NSW-IMOS AN INTEGRATED MARINE OBSERVING SYSTEM FOR SOUTH EASTERN AUSTRALIA: THE EAST AUSTRALIAN CURRENT AND ITS INTERACTION WITH COASTAL ENVIRONMENTS

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ABSTRACT

The East Australian Current (EAC) 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 dominate the shelf circulation. It is in this region that the ocean is predicted to warm faster than anywhere else. The effect of increased ocean temperatures will impact on our climate, our weather and on marine ecosystems, where some species will prosper and others will decline. This region is also where that the majority of the Australian population live. It is thus timely that the Australian government has funded implementation of the Australian Integrated Marine Observing System (IMOS). In this paper we introduce the New South Wales node of the Integrated Marine Observing System (NSW-IMOS), one of 5 regional nodes. The primary goals of NSW-IMOS are to:

(1) Quantify the seasonal and annual variation in the EAC along the coast of southeastern Australia,

(2) Understand the coastal separation of the EAC, the resulting eddy dynamics, and key continental shelf processes,

(3) Determine the biological response to oceanographic and climate effects.

1. INTRODUCTION

The East Australian Current (EAC) influences the climate and marine economies of nearly half of the Australian population and yet we do not understand some of its most fundamental behaviour (e.g. the dynamics of current strength and separation from the coast; ecological effects of cross-shelf flows, larval trajectories and connectivity of populations). We do know the EAC transports heat from the tropics to the poles (Fig. 1), it sporadically stimulates upwelling and phytoplankton blooms through shelf edge interactions and the EAC eddy field; that it transports phytoplankton and the larvae of fish from the southern Great Barrier Reef (Queensland) to southern Australia (Bass Strait and Tasmania).

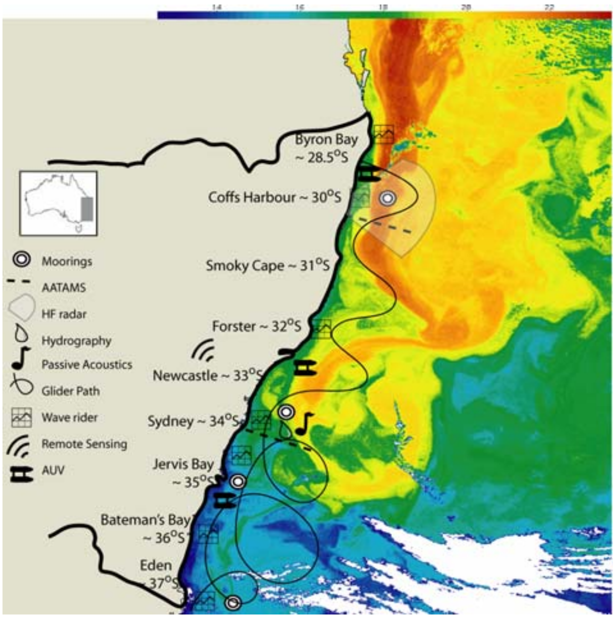

Figure 1: Satellite Image of Sea Surface temperature showing a 'classic' EAC scenario. Overlaid is a schematic of the implementation of IMOS along the coast of New South Wales Australia [1].

We also know that the EAC is changing. In recent years it has penetrated further south and has strengthened, particularly during the past decade where the Maria Island (Tasmania) reference station has recorded an increase of 2.3°C per century, the fastest recorded rise of any regional sea in the world [2]. Climate change scenarios consistently indicate further warming of the Tasman Sea [3] while ocean forecasts reveal large relative error due to mesoscale variability in the Tasman Sea. Downstream of the EAC separation, cold core eddies entrain enriched coastal water transporting it offshore and then either return it to the coast or push it east along the Tasman Front. We wish to monitor this entrained coastal water from off Diamond Head (31^{o}S). The ubiquitous warm core eddies also have biological significance by inducing upwelling along their boundaries [4].

2. GOALS OF NSW-IMOS

The goal of NSW-IMOS is to devise an observing system which will comprehensively examine the physical and ecological interactions of the East Australian Current and its eddy field with coastal waters and to assess the synergistic impacts of urbanisation and climate change. Our specific aims during the IMOS program are to:

(1) Quantify the seasonal and annual variation in the EAC along the coast of southeastern Australia,

(2) Understand the coastal separation of the EAC, the resulting eddy dynamics, and key continental shelf processes,

(3) Determine the biological response to oceanographic and climate effects.

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

• Establishing a network of oceanographic mooring arrays,

• Complimenting the moorings with high frequency coastal radar to enhance spatial coverage,

• Monthly biogeochemical sampling at select locations for temperature and salinity, oxygen, nutrients and chlorophyll concentration, zooplankton abundance and species composition,

• Regular coastal and bluewater surveys by autonomous ocean gliders,

• The deployment of two cross-shelf arrays of acoustic receivers for the acoustic tracking of tagged fish and

• Use an Autonomous Underwater Vehicle (AUV) to make sustained observations of the benthos.

The in situ data when combined with satellite data, enables the modelling 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 the observations necessary to better understand and predict the fundamental connections between coastal biological processes and regional/oceanic phenomena that influence biodiversity. The observing system presented here represents a new way forward for integrated observations of the waters of southeastern Australia and goes some way towards filling some of the knowledge gaps that exist in our understanding of the EAC.

3. ABOUT IMOS

The Australian Integrated Marine Observing System (IMOS, www.imos.org.au) was established as part of the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS) with an initial $A50M allocation. Co-investments from Universities, State and Commonwealth agencies made nearly $A100M available to develop IMOS during the period 2007 to 2011. IMOS is a distributed set of equipment and data-information services which collectively contribute to meeting the needs of marine research in Australia. The observing system provides data in the open oceans around Australia as well as the coastal waters. IMOS provides data to support research on many of the critical marine issues facing Australia, including climate change and sustainability of ecosystems. Further funding ($A52M) has recently been secured out to 2013 through the Super Science Initiative. With co-investment this will double the initial funding allocation. The twenty-seven separate institutions involved in IMOS comprise most of the universities and agencies with capability in ocean and marine research in Australia. The program has strong links with similar international programs and agencies. The IMOS strategic research-goal is to assemble and provide free, open and timely access to streams of data that support research on: 1. The role of the oceans in the climate system, and 2. The impact of major boundary currents on continental shelf environments, ecosystems and biodiversity. The scientific rationale and details of the need for observations were identified by five regional Nodes covering the Great Barrier Reef, New South Wales (southeastern Australia), Southern Australia, Western Australia and the Bluewater and Climate Node. The Sydney Institute of Marine Science (SIMS) hosts the NSW-IMOS node. As host of the NSW-IMOS node SIMS co-ordinates the IMOS activities in south eastern Australia. The NSW-IMOS node has more than 100 members and design of the observing system was determined by consensus. It is the details of the NSW-IMOS observing system that are outlined here.

The funding for IMOS flows through eleven national facilities. The observing facilities include three for bluewater and climate observations (Argo Australia, Enhanced Measurements from Ships of Opportunity and Southern Ocean Time Series), three facilities for coastal currents and water properties (oceanographic and acoustic Moorings, Ocean Gliders and High Frequency coastal Radar) and three for coastal ecosystems (Acoustic Tagging and Tracking, Autonomous Underwater Vehicle and a biophysical sensor network on the Great Barrier Reef). The operators of the facilities are the major players in marine research in Australia.

4. RESEARCH OBJECTIVES AND INFRASTRUCTURE REQUIREMENTS

NSW-IMOS have designed the deployment of research infrastructure around the main research themes and questions that we wish to address. The questions to be answered and the infrastructure required are outlined as follows.

(1) To investigate the EAC dynamics along the coast of SE Australia

• To estimate the seasonal and inter-annual variability; Infrastructure: Moorings (coastal and bluewater) HF radar, ships of opportunity-XBT.

(2) Understand the coastal separation of the EAC, the resulting eddy dynamics, and key continental shelf processes:

• The degree of cross-shelf flows and resultant upwelling; Infrastructure: Cross-shelf mooring arrays, monthly biogeochemical sampling, repeat glider transects, remote sensing.

• Coastal processes associated with the onshore encroachment of the EAC and interaction of EAC and shelf morphology; Infrastructure: Cross-shelf mooring arrays, HF Radar, remote sensing, monthly biogeochemical sampling, repeat glider transects.

• The effects and significance of EAC separation dynamics and mesoscale eddy formation; coastal boundary layer effects; Infrastructure: Cross-shelf mooring arrays, HF Radar, remote sensing.

• Enhanced monitoring and prediction of the coastal wave climate; Infrastructure: Wave resolving HF Radar; wave-rider buoy network.

(3) Determine the biological response to oceanographic and climate effects:

• Long term variability of planktonic communities and rocky reef ecosystems especially those associated with climate variability; Infrastructure: Monthly biogeochemical sampling; remote sensing, repeat AUV and glider surveys.

• Degree of alongshore larval transport and connectivity; Infrastructure: Cross-shelf mooring arrays, HF radar, remote sensing.

• Relationship of the EAC, its eddies and oceanographic conditions on primary productivity, fisheries, and movements by fish and sharks; Infrastructure: Cross-shelf mooring arrays, biogeochemical and plankton.

5. INSTRUMENTATION DEPLOYED

NSW-IMOS has established a national reference transect of moorings and bio-geo-chemical measurements off Sydney (34^{o}S). Hydrographic data has been collected for over 70 years at Port Hacking in the south of Sydney. The NRS transect consists of three moorings in 65, 100 and 140m of water and four water sampling stations in 25, 50, 100 and 125m of water in an area downstream of where the EAC typically separates from the coast, and is hence often influenced by EAC eddies. We have also deployed two moorings across the shelf at Coffs Harbour, upstream of the EAC separation point, and a single mooring at Jervis Bay, south of Sydney (Fig 1.). The arrays will enhance the coverage along the coast of south-eastern Australia to provide long term monitoring of the continental shelf oceanography both upstream and downstream of the EAC separation point. Also, as this is the most densely populated area of Australia, issues such as water quality, waste disposal, shipping hazards, harmful algal blooms and recreation are also of particular research interest.

6. SUMMARY

The development of a complete system from observations to hindcasts, nowcasts and forecasts will likely take decades. What we present here is the initial implementation over the first seven years and the vision for the future. While the initial focus has been on the physical environment this is by no means setting limitations on future directions. It is however recognition of the importance of the physical environment in driving biogeochemical processes, but is also an indication of the maturity of the sensors [5]. As more reliable and cost effective biogeochemical sensors become available the system will be augmented to include more parameters.

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