks of deposition by swell waves propagating into the bay from the southern ocean. Different sediment transport pathways occurred under wet and dry storms, with sediment transport during river flooding exiting the bay towards the northeast while subsequent swell induced resuspension delivered material towards the southwest. Velocity measurements also indicate that divergence in nearshore currents may facilitate the segregation of coarse and fine sediments, with coarse sediments transported towards the beach while fines are exported to deeper water.

Finally, to evaluate how processes within Poverty Bay have been modified over longer timescales, sediment export from Poverty Bay has been numerically examined for a bay geometry modified to represent that present at the last marine transgression, ~7 kya. This preliminary analysis should demonstrate the utility of understanding short-term processes when considering longer time-scale stratigraphic progradation.

Long-term changes in pCO_2 within the Coral Sea

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The present study investigates the possible long-term changes in pCO_2 and pH within the Coral Sea using the coupled regional model ROMS-PISCES. Various IPCC scenarios for predicted atmospheric pCO_2 were used to determine likely changes in the biogeochemistry of the Coral Sea during the 21st century. Increases of atmospheric pCO_2 to 650-1000 ppmv results in a decrease of sea surface pH by 0.14-0.36 units within the Coral Sea in the model. The difference between atmospheric and oceanic pCO_2, in turn, would mostly decrease by 0-50 ppmv. This would result in the Coral Sea changing from a source of pCO_2 in the equatorial region and a seasonal source in the subtropical area (mainly during late summer and autumn), to a predominant sink in the entire Coral Sea. Along with increased ocean acidification and pCO_2, the saturation state of aragonite and calcite will decline significantly, which would have wide-reaching effects on the coral calcification rates and the general health and structural strength of calcifying organisms. To date, there has been surprisingly little effort to monitor changes in biogeochemistry within the Coral Sea and, specifically, within the GBR as a result of increased atmospheric pCO_2. Further large-scale studies are required throughout the entire Coral Sea in order to accurately determine the long-term trends in oceanic pCO_2, CO_3^{2-}, saturation state and pH.

Interannual Variation of Freshwater Transport in the Korea Strait

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Byoung-Ju Choi
Department of Oceanography, Kunsan National University, Korea

A numerical model experiment was performed using (ROMS) for the study of interannual variation of Freshwater Transport in the Korea Strait (FTKS). This model was used to simulate the circulation of the Yellow and East China Seas (117 ~ 131 ºE, 23.5 ~ 41 ºN). The resolution of the model domain is about 0.1° in both directions and 20 vertical levels. The Mellor Yamada level 2.5 closure scheme (Mellor and Yamada, 1982; Durski *et al.*, 2004) is used as vertical parameterization. The model is forced with ECMWF daily mean wind-stress and monthly mean heat flux. The open boundary values (T, S, current and SSH) are taken from the results of the Northwest Pacific Circulation Model (1/4 degree horizontal resolution). The river discharges of Changjiang and Huanghe are incorporated into the model. Eight major tidal components are applied to the open boundaries using NAO 99.JB data (Matsumoto *et al.* 2000).

The model salinity variations in the Korea Strait are comparable to the observation data and show an obvious seasonal and inter-annual signal. The FTKS is more sensitive to wind than river discharge in summer. Results imply that the wind direction is a critical factor to identifying the FTKS. Moreover, the southeasterly wind speed enhances the FTKS.

Five cross sections are used to analyzed the freshwater flux around the East China Sea (ECS). The freshwater flux in the ECS shows maximum freshwater in March and April, with a decrease beginning in May. In the ECS, the freshwater flux is estimated at $9.1 \sim 18.9 \times 10^3$ m^3 s^{-1} annually.

Development of Coastal Ocean Modeling System around Japan for Fisheries Science with the ROMS

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We have started the development of a coastal ocean modeling system around Japan based on ROMS. The main objective is to study fish stock and recruitment variations to help its management. The coastal waters in Japan are strongly affected by the offshore mesoscale activity from the Kuroshio and Oyashio boundary currents. A basin-scale, eddy-resolving model (1/2-degree) was developed to reproduce this offshore mesoscale variability. Then, a fine resolution, regional (1/10-degree) model around Japan was developed. A one-way nesting technique is applied to connect both grids. We found that many realistic mesoscale features can be simulated in the spin-up experiment with monthly climatological forcing based on JRA-25. The Kuroshio path and the Kuroshio Extension with typical meanders (i.e., 1st and 2nd troughs and crests), and the warm core rings occasionally detaching from the Kuroshio Extension were realistically reproduced. However, several problems have remained: southward intrusions of the Oyashio is stronger than observed, stabilized path of the Kuroshio, and overshoot of the East Korean Warm Current.

Change in residual circulation due to 33km-long Saemangeum coastal dyke of Korea

Chang S. Kim, **Hak-Soo Lim**, **Jinah Kim**, **Cheol-Ho Cho**, and **Heung-Jae Lie**
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One of the longest coastal dykes in the world has been constructed in Saenangeum area in the southwest of the Korean Peninsula (center location at 126.5°E and 35.8°N). A 33km-long dyke system connecting a few islands separates the open ocean from the landward water of 401 km^2 area that is planned for reclamation as national coastal development.

The construction of the dyke started in 1991 and finished in 2006. Until the final closure of the dyke in 2006, the sea water exchanged with the fresh water discharging from the Mangeong and Dongjin rivers preserving the meso-tidal (tidal range > 4m) estuarine dynamics. However, the closure of the dyke has changed the tidal dynamics significantly and the associated residual flow system has changed dramatically yielding a new pattern of coastal erosion and deposition problems.

In this study, we investigate the change in residual circulation in the Saemangeum coastal water using field observation data and numerical simulations. ROMS is used to study the circulation patterns of before-dyke and after-dyke conditions.

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Physical mechanisms causing retention of cod eggs in a fjord system

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The fjord system of Nordfolda and Sørfolda in the northern part of Norway is one of the spawning sites for the Norwegian Coastal Cod (CC). The two fjords have a joint opening towards Vestfjorden, one of the main spawning sites for the Arcto-Norwegian Cod (ANC). The combined effect of local density structure and differences in egg buoyancy cause the CC eggs to have a different vertical distribution than the ANC eggs.

A regional ocean model is used to simulate the circulation within the fjord system during two different years. The first year 1960, represents a cold and dry year, and the second year 1989, represents a warm and wet year. Drift patterns of eggs are calculated with a particle tracking model utilizing the modeled velocity fields.

The results show a distinct brackish layer in Sørfolda during both years, with lowest salinity in 1989. The strong stratification causes the CC eggs to be concentrated below the outflowing surface layer, resulting in local retention of eggs close to the spawning grounds. During 1989 the retention was stronger than during 1960, because of increased fresh water input. Due to low river runoff in Nordfolda, combined with larger fjord width, the stratification is weaker than observed in Sørfolda. The CC eggs are still retained inside the fjord, mainly due to eddy activity in the central part of Nordfolda.

The impact of climate change in northern Norway is expected to be increased temperature and precipitation. In narrow fjords with large fresh water input, like Sørfolda, the retention of CC eggs will increase with increased precipitation

Modelling the dispersive and retentive oceanographic features affecting larval dispersal around the Wilsons Promontory Marine National Park, Australia

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The knowledge gap concerning the dispersive larval phase of marine animals poses a problem for effective conservation and fisheries management. For the management of Marine Protected Areas (MPA), knowledge of dispersal pathways helps gauge the area's success in protecting recruitment hotspots, maintaining population persistence, and generating spill over. However, the dispersal pathways into a local population are heavily influenced by both physical (e.g. currents, internal waves) and biological factors (e.g. larval behaviour, settlement cues). As a result, dispersal is often patchy and difficult to predict. To help elucidate the oceanographic drivers behind dispersal, we are developing an ocean model for the Wilson's Promontory Marine National Park. This promontory is the southern most point on the Australian mainland and juts out into Bass Strait, a relatively shallow passage of wind affected water between Victoria and Tasmania. The modelling will look for consistently retentive or dispersive features that could affect larval dispersal into and out of the MPA.

The Integrated Marine Observing System (IMOS)

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The Integrated Marine Observing System (IMOS, www.imos.org.au), a 100 million AUD 5-year project, is a distributed set of equipment and data-information services which collectively contribute to meeting the needs of marine climate research in Australia. The observing system provides data in the open oceans around Australia, out to a few thousand kilometres, as well as the coastal oceans through 11 facilities (Argo Australia, Ships of Opportunity, Southern Ocean Automated Time Series Observations, Australian National Facility for Ocean Gliders, Autonomous Underwater Vehicle Facility, Australian National Mooring Network, Australian Coastal Ocean Radar Network, Australian Acoustic Tagging and Monitoring System, Facility for Automated Intelligent Monitoring of Marine Systems, eMarine Information Infrastructure, and Satellite Remote Sensing) and 5 nodes (Blue Water, Great Barrier Reef Ocean Observing System, New South Wales IMOS, Southern Australia IMOS, and Western Australia IMOS).

The data, a combination of near real-time and delayed mode, are made available to researchers through the electronic Marine Information Infrastructure (eMII). eMII utilizes the Australian Academic Research Network (AARNET) to support a distributed database on OpenDAP servers hosted by regional computing centres. Most data is in CF compliant netcdf format and, where possible, metadata, conforming to standard ISO 19115, is automatically harvested from the netcdf files and catalogued in the OGC GeoNetwork Metadata Entry and Search Tool (MEST). Data discovery, access and download occur via web services through a web portal and tools for the display and integration of near real-time data are in development.

The aim of this poster is to expose the IMOS data to the Australian and Asian/Pacific ROMS community and indicate its value for both operational oceanography and process modelling studies.

Field and numerical study of internal tide dynamics in the Browse Basin, Western Australia

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The Browse Basin, located off the Kimberley in northern Western Australia, is a region of strong tides and internal wave activity. The region has large barotropic tides (tidal amplitude greater than four metres in 500m of water), a steep continental slope with complex topographic features such as Scott Reef, a tall isolated seamount, and seasonally varying stratification. The combination of these features results in a highly complex and dynamic internal wave field that is difficult to describe with field data or analytical models. In the present study, ROMS has been set up to simulate the internal wave generation and propagation process in this region. To be able to capture the complex topographic features, a fine grid with resolution of ~1km was used. Barotropic tidal currents and elevations for eight constituents sourced from the TPXO7.1 global tidal model were used to force the three open boundaries. A combination of radiation condition and numerical sponging was used to ensure that no baroclinic energy was reflected back into the system from the open boundaries. Temperature and salinity fields, used to initialize and force the model, were derived from a combination of monthly averages from a deep water mooring and the CSIRO Bluelink Reanalysis Hindcast dataset. Oceanographic datasets from three vertical moorings in water depths between 200 and 550m located on the shelf slope and near Scott Reef, a tall isolated seamount, were used to evaluate the performance of the model. Model performance was evaluated in terms of barotropic currents, isopycnal displacement and internal wave energy flux (FE = <u’p’>). Initial model results are generally in good agreement with field observations, giving confidence that ROMS, a hydrostatic, sigma coordinate model, is able to capture the important aspects of internal tide generation and propagation processes for a topographically complex region.

Data Interrogation and Visualisation Environment

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The Data Interrogation and Visualisation Environment (DIVE) is a data visualisation and data access tool developed for geographically localised, temporally and spatially varying data. DIVE targets the visualisation of multidisciplinary and multidimensional data. DIVE’s advantage lies in its ease of navigation and ability to combine different data sources. Given an appropriate source, it is able to interrogate the data without additional input from the user, and can differentiate between sediment and water-column variables. DIVE reads and displays data from hydrodynamic, sediment and bio-geochemical models (including ROMS), and observational data from vessels (underway, profiles), moorings, satellites/aircraft and biological data from dive sites, and can also incorporate GIS Map layers.

DIVE can: overlay selected datasets and simultaneously view them over space and time; explore and visualise both local data and data from an on-line repository; and provide metadata and custodian information from data repositories (where made available). Current development includes querying meta data repositories such as GeoNetwork server, incorporation of OGC web services and visualisation in a 3d volumetric environment.

DIVE’s development is supported under WAMSI, theWestern Australian Marine Science Institute.

NSW-IMOS An Integrated Marine Observing System for South Eastern Australia

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The Integrated Marine Observing System, (IMOS), is a centrally coordinated, nationally distributed set of equipment and data-information services which collectively contribute to meeting the needs of marine research in Australia. The observing system provides data in the open oceans around Australia as well as the coastal waters. The *in situ* data, when combined with satellite data, enables the modeling required to explain the role of the oceans in seasonal prediction and climate change. Sustaining the project will allow identification and management of climate change in the coastal marine environment. It will also provide an observational nexus to better understand and predict the fundamental connections between coastal biological processes and regional/oceanic phenomena that influence biodiversity. In this poster we introduce the New South Wales node of the Integrated Marine Observing System (NSW-IMOS), which is one of 5 regional nodes.

The East Australian Current flows poleward from the Coral Sea to the Tasman Sea. It impacts the coastal ocean along its path, particularly along the coast of southeastern Australia where the EAC and its eddy field dominates the shelf circulation. The primary goals of NSW-IMOS are to:

1. Quantify the seasonal and annual variation in EAC inflow along the coast of southeastern Australia and to identify key continental shelf processes;
2. Make sustained observations of the coastal separation of the EAC and the resulting eddy dynamics and biological consequences;
3. Determine the biological response to oceanographic and climate effects (eddies, upwelling, rainfall, dust storms), from fish movements, to phytoplankton communities, to benthic habitats.

We will achieve these goals through an integrated monitoring program along the NSW continental shelf which includes:

1. Establishing a national reference transect of oceanographic moorings, supported by a high frequency coastal radar;
2. Monthly sampling near the oceanographic moorings (for calibration and especially chlorophyll and zooplankton), supported by autonomous ocean gliders;

3. Deploying two cross-shelf transects of acoustic receivers ("listening posts") from the shore to the shelf break off Sydney and off Coffs Harbour, and using an Autonomous Underwater Vehicle (AUV);

Here we describe the observational plan and present a selection of the initial key observations from the program.

The Great Barrier Reef Ocean Observing System: Monitoring the Western Boundary Currents of the Coral Sea and Impacts on the Great Barrier Reef

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Since 1987, the Great Barrier Reef weather and water temperature observations have been transmitted in near real time using HF radio from pontoons or towers on coral reefs by AIMS. In contrast, oceanographic measurements have been restricted to loggers serviced at quarterly to half yearly downloads.

The Great Barrier Reef Ocean Observing System (GBROOS) is a regional node of the Integrated Marine Observing System (IMOS). IMOS is an Australian Government initiative established under the National Collaborative Research Infrastructure Strategy and has been supported by the Queensland Government since 2006. GBROOS comprises real time observations from weather stations, oceanographic moorings, underway ship observations, ocean surface radar, satellite image reception and reef based sensor networks.

This poster focuses on an array of in-line moorings that have been deployed along the outer Great Barrier Reef in order to monitor the Western Boundary currents of the Coral Sea. The Westward flowing Southern Equatorial Current bifurcates into the poleward flowing East Australian Current and the equatorward North Queensland Current.

The 4 mooring pairs consist of a continental slope mooring, nominally in 200m of water and one on the outer continental shelf within the GBR matrix in depths of 30 to 70m. The array is designed to detect any changes in circulation, temperature response, mixed layer depth and ocean-shelf interactions. A review of likely impacts of climate change on the physical oceanography of the GBR is providing a basis upon which to explore what processes may be affected by climate change. Data and results from the initial year of observations will be presented.