

# INTEGRATED MARINE OBSERVING SYSTEM (IMOS)

## IMOS FACILITIES Information for the IMOS 2009 Review

Name of Facility: Argo Australia

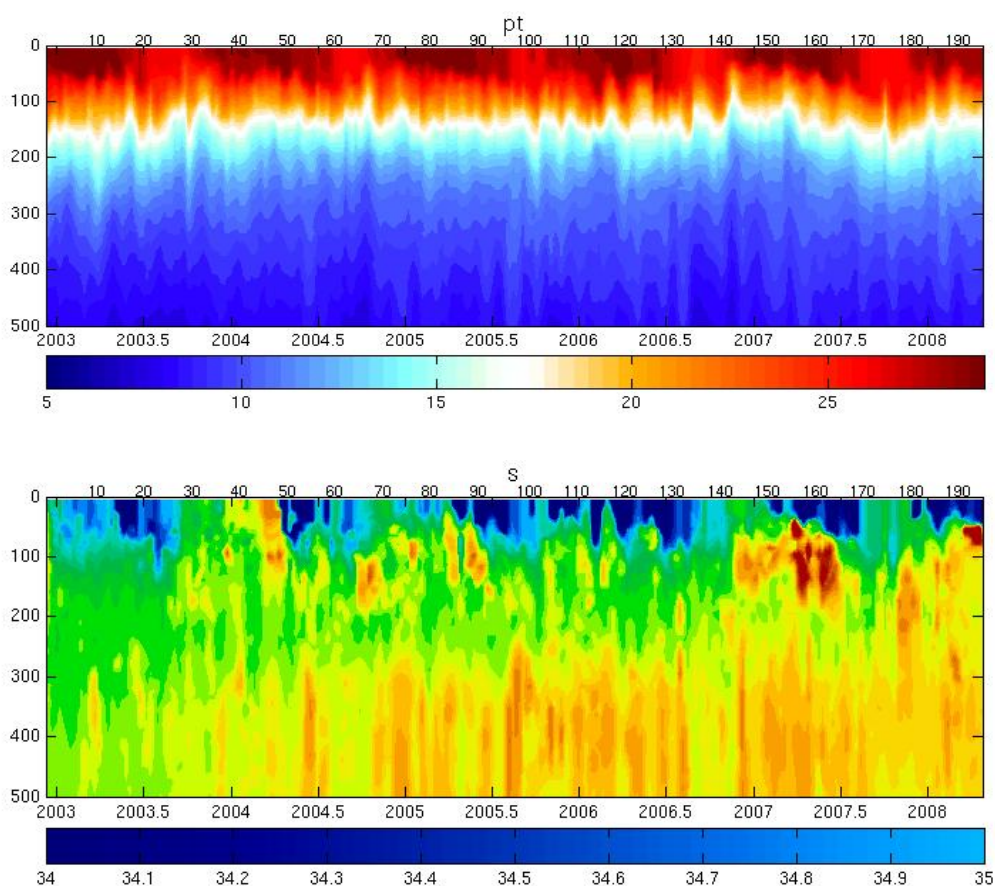
### Facility Leader contact details:

Dr Susan Wijffels: 03 6232 5450 [susan.wijffels@csiro.au](mailto:susan.wijffels@csiro.au)

Dr Ann Thresher: 03 6232 5419 [ann.thresher@csiro.au](mailto:ann.thresher@csiro.au)

### 1. Quality of implementation so far, and soundness of forward plan

The array of profiling floats operated by IMOS Argo has steadily grown as planned with ~100 floats deployed since July 2006 and 172 currently operating. Globally, Argo has reached its design target of 3000 active floats operating in ice-free open ocean regions, providing the first truly global *in situ real-time* ocean data stream. The array is still northern hemisphere biased with the southern hemisphere oceans still somewhat under sampled. IMOS Argo is working with partner countries to try to enhance southern hemisphere deployments. Internationally, Argo has yet to achieve key goals in data quality throughput and is working to remove some subtle biases in the global data set. Despite this, the program has grown from an idea to a fully implemented global observing system in less than 10 years.



*Figure caption:* Example of a continuous data record from a long lived IMOS Argo float between Northwest Australia and Indonesia. The float is profiling through very warm fresh near surface layers in the early part of each year when the Northwest Monsoon is active. Achieving 6 year lifetimes for a float profiling to 2000m in these conditions far outstrips the 3-4 year lifetime expected when Argo first began.

With respect to IMOS Argo, performance comparisons can be made with overseas Argo teams. IMOS Argo engineering performance has been excellent, real-time data timeliness is now excellent (90% of data are made available in 24 hours – recently improved) and data quality control and throughput is high compared to international groups. One expression of good engineering performance are that we have a cohort of IMOS Argo floats deployed in 2002 which are still profiling 6 years later from the surface to 2000m through a warm fresh tropical surface layer.

Pending continuing funding support from its partners, IMOS Argo is well positioned to achieve and possibly surpass (subject to exchange rate variations) its target deployment rate of about 50 floats per year. In addition to the original NCRIS IMOS plan, CSIRO has made capital available to purchase over 20 oxygen-sensor equipped Argo floats which will be primarily deployed in the Southern Ocean. Development of a processing and QC system for this data stream is not far advanced, and pending the completion of the core QC system, work on oxygen data may start in the next few years. Collaboration with other IMOS facilities utilising oxygen sensors will be pursued (e.g. moored arrays and glider facilities) as well as seeking to learn and contribute to international experience.

To date, the program has been able to maintain in kind and cash contributions from its partners, though the future of the Australian Climate Change Science Program (ACCSP) contribution (\$700k/annum of operating and salary funds) remains unknown – the present program ends in June 2009 and the Department of Climate Change is reviewing its Climate Change science strategy. The Antarctic Climate and Ecosystems Co-operative Research Centre is also winding down, but there is interest in supporting IMOS Argo in some options for its proposed successor. If ACCSP funding is not replaced, IMOS Argo will not be able to meet its planned milestones.

## 2. Consistency with principles

- ***Service* - IMOS is a national system and will provide a data-service that broadly supports marine research to maximise the contributions of R&D to economic development, national security, social wellbeing and environmental sustainability.**

IMOS Argo data allows the broad-scale ocean structure on seasonal timescales to be tracked in real-time. This information is being utilised both directly and indirectly to underpin marine and climate research and also national environmental forecasting systems, run operationally by the Bureau of Meteorology, such as numerical weather predictions, seasonal climate forecasting (POAMMA) and ocean forecasting (BlueLink).

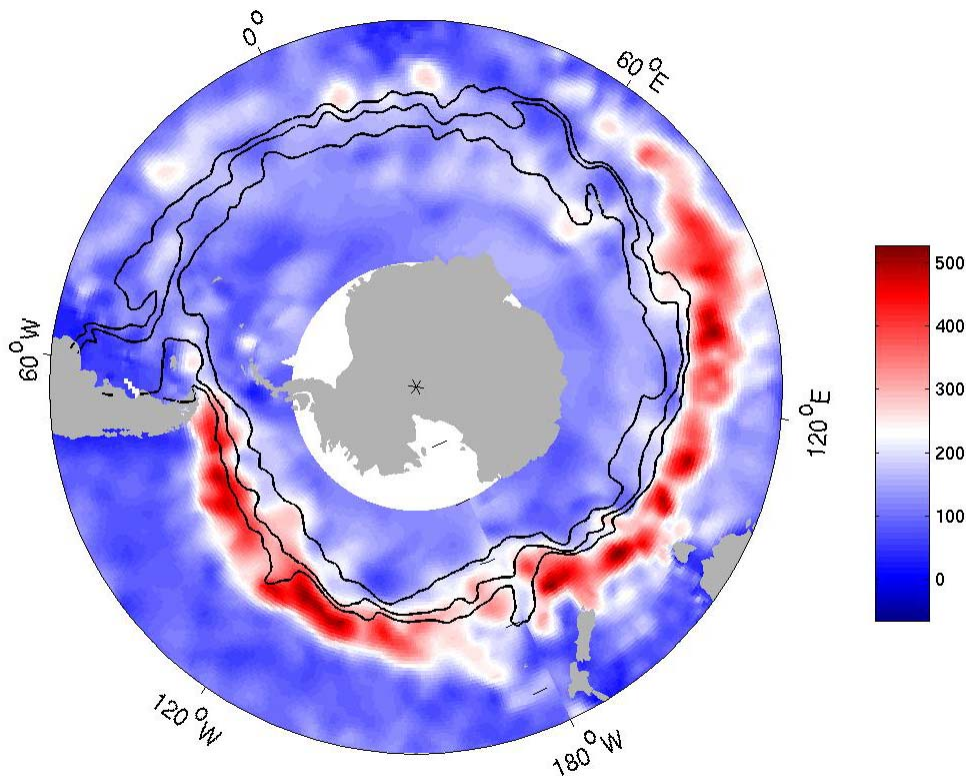
IMOS Argo is seen as a fundamental and key data stream for both Bluewater climate and oceanographic research. Additionally by monitoring offshore ocean variability, it may also be helpful for studies of shelf/coastal processes in some regions by providing a large-scale context for shelf processes.

- ***Data streams* - IMOS data will be delivered freely, openly, in a timely manner, preferably in near real time. Success will be measured in terms of the quality and quantity of data that IMOS delivers, the number of users and the quality of research-results produced with IMOS data.**

IMOS Argo data have been consistently published in real time (within 24 hours of collection). The program has made available over 53, 000 deep ocean profiles around Australia (17,000 from IMOS floats), and 500,000 profiles globally.

Higher quality QC has also been carried out on ~70% of eligible IMOS profiles (more than 1 year old) and these profiles re-delivered to IMOS and the Argo Global Data Centres.

Argo data comprise the single largest sources of real time in situ ocean data and in quantity has outstripped all historical WINTER data in the Southern Hemisphere. As a result, we have the first detailed view of the winter-time upper layer structure of the Southern Ocean, where key ventilation processes and water mass renewals occur in the deep mixed layers.



*Figure caption: Winter mixed layer depths in the Southern Ocean (JB Sallee, in prep). This detailed picture of the anatomy of the winter ocean mixed layers and their relationship to the main fronts comprising the Antarctic Circumpolar Current (black lines), would not be possible without Argo data.*

Products that utilise IMOS Argo data:

1. Ocean data assimilation products from the GODAE (<http://www.godae.org/Ocean-products.html>)
  2. Data only products ( [http://www.argo.ucsd.edu/FrProduct\\_page.html](http://www.argo.ucsd.edu/FrProduct_page.html) )
- **Integration - IMOS will deploy a nationally coordinated, multi-platform system to take advantage of the synergies between instruments, and to provide a comprehensive description of the ocean, as a contribution to national and international programs.**

IMOS Argo is a part of the International Argo Project ([www.argo.net](http://www.argo.net)), directly contributing to the global array through float deployments, helping develop and conforming to Argo data and operational policies (via membership of the Argo Data Team), guiding Argo's design and implementation through membership on the Argo Steering Team and Executive, contributing to Argo's international infrastructure by

supporting the Argo Information Center ( <http://wo.jcommops.org/cgi-bin/WebObjects/Argo> ).

IMOS Argo complements one of the other elements of the IMOS Bluewater node: the high density SOOP lines are aimed at measuring ocean transports and fluxes while Argo monitors large-scale ocean storage changes. There is a clear synergy between Argo and satellite altimetric measurements which track ocean sea level – combined Argo and high precision satellite altimeters are allowing the mean ocean circulation to be detailed as never before (Ridgeway et al, in prep).

Repeat hydrographic and carbon lines (RHC - [http://www.clivar.org/carbon\\_hydro/hydro\\_table.php](http://www.clivar.org/carbon_hydro/hydro_table.php)) also complement Argo – Argo provides a spatial and temporal context for the RHC occupations, while the RHC data provide a calibration check for Argo sensors. In addition while Argo monitors the upper 2km of the ocean, RHC reach full depth (tracking abyssal changes) and also track ocean oxygen, nutrient and carbon inventory changes.

Observing system studies using Australia’s ocean forecasting machinery show that, even for a system tuned to resolve eddy time and space scales, the Argo data stream complements both satellite altimetric and sea surface temperature data streams in constraining the system (Oke et al, 2008).

Oke, P. R., and A. Schiller, 2007: Impact of Argo, SST and altimeter data on an eddy-resolving ocean reanalysis. *Geophysical Research Letters*, **34**, L19601, doi:10.1029/2007GL031549.

- ***Sustainability* - The real value of IMOS will only emerge if systematic, repeated data collection continues for a long time to see the full range of climate variation and change. Sustained streams of data are integrally related to conservation and sustainable development of the marine environment.**

Having overcome many early technical and data system problems, IMOS Argo is now in a position to continue to grow to the target array number (~240 operating floats) and be sustained into the near-term. Ideally, at some future point, Argo may transition to ‘operational funds’ similar to our weather observing network. However, the required national financial and institutional arrangements are not yet in place to achieve this and a phased approach must be sought out.

### **3. Relevance to the IMOS science-goal**

- **Streams of data that support research on the role of the oceans in the climate system and the impact of major boundary currents on shelf-ecosystems**

Argo data now underpin key areas of climate research in Australia – researchers working on seasonal climate variability and climate change are heavy users of the data stream. In addition, many coastal and regional studies are using gridded ocean products derived from Argo and other data, such as those produced by the BlueLink project and its GODAE sister programs overseas.

One of the great challenges facing IMOS is how to connect the broad-scale offshore variability now monitored by Argo/SOOP facilities and satellites with changes on the shelf and at the coasts. On Australia’s western, southern and eastern coasts, this interaction is mediated by an energetic and complex boundary current system and coastal wave guide which is not well monitored by IMOS, except at low temporal resolution by the IMOS SOOP Facility, and sparsely by a few shelf and slope moorings, and glider lines. Argo does not resolve the space and timescales in this

boundary zone. The ability of ocean data assimilation schemes to span this 'gap' is one of the key questions that IMOS can address, with the outcomes helping guide the development of IMOS II. A combination of an array of gliders and lines of inexpensive long-lived deep ocean moorings spanning the boundary region may also be an affordable strategy to directly monitor this boundary current region in the future, and be the basis for testing modelling/data assimilation schemes in these regions.

Argo, as presently conceived, does not yet monitor the broadscale ocean biogeochemical fields. While oxygen sensors exist with the small mass, sensor stability and low power consumption required for deployment on floats, global deployment has not yet been agreed on. It is estimated that a global oxygen program will increase the cost of Argo by 50%. Sizeable regional experiments are required to help progress sensor development and to iron out engineering, implementation and QC issues. IMOS oxygen deployments are a step in this direction. Floats equipped with fluorescence and transmissometers have had mixed success due to sensor leaks and failures.

#### **4. Contribution to national capability building**

No additional information to report.

#### **5. Demonstrated user community / meeting researcher needs**

Uptake of Argo data by the science community continues to grow rapidly – see APB for statistics from recent meetings.

### **OTHER INFORMATION**

*The Review Panel will have access to the detail provided in the 2006/07 and 2007/08 Annual Progress Reports – available at <http://imos.org.au/reports0.html>. Detailed below are any significant changes / additions since June 2008*

#### **A. Changes to the original agreed level of co-investment**

As in 07/08 APB. However, for fy08/09 CSIRO has additionally contributed another 10 oxygen equipped Argo floats to IMOS bringing the total CSIRO contribution to above 20 oxygen equipped floats.

#### **B. Promotional activities**

The 3<sup>rd</sup> International Argo Science workshop will be held in March 2009, Hangzhou, China (<http://www.argo.ucsd.edu/ASW3.html>)

#### **C. Fostering collaborative development of infrastructure**

Argo Australia meetings help maintain coordination with all contributing partners and are held annually – attendees are from the cash and in kind partners: Bureau of Meteorology, Royal Australian Navy, and CSIRO.

#### **D. Scientific publications using IMOS data / participation in scientific seminars and conferences**

See APB and <http://www.argo.ucsd.edu/FrBibliography.html>

## MILESTONES

Below are:

- the Milestones transferred from 2007/08 to 2008/09 (as reported in the 2007/08 Annual Progress Report)
- the 2008/09 Milestones, as provided for the 2008/09 Annual Business Plan
- The post July 2009 planned activities, as provided for the 2008/09 Annual Business Plan

Please review, and amend the tables as necessary for any changes, and note any potential barriers to achievement.

### **MILESTONES TRANSFERRED FROM 2007/08 to 2008/09 (being those Milestones from the 2007/08 Annual Progress Report, recorded as either 'In Progress', or 'Transfer to 2008/09')**

<b>Party(s)</b>	<b><u>Due</u> / Status</b>	<b><u>Milestone</u> / Achievements / [Comments]</b>	<b>Update / Potential Barriers to Achievement</b>
Nil to Report – all 2007/08 milestones were achieved			

### **2008/09 MILESTONES (as provided in the 2008/09 Annual Business Plan)**

<b>Party(s)</b>	<b>Due</b>	<b>Milestone</b>	<b>Update / Potential Barriers to Achievement</b>
1.1 CSIRO	Jun09	Be operating an Argo Array of over 180 active floats	None, unless exchange rate variations drop well below AUD1 = USD0.65.

### **POST JULY 2009 PLANNED ACTIVITIES (for the period July 2009 to June 2011, as listed in the 2008/09 Annual Business Plan)**

<b>Party(s)</b>	<b>Start</b>	<b>Finish</b>	<b>Activity</b>	<b>Update / Potential Barriers to Achievement</b>
CSIRO	Jul09	Jun10	Be operating an Argo Array of over 210 active floats	Lack of continued support from ACCSP follow-on
CSIRO	Jul10	Jun11	Be operating an Argo Array of 240 active floats	Lack of continued support from ACCSP follow-on

# INTEGRATED MARINE OBSERVING SYSTEM (IMOS)

## IMOS FACILITIES Information for the IMOS 2009 Review

**Name of Facility:** Enhanced Measurements from Ships of Opportunity (SOOP)

**Facility Leader:** Ken Ridgway – phone 03 6232 5226, email [ken.ridgway@csiro.au](mailto:ken.ridgway@csiro.au)

### Sub-facility Leaders and contact details:

No	Sub-facilities	Leader	Phone	Email
2a	Multidisciplinary underway network - XBT - Biogeochemical (BGC) - Plankton (CPR)	Ken Ridgway Ann Thresher Bronte Tilbrook Anthony Richardson	03 6232 5226 03 6232 5419 03 6232 5273 07 3826 7183	<a href="mailto:ken.ridgway@csiro.au">ken.ridgway@csiro.au</a> <a href="mailto:ann.thresher@csiro.au">ann.thresher@csiro.au</a> <a href="mailto:bronte.tilbrook@csiro.au">bronte.tilbrook@csiro.au</a> <a href="mailto:anthony.richardson@csiro.au">anthony.richardson@csiro.au</a>
2b	Sensors on tropical research vessels	Miles Furnas	07 4753 4323	<a href="mailto:Miles.Furnas@aims.gov.au">Miles.Furnas@aims.gov.au</a>
2c	Sea surface temperature sensors	Helen Beggs	03 9669 4394	<a href="mailto:h.beggs@bom.gov.au">h.beggs@bom.gov.au</a>
2d	Research vessel real-time air-sea flux	Eric Schulz	03 9669 4618	<a href="mailto:E.Schulz@bom.gov.au">E.Schulz@bom.gov.au</a>

### 1. Quality of implementation so far, and soundness of forward plan

The implementation of this facility has proceeded according to plan and most of the components have either reached or are approaching full implementation.

### 2. Consistency with principles

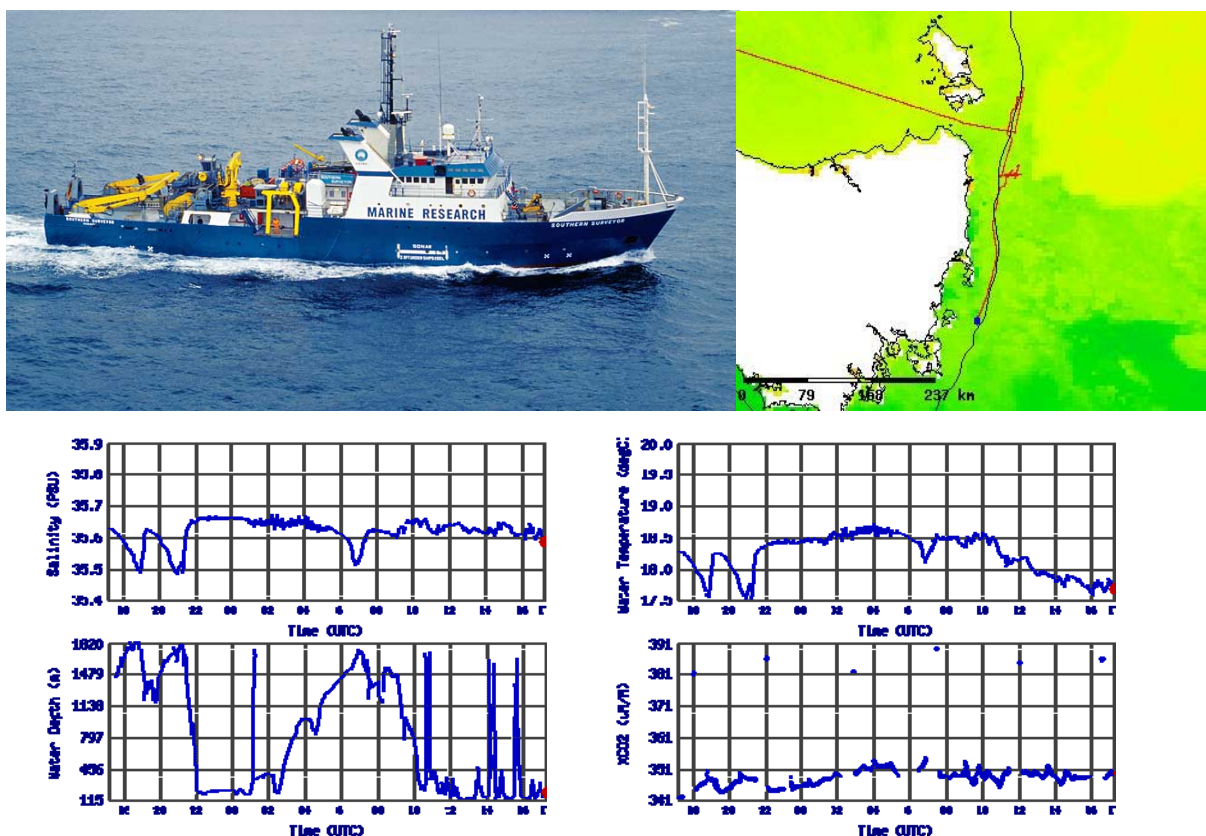
- **Service - IMOS is a national system and will provide a data-service that broadly supports marine research to maximise the contributions of R&D to economic development, national security, social wellbeing and environmental sustainability.**

The output from this facility provides data of national significance, contributes to international networks of physical and biogeochemical observations for the global ocean, and will provide the first regular broad-scale lower trophic level data for the Australian region. While the data streams are valuable in their own right, for example XBT transects providing time series of boundary current transport, much of the impact of the observations collected in this facility is via a range of reanalysis products. These data have a clear synthesis pathway through two major projects in ocean reanalysis: BLUELink, covering operational applications and short term prediction, and the coupled climate model ACCESS. The BLUElink reanalysis has direct application in maritime safety, oil spill monitoring, ship routing, defence requirements, coastal development and management, recreational activities.

Plankton data from the AusCPR program will underpin public-good research in several areas including biodiversity description and protection; baselines for assessing climate change and other global change impacts. These data will also help support Australian industries by providing indices of productivity for fisheries management, detecting and understanding of harmful algal blooms (important for mariculture industries), and for initialising and validating ecosystem models used for marine management.

- **Data streams** - IMOS data will be delivered freely, openly, in a timely manner, preferably in near real time. Success will be measured in terms of the quality and quantity of data that IMOS delivers, the number of users and the quality of research-results produced with IMOS data.

Real-time data streams are either now or soon to be available for the XBT, BGC (pCO<sub>2</sub>), SST, air-sea flux components. These data will be available on existing global data networks (eg GTS) and software protocols are being finalized for transfer to eMII. Data from the tropical research vessel program are presently available in a delayed mode. The CPR data are unique in Australia and will provide the research community with their only large-scale view of changes in plankton (both phyto- and zooplankton) in response to global change. Owing to the species-level analysis methods employed, the data will be delivered to the research community within 3 months of data collection.



*Figure caption:* Near real time data now being delivered for CO<sub>2</sub> from RV Southern Surveyor. The top right plot shows the track of the ship over an SST image as the ship travels down the east coast of Tasmania. The bottom right panel shows CO<sub>2</sub>. The blue line between 341 and 351 are surface water values and the gaps in the record are where standards and atmospheric samples are run. The approximately 4 –hourly dots above values of 381 are atmospheric measurements. These data are delivered every 6 hours and are available on the web. Final QC can take longer and delays to date are due to problems with calibration of ship’s instruments. Data return is close to 100%.

- **Integration** - IMOS will deploy a nationally coordinated, multi-platform system to take advantage of the synergies between instruments, and to provide a comprehensive description of the ocean, as a contribution to national and international programs.

This facility is perhaps the most complex of all the IMOS components. It consists of physical, chemical, & biological measurements obtained from several platforms (research & commercial vessels) covering coastal and bluewater regions. The

individual observation types contribute to international monitoring programs, and provide a fundamental element of the IMOS Bluewater & Climate Node.

The CPR collects plankton over large spatial scales (hundreds of nautical miles) and will have additional physical sensors attached. We will also be able to calibrate and compare with overseas CPR surveys, and with the SO-CPR survey at AAD. We will also be able to integrate physical and biological data along the IMOS National Reference Stations on the east coast of Australia.

- ***Sustainability* - The real value of IMOS will only emerge if systematic, repeated data collection continues for a long time to see the full range of climate variation and change. Sustained streams of data are integrally related to conservation and sustainable development of the marine environment.**

The hi-density XBT transects have been operated for more than 15 years and have already demonstrated the value of sustained ocean time series. Many valuable studies have been made using the data (see list of papers), particularly examining climate variability. The BGC and meteorological data streams “piggy back” on the Marine National Facility (SS), the Antarctic resupply vessel (SS) and the L’Astrolabe. Similarly the tropical sensor component depends on the operation of the AIMS research vessels. As long as there is ongoing support and operation of these vessels and appropriate maintenance of instruments, then the IMOS facility is sustainable. As ships of opportunity retire from participating in the IMOS SOOP SST Sensors sub-facility, new vessels will be recruited. Sustainability after June 2011 depends on further external funding, to maintain, calibrate and replace SST sensors and maintain the quality control and management of data streams. CPR transects collecting data on plankton have been operational in the North Atlantic for the last 70 years; in Australia, with ongoing support beyond the initial IMOS phase, should deliver similar long-term datasets. The current challenges we are facing setting up the program are typical of such surveys and the lessons we are learning along the way will ensure the long-term operational success of the program.

### **3. Relevance to the IMOS science-goal**

- ***Streams of data that support research on the role of the oceans in the climate system and the impact of major boundary currents on shelf-ecosystems***

This facility is particularly focused to address this goal. The suite of measurements, XBT profiles, pCO<sub>2</sub> & plankton time series, SST ground-truthing, improved meteorological & air-sea flux observations support ocean climate research in distinct areas. They provide fundamental sources of data to resolve climate changes, provide data to validate ocean & climate models, provide input to global flux & SST products, provide validation for satellite observations. The CPR data will generate for the first time in Australian waters, time series of biological data covering large spatial scales. The suite of data collected on the transects crossing the Australian coastal boundaries, resolve the major boundary currents - EAC, Leeuwin Current, Indonesian Throughflow, the Tasman Outflow and ACC. All of these systems strongly influence the Australian climate and directly impact the slope and shelf regions.

Plankton are short-lived and respond rapidly to changes in ocean conditions. This makes them invaluable sentinels of environmental changes such as global warming and current changes. Measurements of plankton diversity and distribution over time provide a baseline for detecting impacts of climate change at the base of the marine foodweb. Our two regions of focus, the Southern Ocean and the east coast of Australia, are both areas of substantial projected climate change, and the species data

collected by AusCPR will provide Australia with our best knowledge and understanding of changes in critical components of our marine ecosystems.

Air-sea fluxes form an integral part of the climate system as they quantify the exchange of energy occurring between the ocean and atmosphere. The fluxes can be derived from the high-quality meteorological observations. Over time a regional database of fluxes can be generated. A comprehensive data set of climate quality ship SST will enable more accurate validation/calibration of satellite products, and ocean analyses and models over the Australian region. In particular, IMOS will provide reliable, near real-time, in situ SST data in regions with non-existent or very sparse buoy or mooring coverage.

#### 4. Contribution to national capability building

The IMOS SOOP facility has been built on several existing programs which have been enhanced & expanded. For example the XBT network has now improved capacity for real-time transmission of data. The installation of underway sensors on the tropical research vessels greatly expands the routine data collection capacity of these vessels during all their time at sea. The BGC and air-sea flux components are contributing to enhancing the capability of the Marine National Facility and the Antarctic resupply vessel. The SST project is enhancing the monitoring capability of the Australian Volunteer Observing Fleet.

The development of the CPR component enables the build-up of technical skills in data collection, data processing and analysis. This area has been active in a small way at the Antarctic Division and the Australian skill base will be considerably expanded.

Type	Dates	Trainers	Where	Attendees
Phytoplankton identification	16/9/2008-18/9/2008	Gustaaf Hallegraeff	Hobart	Frank Coman, Claire Davies, Dave McLeod, Anita Slotwinski
Phytoplankton identification	July 2008	Pru Bonham and Ian Jameson	Hobart	Frank Coman, Claire Davies, Dave McLeod, Anita Slotwinski
Copepod identification	7/04/2008-11/04/2008	Dave McKinnon	Townsville	Frank Coman and Anthony J. Richardson
Copepod identification	Feb/Mar 2008	Dave McKinnon	Townsville	Frank Coman

#### 5. Demonstrated user community / meeting researcher needs

There is an existing strong user community of XBT operators and users based around the National SOOP Group. Regular annual meetings are held and the IMOS contribution will provide significant support to the activities of this group. Main user communities for the SST and Air-Sea Flux sub-facilities are the operational Meteorological and Oceanographic centres and international projects like SAMOS (<http://samoss.coaps.fsu.edu/html/>) and the International Group for High Resolution SST (GHRSSST). All the sub-facilities are strongly tied into a range of international data collection groups.

## OTHER INFORMATION

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### **A. Changes to the original agreed level of co-investment**

No changes

### **B. Promotional activities**

The IMOS SOOP activities have been publicized extensively by a range of presentations at National & International conferences (see list below & in progress report).

IMOS Ship SST data to be displayed publicly (with IMOS logo) on the Rottnest Island Ferry, SeaFlyte.

IMOS AusCPR website (see <http://imos.org.au/auscpr.html>)

Wikipedia entry

([http://en.wikipedia.org/wiki/Australian\\_Continuous\\_Plankton\\_Recorder\\_Survey](http://en.wikipedia.org/wiki/Australian_Continuous_Plankton_Recorder_Survey))

AuscPR brochure entitled "The Australian Continuous Plankton Recorder (AuscPR) survey"

### **C. Fostering collaborative development of infrastructure**

We are in discussion with Scripps and others regarding development of an XBT autolauncher to be linked to the Devil system. This will simplify data collection and potentially allow the system to be put on more vessels.

We are also in discussion with BOM about providing them with Iridium transmitters for their Devil systems. As their Argos transmitters need to be replaced, we expect them to use the Iridium system and will help them with this transition.

The CPR program (AUSCPR) retains close links with the international programs operated by the Alistair Ross Foundation. There is extensive collaborative development of infrastructure and broader collaboration with the Southern Ocean CPR program (SO-CPR) run by Graham Hosie of AAD.

### **D. Scientific publications using IMOS data / participation in scientific seminars and conferences**

A list of publications using SOOP IMOS data are included in the 2007/2008 Progress Report

Ann Thresher will be attending the GTSPP meeting to be held in late October in Hawaii. Formats and data management will be major items for discussion. She will report on the historical archive project, Quota, and give an update on the XBT depth bias problem as well as chair a session at this meeting.

Conferences: Asia-Pacific Workshop on Carbon Cycle Observations in Tsukuba 17-19 March, 2008. Bronte Tilbrook gave a plenary talk on Ocean CO<sub>2</sub> observations in Australia and highlighted the IMOS activities for CO<sub>2</sub> system measurements.

Ken Ridgway and Helen Beggs gave presentations on the SOOP Facility & SST Sensor sub-facility to a Chinese State Oceanic Administration delegation at the CSIRO & Bureau of Meteorology, Melbourne, on 4 & 6 October 2008.

Ken Ridgway, Eric Schulz & Helen Beggs gave presentations at the Western Pacific Geophysics Meeting in Cairns (July 2008) describing aspects of the XBT, SST and air-sea flux components.

GLOBEC Newsletter article entitled "The Australian Continuous Plankton Recorder (AusCPR) survey: a plankton observing system in Australian waters", Claire Davies, Frank Coman, Graham Hosie, David McLeod, Anthony J. Richardson, Anita Slotwinski (see pp 17-18 of the newsletter at <http://web.pml.ac.uk/globec/products/newsletter/news14.2.pdf>)

Richardson AJ (2007) Plankton - Sentinels of Climate Change. *Waves* 13(1): 4.

Presentation to CSIRO Hobart on "Challenges for translating climate change impacts to adaptation choices in the marine environment" in Sep 2008.

Presentation to CSIRO Cleveland on "The Australian Continuous Plankton Recorder Program (AusCPR)" in Aug 2008.

AMSA conference NZ July 2008. McLeod et al. "The sensitive side of plankton: Aus-CPR survey monitoring environmental change"

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**MILESTONES TRANSFERRED FROM 2007/08 to 2008/09 (being those Milestones from the 2007/08 Annual Progress Report, recorded as either ‘In Progress’, or ‘Transfer to 2008/09’)**

<b>Party(s)</b>	<b><u>Due / Status</u></b>	<b><u>Milestone / Achievements / [Comments]</u></b>	<b><u>Update / Potential Barriers to Achievement</u></b>
<i>2.1</i>	<i>Dec07</i>	<i>Recruitment and completed training of four staff (biogeochemical sampling (1), CPR sampling (2) and air/sea flux data management (1)); plus PhD student for CPR analysis / interpretation</i>	
<i>BGC</i>	In progress	Recruitment is now in progress.	Late approval of expenditure by CSIRO delayed the process further clashes with heavy commitments for the Southern Ocean field season.
<i>CPR</i>			4 CPR staff employed and undergoing training in phytoplankton and zooplankton identification

<b>Party(s)</b>	<b><i>Due / Status</i></b>	<b><i>Milestone / Achievements / [Comments]</i></b>	<b>Update / Potential Barriers to Achievement</b>
2.2	<i>Apr08</i>	<b><i>Software for transmission of data to eMII developed for all new installations</i></b>	
AIMS	In progress	Local data staff working on data processing software	Competing time demands with local GBROOS data system.
<i>BOM</i> <i>Air-sea</i>	In progress	BoM and CSIRO SST systems completed SS complete, AA in progress	AA by end of 2008
CSIRO <i>XBT</i>	In progress	Software developed for real-time delivery via Iridium. No direct delivery to eMII but to the GTS which distributes the data globally in real-time.	
<i>BGC</i>	In progress	Data delivered to MNF web site in near real time. GUI built for data processing.	Discussions with the IMOS data group are occurring to make these data available in near real time.
<i>CPR</i> BOM	Transfer 08/09		AIMS SST: Not yet ready to send NRT data to BoM. BoM: Systems developed and working to provide QC'd Met and SST data to eMII in near real-time

<b>Party(s)</b>	<b><i>Due / Status</i></b>	<b><i>Milestone / Achievements / [Comments]</i></b>	<b>Update / Potential Barriers to Achievement</b>
2.3  AIMS	<b><i>Jun08</i></b>  In progress/ Transfer to 2008/09	<b><i>Completed on-board, at sea testing of all newly purchased equipment (see 2.2), and final design of all installations</i></b> R.V. Cape Ferguson underway system operational (Feb 2008). Initial validation samples collected.  R.V. Solander underway system being installed	Debubbler on Ferguson underway system being upgraded in July 2008 as turbidity channel saturates on $\mu$ -bubbles. Installation of underway system on Solander has been slowed as the ship has primarily been working out of Broome, making it difficult to access and do fitting. Underway plumbing, T/S and fluorometer to be installed in Fremantle in late-July 2008
BOM <i>SST</i>	In progress (complete Oct 08)	Installed radiometer on Whitsunday Ferry Jun 2008. Two SBE48 hull-contact sensors have had testing/calibration in lab. SBE48 hull-contact sensor tested successfully on Southern Surveyor. Successfully tested microwave modems on Spirit of Tas for data comms. Refurbished SST measurement system installed on Rottnest Is Ferry.	Radiometer still undergoing testing and calibration issues to be resolved. RS-232 modems replaced with microwave modems. Sent test data to BoM. Waiting for Rottnest Is Ferry to be out of winter lay-up to test NRT transmission of data to BoM.
<i>Air-Sea</i>	In progress		Southern Surveyor. complete Jul 08 Aurora Australis. spring 08
CSIRO <i>XBT</i>	In progress	Devil XBT systems, iridium transmitters fitted to all systems, are being tested. Results promising further tests in late July.	Real-time delivery completed and to be tested in 2 weeks. Direct delivery of data to eMII will be implemented as well after discussions with eMII staff.
<i>BGC</i>	In progress (Astrolabe)		Major plumbing improvement for Astrolabe underway seawater supply is in progress. Changes in ships dry dock schedule and multiple problems with engineering companies scheduling work has caused delays in the installation by a few months, but these are now being done.

<b>Party(s)</b>	<b><i>Due / Status</i></b>	<b><i>Milestone / Achievements / [Comments]</i></b>	<b>Update / Potential Barriers to Achievement</b>
<i>CPR</i>	<i>Transfer to 08/09</i>	<i>Purchase and testing of CPRs. Purchase of microscopes</i>	<p>Installation to be completed in 08/09 period. CPRs have been obtained, and AusCPR data from the Southern Ocean are being collected and analysed. Data will be made available shortly through eMII, and discussions are progressing. For the l'Astrolabe route, the fitting of a winch and davit on the ship is almost complete and extended sampling in the Southern Ocean will be possible this austral summer. For the East Australia Current route (Brisbane to Burnie in Tasmania), negotiations with the ship have hit a hitch, days before the ship Kota Peminpin was due to start towing the Continuous Plankton Recorder. Charterers and Captain were very positive about towing the device, as were the Owners initially, but in the end the Owners expressed concerns over liability and health and safety. Negotiations with this and other shipping companies are ongoing. During this process, we have enlisted the help of the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) for guidance in these delicate negotiations, as this organisation deploys &gt;20 CPRs each month on ships of opportunity in the North Atlantic, and AusCPR has strong links (through Richardson &amp; Hosie) with this organisation. We are also sending one of our members over to SAHFOS to become familiar with best practice in working with CPRs aboard SOOPs. We expect that with the help of SAHFOS during the ship negotiations, we will successfully obtain a ship for the east coast route in the near future.</p>

**2008/09 MILESTONES (as provided in the 2008/09 Annual Business Plan)**

<b>Party(s)</b>	<b>Due</b>	<b>Milestone</b>	<b>Update / Potential Barriers to Achievement</b>
2.1 CSIRO	Aug08	Recruitment of pCO2 and plankton analysis staff	Position description for pCO2 analysis staff has been with management for some time and awaiting approval before advertising. In the interim, we have shifted other experienced staff onto the project to cover the staff shortfall. Expect to advertise in Nov 08, if the position is approved by management. Recruitment of plankton analysis staff completed
2.2 CSIRO	Jun09	Routine provision of pCO2 and CPR to eMII	pCO2 data formats submitted to eMII and eMII have the ability to display near real time data from Southern Surveyor. There have been delays of a few months in final QC of data due to finding a problem with the ship's underway salinity data. The final QC of pCO2 has had to wait for the ship's national facility data centre to correct the salinity data. The ship's support staff now has a new procedure in place to avoid a re-occurrence of the salinity problem. Apart from this delay the system is up and running on Southern Surveyor. The Astrolabe system is also installed and working. A required improvement in the Astrolabe plumbing has been completed and is being tested in Oct 2008. We are planning to upgrade the Astrolabe data delivery in 09/10 to better than first proposed in IMOS. This will provide more rapid data delivery to eMII.
2.3 AIMS	Jun09	Routine provision of T/S, Chl data to eMII	
2.4 BOM	Jun09	Near real time SST and weather data from 4 vessels	QC-SST & weather data from Rottnest ferry & Southern Surveyor now available SOT SST: expected by Nov 2008 L'Astrolabe: expected by Mar 2009

<b>Party(s)</b>	<b>Due</b>	<b>Milestone</b>	<b>Update / Potential Barriers to Achievement</b>
2.5 BOM	Oct08	Routine transfer flux data from Southern Surveyor and Aurora Australis to eMII	Transfer of flux data expected by Dec 2008 Routine transfer of met. data from SS achieved AA expected by Dec 2008.

**POST JULY 2009 PLANNED ACTIVITIES (for the period July 2009 to June 2011, as listed in the 2008/09 Annual Business Plan)**

<b>Party(s)</b>	<b>Start</b>	<b>Finish</b>	<b>Activity</b>	<b>Update / Potential Barriers to Achievement</b>
BOM	Jul09	Jun11	Routine instrument maintenance and calibration (ongoing).	Commenced routine calibration of met. sensors on the SS Sep 08. Lack of BoM RIC staff may require the US manufacturer to do the routine, annual recalibration of SBE48 SST sensors (cost > \$US500 per sensor, ~\$10,000 pa).

# INTEGRATED MARINE OBSERVING SYSTEM (IMOS)

## IMOS FACILITIES Information for the IMOS 2009 Review

**Name of Facility:** Southern Ocean Time Series (SOTS)

**Facility Leader Contact details:**

Dr Tom Trull : 03 6226 2988 [tom.trull@utas.edu.au](mailto:tom.trull@utas.edu.au)

Dr Eric Schulz: 03 9669 4618 [e.schulz@bom.gov.au](mailto:e.schulz@bom.gov.au)

### 1. Quality of implementation so far, and soundness of forward plan

Platform 1 SOFS – The implementation has been restricted to design, planning and organising the ships and facilities at CSIRO Hobart, The execution of the plans are being hampered by delays in agreeing to a Bureau-WHOI contract to construct SOFS.

Platform 2 Pulse - The build and deployment of the 2 test Pulse moorings that went out in early October has gone smoothly. Historically, personnel for Pulse had been in short supply and that has hampered development efforts. This deployment we had adequate funding and manpower. We have developed what appears to be a reliable telemetry system. We plan to retrieve these moorings in March 09, analyse the load cell and MRU data from them and integrate everything we've learned into a fully instrumented mooring to be deployed in spring 09.

Platform 3 Tethered Profiler – we are experiencing delays in delivery from the manufacturer of the profiling float, Webb Research Corporation, owing to problems with the bio-optical FLNTUS sensor provided by Wetlabs.

Platform 4 Glider – this component will be included via ANFOG in future years after they and we have had more successful deployments.

Platform 5 SAZ sediment trap mooring – this work is delivering more than expected, including the addition of two new in-situ settling columns deployed on the mooring in Oct. 2008 to measure particle settling rates.

### 2. Consistency with principles

- **Service** - IMOS is a national system and will provide a data-service that broadly supports marine research to maximise the contributions of R&D to economic development, national security, social wellbeing and environmental sustainability.
- **Data streams** - IMOS data will be delivered freely, openly, in a timely manner, preferably in near real time. Success will be measured in terms of the quality and quantity of data that IMOS delivers, the number of users and the quality of research-results produced with IMOS data.
- **Integration** - IMOS will deploy a nationally coordinated, multi-platform system to take advantage of the synergies between instruments, and to provide a comprehensive description of the ocean, as a contribution to national and international programs.
- **Sustainability** - The real value of IMOS will only emerge if systematic, repeated data collection continues for a long time to see the full range of climate variation and change. Sustained streams of data are integrally related to conservation and sustainable development of the marine environment.

SOTS targets all these objectives. Details on progress were provided in the 07-08 Progress Report

**3. Relevance to the IMOS science-goal**

- **Streams of data that support research on the role of the oceans in the climate system and the impact of major boundary currents on shelf-ecosystems**

This the core motivation for SOTS

**4. Contribution to national capability building**

SOTS is designed to both deliver data streams and to advance the personnel and technical capability.

**5. Demonstrated user community / meeting researcher needs**

Several papers have been submitted using samples collected by Platform 5 SAZ sediment trap mooring

**OTHER INFORMATION**

*The Review Panel will have access to the detail provided in the 2006/07 and 2007/08 Annual Progress Reports – available at <http://imos.org.au/reports0.html>. Detailed below are any significant changes / additions since June 2008.*

**A. Changes to the original agreed level of co-investment**

Essentially as planned – slightly larger in 07-08

**B. Promotional activities**

We have issued media releases, updated the web-site, and co-P.I. Tom Trull was interviewed on TV and radio in October 2008.

**C. Fostering collaborative development of infrastructure**

There is lot of synergy between the PULSE and NRS mooring developments. The two facilities now share surface float designs, and some aspects of the telemetry systems. Mostly the same personnel are working on developing both platforms. What we are learning on one of the projects often helps us understand or anticipate problems with the other.

**D. Scientific publications using IMOS data / participation in scientific seminars and conferences**

See the 06-07 and 07-08 Progress reports.

## MILESTONES

Below are:

- the Milestones transferred from 2007/08 to 2008/09 (as reported in the 2007/08 Annual Progress Report)
- the 2008/09 Milestones, as provided for the 2008/09 Annual Business Plan
- The post July 2009 planned activities, as provided for the 2008/09 Annual Business Plan

Please review, and amend the tables as necessary for any changes, and note any potential barriers to achievement.

**MILESTONES TRANSFERRED FROM 2007/08 to 2008/09 (being those Milestones from the 2007/08 Annual Progress Report, recorded as either ‘In Progress’, or ‘Transfer to 2008/09’)**

<b>Party(s)</b>	<b><u>Due / Status</u></b>	<b><u>Milestone / Achievements / [Comments]</u></b>	<b><u>Update / Potential Barriers to Achievement</u></b>
3.1 BOM	<b>Jan08</b> BOM: Transfer to 2008/09	<b>Employ Staff</b> [BOM: staff not needed until SOFS platform deployed]	
3.2 BOM	<b>Jan08</b>  In Progress	<b>Complete design and commence building of meteorological mooring at WHOI</b> Design completed. [Construction pending contract finalisation]	Contract negotiations ongoing.
3.3 CSIRO UTAS	<b>Jun08</b> In Progress	<b>Deploy tethered profiler after testing</b> Biogeochemical instruments and profiler specified and order placed with Webb Research Inc. [Problems with instruments as supplied to Webb Research have slowed delivery of profiler. Project currently focusing on developing 2-way Iridium communication so that profiler mission can be achieved]	<b>Webb is still awaiting delivery of redesigned sensor and would not promise any delivery time on floats. Plan is to buy a float without this FLNTU sensor so we can practice communicating our “dual mission” to a float and get a data stream.</b>
3.4 BOM	<b>Jun08</b>  BOM: In Progress	<b>Test real-time data system and transmission of data to eMII</b> BOM:Version 1 system completed [Has been tested on ship met data]	Real time data is being received from the two PULSE test moorings deployed in Oct. 2008 and is being delivered to eMII. It is expected to go live to the web in late November 2008.

**2008/09 MILESTONES (as provided in the 2008/09 Annual Business Plan)**

Party(s)	Due	Milestone	Update / Potential Barriers to Achievement
3.1 CSIRO UTAS	Mar09	Construct and deploy operational version of platform 2. PULSE biogeochemical mooring	<b>This is recovery date for pulse test moorings. Minimum of 3 months added to this date for construction. Deploy in Sep/Oct 09</b>
3.2 BOM CSIRO UTAS	Apr09	Complete construction of engineering test version of platform 1. SOFS meteorology mooring	Current deployment date for engineering test version is October 2009. Dates will depend on contract signing date.

**POST JULY 2009 PLANNED ACTIVITIES (for the period July 2009 to June 2011, as listed in the 2008/09 Annual Business Plan)**

Party(s)	Start	Finish	Activity	Update / Potential Barriers to Achievement
BOM	Jul09	Jun11	Employ real-time data management staff at 0.4 FTE	
BOM	Apr09	Sep09	Complete full version of platform 1 at WHOI	Current deployment date for full version is April 2010. Dates will depend on contract signing date.
BOM	Sep09	Sep10	Deploy full version of platform 1 (12 or 6 month deployment)	
CSIRO UTAS	Jul09	Jun11	Provide data from platforms 2-5	<b>Platform 2 (PULSE) and 3 (Profiler) delayed to Oct 09 because of engineering and supplier delays. Platform 5 being distributed already. Platform 4 (Glider) to be developed on 2010 via ANFOG.</b>

# INTEGRATED MARINE OBSERVING SYSTEM (IMOS)

## IMOS FACILITIES Information for the IMOS 2009 Review

**Name of Facility:** Australian National Facility for Ocean Gliders (ANFOG)

**Facility Leader:** Prof Chari Pattiaratchi - Phone: 08 6488 3179; Email: [chari.pattiaratchi@uwa.edu.au](mailto:chari.pattiaratchi@uwa.edu.au)

### 1. Quality of implementation so far, and soundness of forward plan

Ocean gliders are autonomous vehicles designed to operate in water depths up to 1000 m. By changing its buoyancy, the glider is able to descend and ascend. For IMOS, two different types of gliders have been purchased. The Slocum glider is designed to operate to a maximum depth of 200m and a maximum endurance of 30 days, whilst the Seaglider is able to operate to a maximum depth of 1000m and a maximum endurance time of up to 6 months. Both gliders have the same suite of sensors to measure conductivity (for salinity), temperature, dissolved oxygen, fluorescence, turbidity and CDOM (dissolved organic matter) with depth.

IMOS has taken delivery of delivery 3 Slocum gliders and 5 Seagliders. An additional Slocum glider has been purchased and is scheduled for delivery in November 2008.

Software and data management procedures for the ANFOG data have been developed together with the development of real-time web based data visualization system for the display of glider tracks and data plots.

Difficulties have been encountered with satellite communications with the gliders. The glider systems have been developed for the US telecommunication systems and required modification and testing, including the development of new software by the manufacturers has delayed the planned deployments for the IMOS nodes.

Slocum gliders were deployed in Western Australia (July) and South Australia (August), but were aborted due to problems associated with leakage. Deployment of another glider in South Australia had to be aborted due to problems with a faulty pressure sensor. One Slocum glider had to be returned to the manufactures for repair.

In the next few months (November/December) gliders are scheduled to be deployed in South Australia, New South Wales, Tasmania and Western Australia.

### 2. Consistency with principles

- ***Service* - IMOS is a national system and will provide a data-service that broadly supports marine research to maximise the contributions of R&D to economic development, national security, social wellbeing and environmental sustainability.**
- ***Data streams* - IMOS data will be delivered freely, openly, in a timely manner, preferably in near real time. Success will be measured in terms of the quality and quantity of data that IMOS delivers, the number of users and the quality of research-results produced with IMOS data.**
- ***Integration* - IMOS will deploy a nationally coordinated, multi-platform system to take advantage of the synergies between instruments, and to provide a comprehensive description of the ocean, as a contribution to national and international programs.**

- ***Sustainability*** - The real value of IMOS will only emerge if systematic, repeated data collection continues for a long time to see the full range of climate variation and change. Sustained streams of data are integrally related to conservation and sustainable development of the marine environment.

No additions to that previously reported for these areas

### **3. Relevance to the IMOS science-goal**

- **Streams of data that support research on the role of the oceans in the climate system and the impact of major boundary currents on shelf-ecosystems**

No additions to that previously reported for this

### **4. Contribution to national capability building**

Ocean gliders are a relatively recent development and therefore could still be classified as in an experimental stage. Currently, ANFOG has encountered problems, specific to Australia, due to problems with the Iridium communications. This has now been resolved. As the gliders are deployed routinely, technicians from the individual nodes are being trained in the deployment and recovery. For example, SAIMOS personnel were able to recover a Slocum glider without the presence of an ANFOG technician on-site. This will continue and will contribute to a national capability in the glider deployment and recovery.

### **5. Demonstrated user community / meeting researcher needs**

As a 'new' technology, there is a great interest and enthusiasm from the nodes for the deployment of gliders in their respective nodes. Even the two deployments to date, although only for a period of 3-4 days have provided glimpses of data which show much promise in the longer term deployments. It is expected that glider data will provide not only routine monitoring data, but also data which allow the documentation of particular processes, including physical-biological interactions within the water column.

## **OTHER INFORMATION**

The Review Panel will have access to the detail provided in the 2006/07 and 2007/08 Annual Progress Reports – available at <http://imos.org.au/reports0.html>. Detailed below are any significant changes / additions since June 2008.

#### **A. Changes to the original agreed level of co-investment**

None

#### **B. Promotional activities**

1. UWA Expo (Open Day) – 10 August 2008
2. UWA Faculty of Engineering and Mathematical Sciences Research Showcase (12 Nov 2008)

#### **C. Fostering collaborative development of infrastructure**

ANFOG is discussing with Australian Acoustic Tagging and Monitoring System (AATAMS) the possibility of mounting an acoustic receiver on a Slocum glider. Through discussion with AATAMS personnel, we have sourced a small ('business card') receiver which we will test for ballasting in the laboratory and then undertake a test deployment in an area of AATAMS deployments (e.g. Ningaloo) as a feasibility study.

#### **D. Scientific publications using IMOS data / participation in scientific seminars and conferences**

Scientific Seminars and Conferences (Since 1 July 2008)

ANFOG 2008 REVIEW TEMPLATE Sep08

Australian Geophysical Union (AGU) Western Geophysics Meeting (July 2008)  
Department of Environment (WA) - Seminar  
Physics of Estuaries and Coastal Seas (PECS) Conference, Liverpool, UK (August 2008)  
4<sup>th</sup> Australian National Abalone conference, Port Lincoln, AUS (September 2008)  
European Glider Observatories workshop, La Spezia, Italy (October 2008).

## MILESTONES

Below are:

- the Milestones transferred from 2007/08 to 2008/09 (as reported in the 2007/08 Annual Progress Report)
- the 2008/09 Milestones, as provided for the 2008/09 Annual Business Plan
- The post July 2009 planned activities, as provided for the 2008/09 Annual Business Plan

Please review, and amend the tables as necessary for any changes, and note any potential barriers to achievement.

**MILESTONES TRANSFERRED FROM 2007/08 to 2008/09 (being those Milestones from the 2007/08 Annual Progress Report, recorded as either ‘In Progress’, or ‘Transfer to 2008/09’)**

<b>Party(s)</b>	<b><i>Due / Status</i></b>	<b><i>Milestone / Achievements / [Comments]</i></b>	<b>Update / Potential Barriers to Achievement</b>
4.1 UWA	<b><i>Dec07</i></b> In progress	<b><i>Recruit and train three technicians</i></b> 2 Personnel working full-time. <i>[1 position to be advertised]</i>	Advertisement for glider technician now with UWA Human Resources, to be advertised in Nov/Dec 2008.
4.2 UWA	<b><i>Jun08</i></b> In progress	<b><i>Availability of real-time data for the three initial deployments in Western Australia, South Australia and Tasmania</i></b> Shallow water Slocum gliders have been deployed in Western Australia and South Australia. <i>[Tasmania required deep water gliders, which are still being tested for communications. All gliders have been purchased and delivered to UWA.]</i>	Gliders were deployed but the glider missions had to be aborted due to leakage problems.  Seaglider has yet to be tested in the ocean prior to deployment due to communication and base station problems
4.4 UWA	<b><i>Jun08</i></b> In progress	<b><i>Assessment of national capability to use gliders</i></b> <i>[At present sufficient gliders have not been deployed to make an assessment.]</i>	

**2008/09 MILESTONES (as provided in the 2008/09 Annual Business Plan)**

<b>Party(s)</b>	<b>Due</b>	<b>Milestone</b>	<b>Update / Potential Barriers to Achievement</b>
4.1 UWA	Jun09	Deployments of gliders in NSW, SA, Tas and WA	

**POST JULY 2009 PLANNED ACTIVITIES (for the period July 2009 to June 2011, as listed in the 2008/09 Annual Business Plan)**

<b>Party(s)</b>	<b>Start</b>	<b>Finish</b>	<b>Activity</b>	<b>Update / Potential Barriers to Achievement</b>
UWA WAIMOS	Jul09	Jun11	deployments of Seaglider and Slocum gliders off Western Australia	
UWA SAIMOS	Jul09	Jun11	deployments of Seaglider and Slocum gliders off South Australia	
UWA Bluewater	Jul09	Jun11	deployments of Seaglider off Tasmania	
UWA NSWIMOS	Jul09	Jun11	deployments of Seaglider and Slocum gliders off New South Wales	

# INTEGRATED MARINE OBSERVING SYSTEM (IMOS)

## IMOS FACILITIES Information for the IMOS 2009 Review

**Name of Facility/Sub-facility:** Autonomous Underwater Vehicle (AUV)

**Facility Leader:** Stefan Williams - Phone: 02 9351 8152; Email: stefanw@acfr.usyd.edu.au

### 1. Quality of implementation so far, and soundness of forward plan

To date the AUV Facility has shown good progress against the initial goals proposed to IMOS. The AUV has operated successfully on four major cruises with the support of IMOS over the 2007/2008 timeframe. The vehicle itself has repeatedly demonstrated its capacity to collect high resolution, near bottom imagery and multibeam data. It has been upgraded with a number of additional instruments, including a Wetlabs Ecopuck fluorometer for measuring chlorophyll-a, CDOM and scattering/turbidity (red). We have integrated an Imagenex DeltaT multibeam sonar on the AUV and trialled it on a number of cruises. The IMOS Steering Committee has endorsed proposals for deployments in South Australia and Tasmania. New proposals are being solicited from other nodes, including NSW, WA and Queensland.

A series of trials were undertaken in collaboration with scientist from the Australian Institute of Marine Science (AIMS) to assess benthic habitats off the Ningaloo Reef, Western Australia in May, 2007. These trials were aimed at evaluating the effectiveness of using an AUV for conducting biodiversity assessment in waters beyond diver depths. The particular focus of these deployments was on documenting sponge habitats in 40m to 80m depths and in exploring canyons in depths up to 250m.

The AUV was also part of a three week research cruise in September 2007 aboard the R/V Southern Surveyor documenting drowned shelf edge reefs at multiple sites in four areas along the Great Barrier Reef. This collaborative cruise included scientists from the University of Sydney, James Cook University, CSIRO, Oxford, the University of Edinburgh and Fugro Seafloor Survey. We were able to document relic reefs up to 20k years old formed during previous ice ages when sea levels were up to 100m lower than today. The study of these structures may yield insights regarding potential future sea level changes and their potential impact on sensitive reef areas such as the GBR.

The AUV surveyed benthic habitats around the Sir Joseph Banks Island group in June 2008 as part of an IMOS-funded research effort led by DEH SA. The island group is being considered for the establishment of a marine park and the objective of the cruise was to document the surrounding benthic habitats. The imagery collected by the AUV will be used to validate habitat assessment to be made with sidescan sonar surveys over the coming months. Ship time for supporting AUV operations was secured by DEH SA aboard the SARDI research vessel R/V Ngerin.

National Geographic funding was also secured for a deployment in collaboration with Roger Hanlon from the Marine Biological Laboratory in Woods Hole, MA. The objective of the trip was to document nocturnal cuttlefish camouflage behaviour near spawning grounds in Whyalla, SA. In excess of 100,000 cuttlefish aggregate in this area each year to spawn. The AUV spent one week following the Sir Joseph Banks trip being deployed at night in the shallow waters around these spawning grounds.

Finally, the AUV spent two weeks in Tasmania in October 2008 surveying sites as part of the Commonwealth Environmental Research Facility (CERF) Marine Biodiversity Research Hub. This research hub is a collaborative joint venture between the University of Tasmania, CSIRO Marine Research, Geosciences Australia, Australian Institute of Marine Sciences and the Museum of Victoria. The AUV deployments focused on sites along the Tasman Peninsula in SE Tasmania and in the Huon MPA. The objective of the cruise was to describe biological assemblages associated with rocky reef systems in deep shelf waters beyond normal diving depths. Detailed multibeam mapping of the survey areas had been undertaken prior to the AUV deployment to determine suitable survey locations and to identify any hazards to operation. At each location, multiple reefs were selected for detailed survey work at a range of depths from approximately 50 m to 150 m. Dive profiles were designed to include sufficient replication to quantitatively determine abundances of key species/features within depth strata, within reefs, between reefs (km to 100 km scale), and between differing levels of reef complexity. Over the course of the 10 days of operation, the vehicle undertook 19 dives and visited all the sites of interest identified prior to the voyage. At the conclusion of the trip, we delivered a largely complete dataset to the science party, including over 1TB of geotiff imagery, multibeam, AUV tracks, 3D textured meshes and hydrographic data.

Overall, the AUV Facility is fulfilling its commitments to IMOS. Our team of engineers have worked well on-board various ships and we are working at streamlining the data management process. We will need to work closely with eMII to ensure that the data is accessible and stored in a suitable format for archiving and distribution. We are currently preparing the Tasmanian dataset as a first test case for data delivery and wider dissemination.

The forward plan for the AUV Facility needs further consideration. The initial commitment from IMOS was for two years of funding as a pilot to gauge the interest from the community in the capabilities of this vehicle – and of AUV services in general in support of marine science activities. There has been considerable interest in the Facility and the imagery and three dimensional seafloor reconstructions being generated with the data. In addition to the expeditions undertaken to date, we have received proposals or are in discussion with the following groups who have expressed interest in using the AUV as part of future expeditions.

<b>Party</b>	<b>Node</b>	<b>Description</b>	<b>Timeframe</b>
SARDI (David Currie & Tim Ward)	SAIMOS	DuCouedic Canyon and Great Australian Bight Marine Park – surveying of canyon habitats and within the GAB MPA	June, 2009 – proposal approved
TAFI (Neville Barrett)		Freycinet MPA, scallop fisheries sites and St Helens urchin barrens – further survey work associated with the CERF initiative	Feb, 2009 – proposal approved
CSIRO WA (Cedric Griffith) & West Australian Museum (Corioli Souter)	WAIMOS	Rottneest Island ship graveyard – surveying sediment mobility around known ship dumping grounds and documenting condition of historic wrecks	early 2009 – draft proposal received
AIMS WA (Andrew Heyward)	WAIMOS	Scott Reef and Kimberley Coast – habitat assessment in sensitive coastal and offshore reef areas	TBA – in discussion
SIMS (David Booth)	SEAMOS	Sydney Harbour and offshore reefs – assessment of deep water reef habitats	TBA – in discussion
Sydney University (Jody Webster and Maria Byrne)	SEAMOS	Documentation of reef and lagoonal habitats around One Tree Island and drowned reefs on the continental margin	TBA – in discussion
JCU (Thomas Stieglitz)	GBROOS	Investigation of fresh water outflows on the Great Barrier Reef	TBA – in discussion

Victoria Parks (Steffan Howe)		Marine habitat mapping for the Victorian system of MPAs	TBA – in discussion
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These proposals suggest that there is interest from the community in continued funding for the AUV Facility. The present level of funding is supporting a single technical officer as well as providing funding for the acquisition of new sensors and to cover the logistical costs of transporting the equipment and operating team to study sites. We have generated significant levels of in-kind contributions in the form of ship time and contributions from the University of Sydney to cover insurance, the purchase of additional sensors and support for personnel associated with the facility. A proposal has been prepared outlining the requirements for on-going support of the AUV Facility in terms of the logistical and data processing requirements to continue delivering high-resolution seabed imaging services to the marine science community. This would allow the AUV Facility to continue operations in the period covered by the initial IMOS funding out to 2011. A proposal for funding as part of a second round of IMOS, in which we would propose to expand the Facility and offer a wider range of AUV support to the community, is also being prepared.

## 2. Consistency with principles

- ***Service - IMOS is a national system and will provide a data-service that broadly supports marine research to maximise the contributions of R&D to economic development, national security, social wellbeing and environmental sustainability.***

As outlined above, the IMOS AUV Facility has provided services to a number of institutions around the country over the past year and a half. The AUV has been deployed in Western Australia, Queensland, New South Wales, South Australia and Tasmania, representing a truly national focus for this facility. The proposals received, and serviced, have been tied to research, development and management programs around the country. These include programs associated with the designation of marine parks, the Commonwealth Environmental Research Facility (CERF) Marine Biodiversity Research Hub and AIMS' on-going biodiversity assessment programs in WA. These are all making important contributions to environmental sustainability and providing a better understanding of some of our vulnerable marine habitats.

- ***Data streams - IMOS data will be delivered freely, openly, in a timely manner, preferably in near real time. Success will be measured in terms of the quality and quantity of data that IMOS delivers, the number of users and the quality of research-results produced with IMOS data.***

The AUV Facility has generated substantial, innovative data as part of the operations undertaken to date. We have been actively developing the tools required to support the volume of data generated during deployments and have managed to streamline our operations to the point where we have been able to provide a first pass data set to the science party at the conclusion of the last two cruises. We are working to get this data to eMII for both archival as well as data delivery purposes. The more traditional hydrographic data streams, such as CT and fluorometer data, can be delivered in standard formats, however the volume of stereo imagery collected is more difficult to manage. The most recent Tasmanian data set is being treated as a test case for delivering data to the IMOS eMII office and will be used to agree on preferred formats and delivery mechanisms. We have made it clear to end users that data is to be made freely available to the marine science community and to date have had no objections or issues associated with this policy.

- ***Integration* - IMOS will deploy a nationally coordinated, multi-platform system to take advantage of the synergies between instruments, and to provide a comprehensive description of the ocean, as a contribution to national and international programs.**

To date there has not been substantial integration of the AUV data with other IMOS facilities' data streams. The nature of the AUV Facility is such that the data streams produced are focused on benthic habitats. Most of the other IMOS Facilities deal with oceanographic conditions within the water column. However, there have been good synergies between the data collected by the AUV and bathymetric data collected using ship-borne instrumentation on both the Great Barrier Reef expedition to map drowned shelf edge reefs and on the recent Tasmanian voyage. In these cases, the AUV data is being used to validate benthic habitat assessments derived from the multibeam bathymetry.

There is a possibility of coordinating one of the upcoming South Australia cruises with IMOS related moorings servicing work but this still does not represent an integrated deployment. There may be some value in periodically visiting areas around moorings to provide spatial context to time series data collected at mooring locations, but this type of deployment, just like all others performed by the AUV should be driven by science needs.

We have also been discussing the possibility of deploying the AUV to support work being undertaken by Thomas Stieglitz at JCU who has successfully proposed that the AATAMS Facility deploy receivers in one his study sites. This would provide an interesting use of data from very different IMOS Facilities.

- ***Sustainability* - The real value of IMOS will only emerge if systematic, repeated data collection continues for a long time to see the full range of climate variation and change. Sustained streams of data are integrally related to conservation and sustainable development of the marine environment.**

Sustainability of the IMOS AUV Facility will require further, and on-going, investment in this facility. The AUV by its nature requires a certain amount of logistical support for its deployment. Ship time and suitably qualified personnel are instrumental for both the operation of the facility and the management of the data streams being produced. A decision will also have to be made as to whether the AUV Facility is best used at a select number of sites in a long term monitoring role or should continue to visit sites as proposals are received. Some combination of the two may provide a good compromise allowing us to aid with monitoring change as well as continuing to support more exploratory science.

### 3. Relevance to the IMOS science-goal

- **Streams of data that support research on the role of the oceans in the climate system and the impact of major boundary currents on shelf-ecosystems**

The high-resolution imagery collected by the AUV Facility has been used in a variety of studies aimed at understanding benthic habitats. There is considerable interest in understanding the impact of climate related changes on the benthos and the AUV provides a repeatable, non-destructive mechanism for monitoring the seafloor. The AUV has proven well suited to providing high quality optical ground-truthing for broad scale acoustics-based surrogate habitat maps. As such, the AUV system has the potential to affect monitoring efforts at much larger scales than it directly covers. The ability to examine spatial patterns within the data using the high-resolution 3D reconstructions we are generating is novel in its ability to place observations within the geographic context in which they were taken.

#### **4. Contribution to national capability building**

Unmanned Underwater Vehicles (UUVs) are providing effective access to areas of the seafloor in waters beyond scuba diving depths. National capability building is being enhanced through support for the IMOS AUV Facility in terms of the development, deployment and collection of these novel data streams. The high-resolution benthic imagery and multibeam data represent a compliment to more traditional towed video data. As outlined above, the AUV has demonstrated its capacity to yield data that can enhance the habitat assessments made using ship-borne instrumentation. The data being generated by the IMOS AUV Facility is seen as world class in terms of the quality of the imagery and the level of detail captured by the 3D reconstructions. We have been awarded funding by NASA in a collaborative proposal with the Woods Hole Oceanographic Institution to use these techniques as part of adaptive AUV survey work. We have also secured a number of ARC grants to support our research in the area of navigation and seafloor modelling.

Australia currently has very limited capability in the area of UUVs. A number of institutions around the country are using small ROVs for habitat assessment purposes. The IMOS glider facility is introducing autonomous gliders for long term monitoring of the water column, with a particular focus on Australia's boundary currents. At present there are only three groups in Australia who have AUVs capable of oceanic deployment: Navy, CSIRO and the University of Sydney. The Australian Navy Hydrographic Office has recently purchased a Remus 600 vehicle capable of surveying in depths up to 600m. DSTO also has a number of smaller, shelf based AUVs but these are generally not accessible to the marine science community. We have discussed the possibility of making these vehicles available through the IMOS AUV Facility and there is interest from our DSTO colleagues although no official partnership is in place yet. CSIRO have also developed a small, low cost AUV to support benthic habitat studies. It is considerably smaller than the *Sirius* AUV and has a significantly more limited suite of sensors. However, it is being used by CSIRO CMAR to support a number of studies in Tasmania and Queensland and may be a vehicle worth considering in future as its performance is proven in the field. One of our recent ARC Linkage grants has been awarded to look at transitioning our imaging payload onto smaller more easily manageable AUVs and to explore the requirements for repeatable surveying. This may represent an option for purchasing additional smaller AUVs for deployment using smaller vessels and may fit well within the timeframes associated with a second round of IMOS funding.

#### **5. Demonstrated user community / meeting researcher needs**

The user community for the AUV Facility is relatively new. Each of the proposals received from the nodes around the country have included researchers who are new to this technology but see it as a valuable addition to their on-going research programs. We have received proposals, or are in discussion, with groups in South Australia, Western Australia, New South Wales, Tasmania and Queensland. As more researchers are made aware of the IMOS AUV Facility through our continuing deployments, promotional activities and the availability of data we expect the user community to grow substantially.

## OTHER INFORMATION

*The Review Panel will have access to the detail provided in the 2006/07 and 2007/08 Annual Progress Reports – available at <http://imos.org.au/reports0.html>. Detailed below are any significant changes / additions since June 2008.*

### A. Changes to the original agreed level of co-investment

The initial level of co-investment for the AUV Facility was to be provided by the University of Sydney in the form of salary for technical officers and research staff contributions to the development, maintenance and operation of the AUV. Additional co-investment in the AUV facility has come mainly from the ship time used to support deployments. As the particulars of the deployments was not known at the time of the original proposal and subsequent Annual Progress Reports, co-investment levels were not able to be confirmed at that time. Based on the recent deployments in South Australia and Tasmania, additional co-investment in the Facility has been achieved and this pattern is likely to be continued with future deployments. In-kind investments include:

- TAFI – 10 days of ship time aboard the R/V Challenger
- DEH SA – six days of ship time aboard the R/V Ngerin to document benthic habitats around the Sir Joseph Banks Islands
- National Geographic – additional funding secured for deployment of the AUV at Whyalla, SA
- Southern Surveyor – 3 week ship time associated with documenting of drowned shelf edge reefs
- Navy – support for M/V Kimbla used for pre-trial engineering deployments
- DSTO – funding to support research associate

In addition, it has been necessary to add an extra member of staff to the AUV Facility in order to support our current activities. This staff member's salary is currently supported using other sources secured at the University of Sydney. The University of Sydney is also covering the costs associated with insuring the AUV. There have also been substantial in-kind contributions made by our PhD students who have been developing many of the tools and techniques for high-resolution mapping and three dimensional scene reconstruction and visualisation. These contributions have not been explicitly included here but are a substantial investment in the Facility.

Description	Duration	Support	Value
R/V Challenger ship time + scientific personnel	2 weeks	TAFI	\$30k
R/V Ngerin ship time + scientific personnel	1 week	DEH SA	\$25k
Vessel hire and transport, Whyalla SA	1 week	Nat'l Geographic	\$15k
Southern Surveyor ship time	3 weeks	CSIRO	\$68k
Support for M/V Kimbla	2 weeks	Navy	\$10k
Research fellow funding	0.5 year	DSTO	\$50k
Research Staff	1 year	USyd	\$100k
Technical Officer	1 year	USyd	\$81k
AUV Insurance	2 year	USyd	\$55k
		<b>TOTAL</b>	<b>\$434k</b>

### B. Promotional activities

Promotional activities initiated by SARDI resulted in a number of press releases following the deployment to the Sir Joseph Banks Island and Whyalla cruises in June 2008.

Interviews were also conducted in the lead up to the Tasmania deployment in October 2008 and the AUV work conducted there resulted in Radio and internet segments presented by the ABC. The Great Barrier Reef trip also generated media attention and was featured on radio segments. The work of the AUV group, and data collected by IMOS, was also featured on the Channel 10 program Scope in July 2008. In addition, the

Facility has been promoted at a variety of scientific meetings, including the annual AMSA Conferences in Christchurch in 2008 and Melbourne in 2007, the Society for Underwater Technologies annual AUV Symposium in Perth and at labs and marine science centres around the world.

### **C. Fostering collaborative development of infrastructure**

Development work for the AUV, the integration of additional sensors and the logistical aspects of working the vehicle have been largely restricted to the University of Sydney's Australian Centre for Field Robotics. However, we have held discussions with some of our colleagues at DSTO examining the prospect of using their AUV vehicles as part of the IMOS AUV Facility. As part of our on-going commitment to maintaining the calibration of the AUV sensor suite, we have also had our CT sensor calibrated by CSIRO CMAR.

### **D. Scientific publications using IMOS data / participation in scientific seminars and conferences**

#### ***Publications***

1. S.B. Williams, O. Pizarro, M. How, D. Mercer, G. Powell, J. Marshall and R. Hanlon, "Surveying Nocturnal Cuttlefish Camouflage Behaviour using an AUV", Proc. IEEE Int'l Conference on Robotics and Automation, 2009 (submitted 09/2008)
2. S.B. Williams, O. Pizarro, I. Mahon, M. Johnson-Roberson, "Simultaneous Localisation and Mapping and Dense Stereoscopic Seafloor Reconstruction using an AUV", in G. Pappas, V. Kumar and O. Khatib, *Springer Tracts in Advanced Robotics*, 2008, in press (accepted 08/2008)
3. I. Mahon, S.B. Williams, O. Pizarro and M. Johnson-Roberson, "Efficient View-based SLAM using Visual Loop-closures", *IEEE Transactions on Robotics*, 2008, in press (accepted 05/2008)
4. S.B. Williams, O. Pizarro, J. Webster, R. Beaman, M. Johnson-Roberson, I. Mahon and T. Bridge, "AUV-assisted Surveying of Relic Reef Sites", Proc. Of MTS/IEEE Oceans, Quebec, Canada, Sept. 2008
5. O. Pizarro, J. Colquhoun, P. Rigby, M. Johnson-Roberson and S.B. Williams, "Towards Image-based Marine Habitat Classification", Proc. Of MTS/IEEE Oceans, Quebec, Canada, Sept. 2008
6. J. Webster, R. Beaman, T. Bridge, P. Davies, M. Byrne, S.B. Williams, P. Manning, O. Pizarro, K. Thornborough, A.A. Thomas, and S. Tudhope, S. "From corals to canyons: The great barrier reef margin". *EOS, Transactions American Geophysical Union*, 89(24):217-218, 2008
7. S.B. Williams, O. Pizarro, I. Mahon, M. Johnson-Roberson, "Simultaneous Localisation and Mapping and Dense Stereoscopic Seafloor Reconstruction using an AUV", International Symposium on Experimental Robotics (ISER), Greece, June 2008
8. S.B. Williams, O. Pizarro, I. Mahon and M. Johnson-Roberson, "IMOS AUV Facility", Australian Marine Science Association Conference, Christchurch, New Zealand, July, 2008
9. T. Bridge, P. Bongaerts, N. Englebert, E. Sampayo, T. Ridgway, M. Rodriguez-Lanetty, S.B. Williams, O. Pizarro, J. Webster, J. and O. Hoegh-Guldberg, "Scleractinian Corals and their associated Symbiodinium on Mesophotic Coral Ecosystems of the Great Barrier Reef", Poster at International Coral Reef Symposium, Florida, USA, July, 2008
10. S.B. Williams, O. Pizarro, I. Mahon, M. Johnson-Roberson, P. Rigby and S. Barkby, "Advances in Autonomous Benthic Surveying and Characterization of Benthic Habitats", Poster at 2008 Ocean Sciences Meeting, Orlando, Florida, March 2008

11. O. Pizarro, S.B. Williams, M. Johnson-Roberson, I. Mahon, P. Rigby, and S. Barky, “IMOS AUV Facility”, invited talk at ArcheoMed Meeting, Castellammare di Stabia, Italy, Nov., 2007
12. M. Johnson-Roberson, I. Mahon, O. Pizarro, and S.B. Williams, “Generating Visually Consistent Benthic Surface Meshes Using Visual Features”, Proceedings of MTS/IEEE Oceans, Vancouver, Canada, Oct. 2007
13. S.B. Williams, O. Pizarro, M. Johnson-Roberson, I. Mahon, P. Rigby, S. Barkby, “IMOS—Integrated Marine Observing System: Integrating IMOS with underwater cultural heritage research”, New Ground Archaeology Conference, Sydney, Sept. 2007
14. P. Rigby, S.B. Williams, O. Pizarro, and J. Colquhoun, “Effective benthic surveying with autonomous underwater vehicles”, Proceedings of MTS/IEEE Oceans, Vancouver, Canada, Oct. 2007
15. M. Johnson-Roberson, O. Pizarro, and S.B. Williams, “Towards Three-Dimensional Heterogeneous Imaging Sensor Correspondence and Registration for Visualization”, Proceedings of IEEE Oceans Europe, Aberdeen, Scotland, April 2007

***Seminars, Workshops and Conferences***

CSIRO Petroleum Division, Perth (Oct 2008)  
 AHS/SUT AUV Workshop (Oct. 2007 and 2008)  
 Second Australia-Japan Marine Science Forum (Oct 2008)  
 CSIRO CMAR, Hobart (Sept 2008)  
 IEEE Oceans, Quebec City (Sep 2008)  
 AMSA Conference (July, 2007 and 2008)  
 Hellenic Marine Research Centre, Athens – invited seminar (July, 2008)  
 Johns Hopkins University – invited seminar (July, 2008)  
 University of Washington – invited seminar (July, 2008)  
 Oceans Sciences 2008, Orlando (March 2008)  
 ArcheoMed, Castellammare di Stabia, Italy (Nov 2007)  
 IEEE Oceans, Vancouver (Sep 2007)  
 AIMS, Townsville – invited seminar (July 2007)

## MILESTONES

Below are:

- the Milestones transferred from 2007/08 to 2008/09 (as reported in the 2007/08 Annual Progress Report)
- the 2008/09 Milestones, as provided for the 2008/09 Annual Business Plan
- The post July 2009 planned activities, as provided for the 2008/09 Annual Business Plan

Please review, and amend the tables as necessary for any changes, and note any potential barriers to achievement.

### MILESTONES TRANSFERRED FROM 2007/08 to 2008/09 (being those Milestones from the 2007/08 Annual Progress Report, recorded as either 'In Progress', or 'Transfer to 2008/09')

Party(s)	<u>Due / Status</u>	<u>Milestone / Achievements / [Comments]</u>	<u>Update / Potential Barriers to Achievement</u>
5.6  SIMS	<i>Jun08</i>  In progress	<i>Software for transmission of data to eMII developed for all data streams</i> Have attended a MEST workshop to learn about the tools available for making data available. Have been working with end users to define data requirements and to deliver post-cruise data sets. <i>[We will work with eMII on how best to manage the AUV data in the long term.]</i>	

### 2008/09 MILESTONES (as provided in the 2008/09 Annual Business Plan)

Party(s)	<u>Due</u>	<u>Milestone</u>	<u>Update / Potential Barriers to Achievement</u>
	Nov. 08	Delivery of first test case of data from Tasmania 2008 expedition to eMII for archiving and dissemination	
	Feb. 09 (tentatively)	Deployments of AUV in WA	Dates and ship time for these deployment are yet to be finalized
	Mar. 09	Deployments of AUV in Tasmania	Dates and ship time for these deployment are yet to be finalized

<b>Party(s)</b>	<b>Due</b>	<b>Milestone</b>	<b>Update / Potential Barriers to Achievement</b>
	Apr. 09	Delivery of additional data sets to eMII once data formats are agreed, tools have been built and reprocessing undertaken [ <i>It is anticipated that this will be complete by April but that data will be delivered as it becomes ready.</i> ]	
5.1 SIMS	June 09	Deployments of AUV in South Australia	“

**POST JULY 2009 PLANNED ACTIVITIES (for the period July 2009 to June 2011, as listed in the 2008/09 Annual Business Plan)**

<b>Party(s)</b>	<b>Start</b>	<b>Finish</b>	<b>Activity</b>	<b>Update / Potential Barriers to Achievement</b>
SIMS	Sept. 09		Deployment of AUV in Qld	Dates and ship time for these deployments are yet to be finalized
	Nov 09		Deployment of AUV in WA	“
	Dec 09		End of current funding commitment from IMOS	

# INTEGRATED MARINE OBSERVING SYSTEM (IMOS)

## IMOS FACILITIES Information for the IMOS 2009 Review

**Name of Facility:** Australian National Mooring Facility

**Facility Leader:** Simon Allen, Phone 03 6232 5476, Email [simon.allen@csiro.au](mailto:simon.allen@csiro.au)

### Sub-Facility Leaders:

Name	Facility	Organisation
Craig Steinberg	Queensland and Northern Australia	AIMS, Townsville, QLD.
Moninya Roughan	New South Wales	UNSW, Sydney, NSW
John Middleton	South Australia	SARDI, Henley Beach, SA
Tim Lynch,	Western Australia	CSIRO Marine & Atmospheric Research, Hobart, TAS.
Rob McCauley	Acoustic Observatories	Curtin University, Perth, WA
Tim Lynch	National Reference Stations, Analysis & Coordination	CSIRO Marine & Atmospheric Research, Hobart, TAS
Vittorio Brando	Satellite Ocean Colour Calibration/Validation	CSIRO Land & Water, Canberra, ACT

### 1. Quality of implementation so far, and soundness of forward plan

The expansion of long term delivery of coastal oceanographic mooring capability into four new regions around Australia was an ambitious target. Prior to IMOS, moorings had been deployed in all regions around Australia, but on a process study, limited deployment, basis. The results of these mooring deployments were considered the intellectual property of the scientist in charge of the project and in many cases it was difficult to discover the data and negotiate access. The data collected was fit for process study analysis but in many cases cannot be used for longer term studies.

Moorings expertise for oceanographic research in 2006 was concentrated in Hobart within CMAR with some moorings capability in Townsville within AIMS. Commercial delivery of moored instruments existed in NSW, servicing the Sydney Ocean Reference Station and the NSW waveriders. Perth supported a commercial metocean consultancy with a price structure and operational mode geared to the support of the oil & gas industry.

Each sub-facility therefore adopted a path to delivery dependent on the strengths of the region, but constrained by the budgets delivered through IMOS.

- In Hobart the teams required for both SOTS, National coordination and the build of WA moorings were combined to enhance the existing moorings team and for the first time move away from personality based capability (which is not true capability) to team based capability.

- In Townsville the existing AIMS technical support team was bolstered. In NSW existing met-ocean service deliverers were approached for the delivery of services, managed through a scientist-in-charge.
- SA have built a moorings facility from scratch heavily leveraging on the capabilities of the R.V. Ngerin crew for deployment skills.
- In WA a single technician has been appointed to work closely with both the Hobart based CMAR staff and the staff within WAMSI to ensure moorings are deployed and turned around.
- At Curtin the specialist team deploying acoustic monitoring stations has stabilised with IMOS funding
- For the Colour Reference Station, technicians are being utilised in Townsville to service and maintain instruments with direction coming from CSIRO Land and Water in Canberra.

### Planning

Baseline planning contained in the IMOS funding agreement that was signed on 25 May 2007 was based on the funding reaching the facilities by 01 January 2007. In the worst case, the subcontract with CSIRO, this was not signed until mid October 2007.

As the plans have met with reality, there have been some significant changes, the reduction from two to one colour reference station, and the reduction in the SA array size, as two examples. But all the reductions have been implemented with the purpose of building long term sustainable observations and observational capability.

In some regions the gap between initial planning and funding saw a changing of the priorities in a region. These were reconciled through regional node meetings in conjunction with the broad potential user base.

By December 2008 the initial IMOS ANMN moorings plan was to have had 25 of 49 discrete moorings deployed. It is expected that despite the late start 30 of 50 discrete moorings locations will be populated. There has been some movement of locations due to logistical issues and availability of resources.

Two additional moorings in the Bass Strait are currently deployed to allow intercalibration between Jason1 & Jason II satellite altimetry.

At some of the mooring locations, the full suite of deployed sensors planned to be deployed has not yet been achieved. Most notably at the national reference stations real time data transmissions are on the plans for rollout from February 2009, but currently are deployed as sub-surface moorings only.

Considerable delivery delays have been experienced with key sensors, the worst case being that of the Wetlabs Water Quality Monitor (WQM), which monitors conductivity, temperature, pressure, dissolved oxygen, turbidity and fluorescence with a unit designed for long in situ deployments. This was a key element of the National Reference Stations and was adopted in many of the other mooring arrays because of the promise of long deployment times. Initially delays were experienced in delivery due to problems experienced as Wetlabs 'upscaled' their

production to cope with increased demand, this was followed by some firmware issues, that were not diagnosed until the completion of their first Australian deployment. SA took delivery of their WQM's in September 2008 having placed the order in February 2008. On the positive side, despite these start up difficulties the instrument is proving to deliver stable records throughout the deployment period, a testimony to the anti-fouling measures incorporated in its design. The next step is to extend the deployment period in a controlled manner to reduce the ongoing turn-around costs.

Staff recruitment in an environment of high employment has proved challenging, particularly in WA. All full-time IMOS positions are now filled, but there may be some small adjustments to personnel working across multiple projects and some part time positions or casual labour employed.

With each deployment at a new site and each mooring construction the level of remaining uncertainty reduces as the logistical issues associated with supporting a mooring at each of the locations becomes understood.

Logistical issues have resulted in the moving of the proposed location of the Dampier NRS to Ningaloo for deployment in the 2009 calendar year. This change was implemented in consultation with the WAIMOS node.

The forward plan after having funding agreed for all parties involved for 12 months with 32 months remaining is increasingly robust. However, the ANMN has been about capability building and this review comes earlier than would have been hoped for in assessing the ongoing delivery of a new open & accessible data stream that has yet to see a consolidated outlet developed through EMII for the distribution of its data and prior to the planned deployment of the full national mooring array.

With approximately \$3M of equipment still to be purchased from suppliers in the USA, the facility is at risk of currency fluctuations. Most sub-facilities produced budgets for equipment with the Australian \$ at US80c, it now sits at US65c, but will hopefully return nearer to US70c by the time delivery is taken. Even in this scenario the remaining purchases will cost AU\$430K more than anticipated. Either the array is paired back to absorb the uncertainty, or the uncertainty is born by IMOS. This is the ANMN's biggest remaining uncertainty with respect to delivery.

The delivery of an Australian National Moorings Network to date represents the non-partisan collaboration and cooperation of many organisations through the leadership of the sub-facilities. The sub-facility leaders are listed below:

Deployed moorings by end of 2008.

<b>Name</b>	<b>Deployment</b>	<b>Notes</b>
<b>GBROOS</b>		
H1 - Heron Island 1	Sep 2007	
H2 – Heron Island 2	Sep 2007	
H3 – Heron Island 3	Sep 2007	
Lizard Island Shelf	Oct 2007	
Lizard Island Slope	Oct 2007	
Myrmiddon Reef Slope	Oct 2007	
Palm Passage Shelf	Oct 2007	
Capricorn Channel	May 2008	
Swains Reef 1	Sep 2007	
Swains Reef 2	Sep 2007	
Yongala NRS	Jun 2008	Subsurface only until permit confirmed
<b>NSW</b>		
Ocean Reference Station	Feb 2008	
SYD 100	Jun 2008	
SYD 140	Jun 2008	
Jervis Bay *	Jan 2008	ADFA mooring lost July 2008. Also data quality issues. Replacement strategy unclear.
Enhanced Sampling Port Hacking transect	Oct 2008	
<b>SA</b>		
Kangaroo Island NRS M3	Jul 2008	ADCP only initially due to WQM supply issue
M1	Dec 2008	
<b>WA</b>		
Rottneest NRS	Nov 2008	Initially sub surface only
Esperance NRS	Nov 2008	Initially sub surface only
<b>Passive Acoustic Observatories</b>		
Perth Canyon 1	Feb 2008	
Perth Canyon 2	Nov 2008	
Perth Canyon 3	Nov 2008	
Perth Canyon 4	Nov 2008	
Cape Nelson 1	Dec 2008	
Cape Nelson 2	Dec 2008	
Cape Nelson 3	Dec 2008	
Cape Nelson 4	Dec 2008	
<b>NRS</b>		
Maria Island	Apr 2008	Subsurface only until Feb 2009
Moreton Bay sampling	Oct 2008	No in-situ measurements. Physical sampling only

Remaining moorings to be deployed by end 2009

Name	Deployment	Notes
<b>GBROOS</b>		
Darwin NRS	Jun 2009	Negotiations underway for local responsibility for deployment
<b>NSW</b>		
Coffs Harbour 1	Jan 2009	
Coffs Harbour 2	Jan 2009	
Eden / Bateman's Bay	Jun 2009	
<b>SA</b>		
M4	Nov 2008	Successful M1&M3 required
M5	Oct 2008	Successful M1&M3 required
M2	Nov 2008	Successful M1&M3 required
<b>WA</b>		
Two Rocks thermistor 1	Jun 2009	
Two Rocks BGC	Jun 2009	
Two Rocks thermistor 2	Jun 2009	
Canyon BGC	Jun 2009	
Canyon Thermistor 1	Jun 2009	
Canyon Thermistor 2	Jun 2009	
Two Rocks thermistor 3	Jun 2009	TBC
Two Rocks thermistor 4	Jun 2009	+ADCP TBC
Ningaloo NRS	Sep 2009	
<b>Passive Acoustic Observatories</b>		
NSW1	Jun 2009	
NSW2	Jun 2009	
NSW3	Jun 2009	
NSW4	Jun 2009	
<b>Colour Reference</b>		
Lucinda Jetty	Mar 2009	

## 2. Consistency with principles

- **Service - IMOS is a national system and will provide a data-service that broadly supports marine research to maximise the contributions of R&D to economic development, national security, social wellbeing and environmental sustainability.**

The development of the mooring plans in each region has been undertaken with the full engagement of the marine research community through the regional node. In all areas outreach has been undertaken to expand the input to include other users of marine data. In WA for example, much input has been received from the physical oceanography community that services the oil and gas sector. The GBROOS node meetings have been well attended by regulators and environmental agencies.

In all cases the variables to be collected, locations of the mooring arrays, and mode of delivery have been open to debate and modification throughout the consultation process whilst keeping in mind the guiding principles of IMOS.

These consultations in themselves have broadened the awareness of IMOS to a wider marine community and exposed data users and interested parties who in the past would not have been engaged.

- ***Data streams* - IMOS data will be delivered freely, openly, in a timely manner, preferably in near real time. Success will be measured in terms of the quality and quantity of data that IMOS delivers, the number of users and the quality of research-results produced with IMOS data.**

ANMN is working actively with eMII to ensure that all data collected through ANMN is delivered through eMII in a free open and timely manner. In the short term absence of clearly defined standards and an easy path to discovery each of the sub-facilities has been storing data locally, but making it available on request to all parties.

A data handling workshop was held in Townsville in February 2008 where it was agreed that the AIMS moorings deployment database would be adapted and adopted as the tool to administer moorings in GBROOS, NSWIMOS, WAIMOS, SAIMOS and in national coordination. The tool will ensure consistency of metadata and recordkeeping across the regions. For the colour reference station (1 mooring) and the passive acoustic monitoring sub-facility (3 sites) it was felt this approach was unnecessary, but *may* be adopted.

In the absence of a MEST delivering a useable web portal to the data the ANMN has tried to resist creating a cottage industry of regional portals to the data, but this is getting increasingly difficult to avoid.

Data is available on request from each of the subfacilities from moorings that have been deployed and recovered. Realtime data from moorings with surface signatures will be available from February 2009. This will be delivered in its raw form through a google earth web page API along with information on all mooring deployments. It is hoped that at this time all links for historical data can be made to the MEST through this interface.

- ***Integration* - IMOS will deploy a nationally coordinated, multi-platform system to take advantage of the synergies between instruments, and to provide a comprehensive description of the ocean, as a contribution to national and international programs.**

In each region the moorings deployments have been planned in consultation with the research and user community through attendance at workshops and working groups. The moorings arrays have been developed as key elements of larger observational programs including other elements of the IMOS infrastructure. They are integrated with planned ACORN, AATAMS, and ANFOG deployments to answer boundary current questions and provide long term synoptic monitoring.

To date ANMN has focussed on actively ensuring national and regional cohesiveness, through international meetings and collaborations it is ensuring that the data collected is of relevance to the broader international research community. The variables observed agree closely with those determined through GCOOS, but with a greater emphasis on the biogeochemical and

through the physical sampling at the NRS's the planktonic communities. This is in alignment with thinking since the GCOOS variables were developed as we move towards the 'so what' of observing change in the oceans.

The review panel are encouraged to read *IMOS Data Streams and Their Uncertainties* for a comprehensive review of the variables collected through IMOS and their integration. It is only when IMOS as a whole is viewed as a data source can the integration between facilities and nodes be fully understood.

- **Sustainability - The real value of IMOS will only emerge if systematic, repeated data collection continues for a long time to see the full range of climate variation and change. Sustained streams of data are integrally related to conservation and sustainable development of the marine environment.**

If the first goal of the Australian National Mooring Network was capability building, the secondary goal is to build a national mooring infrastructure that is sustainable. The evidence of this is seen in the different approaches adopted to build the infrastructure dependent on regional strengths (see implementation so far). The regional observational plans as they developed showed significant gaps in our understanding of the boundary current processes around Australia. Whilst all moorings arrays were set up with the view to long term deployment, some have the flavour of long term process studies to address this lack of process understanding. The Perth Canyon and Bonnie upwelling arrays are examples of this approach. This said, the deployments fall far short of the sort of comprehensive coastal observational arrays envisaged into the future. It is therefore considered that the current arrays will form part of expanded future observations. If expansion does not form part of IMOSII then in these two regions the community views will be sought with respect to the longevity of observations at these locations taking into account the IMOS philosophy of building long term data sets.

Within the regional arrays the National Reference Station positions, once set, are considered un-moveable. Within all regional plans the financial footprint of each NRS is separately identified. This is undertaken so that the future of these stations can be assured through any future changes to the funding environment, and if necessary funding sought outside of nodes should they cease to exist, or change their focus.

### 3. Relevance to the IMOS science-goal

- **Streams of data that support research on the role of the oceans in the climate system and the impact of major boundary currents on shelf-ecosystems**

Each regional mooring array was designed through the node consultation process to address questions associated with the boundary currents and their interactions with the shelf ecosystems. At the NRS's it was recognised that in situ sampling could not fully describe the environment from physical properties to the primary producers and consumers. A nationally consistent physical sampling and analysis protocol has been developed and is being deployed at these sites. The parameters measured are listed below, but more

than this, the protocols represent a new national standard for comprehensive physical and BGC sampling developed for the deployment from small (approx. 8m) coastal vessels and the services required to analyse them.

1. Carbon Parameters
  - Dissolved Inorganic Carbon
  - Alkalinity
2. Hydrochemical parameters:
  - Nitrate/nitrite
  - silicate
  - phosphate
  - ammonia
  - salinity
  - Dissolved Oxygen - carried out at a few selected stations
  - total, organic and inorganic suspended solids
3. Biological parameters:
  - Phytoplankton
    - pigment composition
    - phytoplankton microscopy (species composition)
    - flow cytometry (population size, physical and chemical composition) – capability currently being developed (new co-investment - CSIRO)
  - Zooplankton
    - dry weights (mg per m<sup>3</sup>)
    - community composition (species per m<sup>3</sup>)
    - average size of the zooplankton community (µm)
4. Molecular Analysis (Genetics)
  - phytoplankton – capability to be developed
  - zooplankton – capability to be developed
5. Physical/profiling instrument measurements
  - Secchi disk - black and white
  - CTD with capabilities for:
    - temperature
    - pressure (depths)
    - conductivity
    - fluorescence
    - turbidity
    - dissolved oxygen (sensor)

The infrastructure in place for deployment of moorings and the physical sampling at the NRS sites represent great opportunities for the field testing of new sensors as they become available.

#### **4. Contribution to national capability building**

ANMN has built new moorings design, build, and deployment capability in three regions of Australia, Queensland, South Australia, and Western Australia. In NSW it has forged new links between the commercial met-ocean delivery sector and the marine research community strengthening that regions ability to deliver observational data from moorings, it has also allowed open access to historical and current wave data from a string of seven waverider buoys that were previously unavailable. In many of these regions the capability consists of one or two individuals, and thus, it is not true capability. However, the closer links formed between the institutions involved allows each region to call upon the others for support both technical and physical, therefore we have developed a distributed capability spread over the regions. As the moorings array reaches

completion and the time commitments associated with routine servicing become known, it is envisaged that more use may be made of this distributed capability, but currently it appears stretched a little thinly.

## **5. Demonstrated user community / meeting researcher needs**

The lack of easily available data makes it difficult to demonstrate the user community / researcher needs being met. At this point it is relevant to again re-iterate the process by which the mooring arrays were developed in the regions and the list of PhD students and modellers who intend to utilise the data.

- Eric Wolanski SLIM model of the GBR. Forcing and validation
- Development of a hydro-biochemical modeling facility of the region that is validated against the SAIMOS data. This has been funded by SARDI (\$386k) until July 2011 (Drs J Middleton, L Seuront, C James, J Luick and S Leterme)
- Analyses of Biochemical data for the Kangaroo Is ecosystem (Virginie Van Dongen-Vogels; PhD)
- Analyses of bacterial and viral data for the Kangaroo Is ecosystem (James Patterson; PhD)

At a recent NSW IMOS node meeting many of the students in their proposals for IMOS data usage had difficulty separating out data by facility and in fact many of them considered using the synthesis of them through the BlueLink model the ideal delivery mechanism.

Within IMOS the SRS facility will use all realtime observations of SST to further constrain their products. This use is actively driving the SST sampling strategy of ANMN surface buoys.

## **OTHER INFORMATION**

*The Review Panel will have access to the detail provided in the 2006/07 and 2007/08 Annual Progress Reports – available at <http://imos.org.au/reports0.html>. Detailed below are any significant changes / additions since June 2008.*

### **A. Changes to the original agreed level of co-investment**

In no region has the level of agreed co-investment reduced. In all regions the requirement to service moorings or physical sampling has lead to significant increases in the degree of in-kind support provided. In many cases the agencies involved have filled the gaps in the infrastructure needed to service IMOS.

- WA – CSIRO R.V. Linneaus fitted out for deployment and recovery of Perth Canyon moorings. Provided to IMOS at “fuel+labour” rates, which are approx \$5000 a day less than commercial rates.
- NSW – EPA upgraded vessel for Hydrographic sampling along Port Hacking transect.
- QL – Moreton Bay CSIRO new vessel R.V. Scylla purchased specifically to service NRS Hydrographic sampling in Moreton Bay
- QL – Lucinda Jetty, CSIRO provide Cimel sun photometer to be included in colour reference station instrumentation.
- QL – DEWHA investment in surface buoy for Yongala NRS.

## **B. Promotional activities**

The Science Of Observation, CMAR Auditorium, August 8 2007, Science Week public Lecture.

“The Integrated Marine Observing Systems”, SIMS, 4 March 2007, Open Day, General public

“Sydney Institute of Marine Science (SIMS)”, Australian Museum, 13 June 2007, museum staff

“The who, what and why of SIMS and IMOS”, DPI-Fisheries, Cronulla, 27 June 2007, DPI staff.

*Southern Australian Marine Observing System*, SARDI West Beach, 12<sup>th</sup> June 2007, (38 registered attendees).

Steinberg C, C. Mclean, F. McAllister, B. Bennett, G. Brinkman and S. Choukroun (2007) GBROOS Mooring Array. IMOS GBROOS Workshop, Townsville May 11.

“NSW-IMOS”, Univ. of Tasmania, 30 Jan.2007, Chair of NSW-IMOS and speaker

“NSW-IMOS and oceanographic science”, University of Melbourne, 11 July 2007, AMSA Talk IMOS, Coastal Mooring Network, Roughan – speaker

“SIMS and the Australian Acoustic Telemetry & Monitoring System”. University of Melbourne, 11 July 2007, AMSA

AMSA Conference, University of Melbourne, 11 July 2007, IMOS Symposium. The symposium was coordinated by Simon Allen in his dual role of Facility Leader and IMOS Technical Director.

At each of the following, a 5-10 minute presentation was given with title, “IMOS/SAIMOS”:

*CRC Aquafin Workshop*, November 28<sup>th</sup> 2006, Port Lincoln; John Middleton

*International Coastal Symposium*, Gold Coast, April 18<sup>th</sup>, Invited talk by John Middleton

*Scientific Committee on Oceanic Research*, Working Group 129, Deep Ocean Exchange with the Shelf, IUGG, Perugia, Italy, 10-11<sup>th</sup> July, 2007, John Middleton, WG member.

The Australian National Mooring Network, University of WA, 23 February 2007, Simon Allen, WA Oceanographic community.

NSW IMOS Overview, M Roughan NSW DPI Fisheries Port Stephens, to

give an over view of NSW IMOS activities. Q1 2008.

Public Meeting held August 2008 'for all Tasmanian Marine Professionals, under the auspices of the IMarEST, SUT, MTS and AHS outlining IMOS and its challenges.

**C. Fostering collaborative development of infrastructure**

- GBROOS Planning Workshop, Townsville, May 22, 2008. Presentations by Steinberg, McAllister, Mclean C, Choukroun S, Brinkman G and Mahoney on Moorings, Remote Sensing and Underway SST were given.
- Allen S, L Pender, C Steinberg, J Middleton, R MacCauley, V Brando & Roughan (2008) The Australian National Moorings Network. In situ observations for Australian Marine Research. 15<sup>th</sup> National Conference of the Australian Meteorological and Oceanographic Society, Geelong on 29 January to 1 February 2008.
- Steinberg C, Herzfeld M, Schiller, A and Feng M (2008) Downscaling Climate Change to a reef on the GBR: Heron Island case study: Project 2.5i.1. Presentation at 2008 MTSRF Annual Science Conference, Cairns 28 April to 1 May.
- Steinberg and Brinkman, R (200) The status of Physical Oceanographic research in the GBR. AIMS Acidification workshop March 11

SCOR WG Deep Ocean Exchange with the Shelf, Perugia, Italy, July 2007. John Middleton gave outline of IMOS to the international workshop.

• AMSA (SA) Workshop on Environmental Monitoring. SARDI, September 2007. John Luick gave a 20 minute talk on SAIMOS.

• Climate Change Planning workshop: the Bonney Coast. Held at the Marine and Freshwater, Fisheries Research Institute (Queenscliff, Victoria, 4/4/2008. John Middleton delivered a talk on the Oceanography and SAIMOS for the Bonney Coast.

• Workshop: Integrating Oceanography and Environmental Monitoring for SA., SARDI, Lauront Seuront gave 25 min talk on SAIMOS to SA marine researchers.

• Rocklobster Industry Workshop, 20<sup>th</sup> June 2008, SARDI. John Middleton gave a 25 minute presentation on SAIMOS and Oceanographic capability at SARDI.

A National Reference Station infrastructure for Australia – using telemetry and central processing to report multi-disciplinary data streams for monitoring marine ecosystem response to climate change

*Lynch, T.P\*, Roughan, M., Mclaughlan, D., Hughes, D., Cherry, D.,*

*Critchley, G., Allen, S., Pender, L., Thompson, P., Richardson, A.J., Coman, F., Steinberg, C., Terhell, D., Seuront, L., Mclean, C., Brinkman, G. and G. Meyers – Oceans 2008 Quebec, Canada*

**D. Participation in international programs collecting similar data streams**

*A Coastal Observing System:* At the June 12th 2007 SAIMOS meeting, Tony Flaherty from Adelaide Natural Resource Management gave a talk on the proposed NRM coastal marine observing system. The synergies with IMOS may be extensive.

September 2006 – Discussions with other moorings programs at Oceans 2006, Boston and Ocean 2008, Quebec.

GBROOS is engaged with the RRRC MTSRF, NOAA, ARC Linkage

The passive acoustic observatories will be hosting a young and capable, PhD student from the British Antarctic Survey (BAS) in late 2008 for 1-2 months and assisting her with analysis of sea noise records collected by the BAS around the Antarctic Peninsula. We are in collaboration with a major European group for supply of sea noise loggers as back ups on Arctic Ocean moorings to be deployed for acoustic tomography and environmental monitoring.

The Australian Environmental Mooring Network was contacted to determine what synergies or overlap existed between our programmes, however the AEMN is concerned with the environment *impact* of boat moorings not the collection of environmental data.

**E. Scientific publications using IMOS data / participation in scientific seminars and conferences.**

Awaiting a common interface through EMII to present moorings data.

**MILESTONES**

*No detailed Milestone update provided for the Mooring Facility, as Section 1 above provides in tabular format the deployments to December 2008, plus the plans for 2009.*

# INTEGRATED MARINE OBSERVING SYSTEM (IMOS)

## IMOS FACILITIES Information for the IMOS 2009 Review

**Name of Facility:** Australian Coastal Ocean Radar Network (ACORN)

**Facility Leader:** Mal Heron, Phone: 07 4781 4981, Email: [mal.heron@jcu.edu.au](mailto:mal.heron@jcu.edu.au)

### 1. Quality of implementation so far, and soundness of forward plan

#### Installations:

By 30 June 2011, the ACORN Facility will have installed 13 HF coastal ocean radar stations as 6 Systems operating in pairs or triples. The stations will be maintained and operational with near real-time data flowing in Quality Controlled form to the IMOS archive. The status of the stations at September 2008 is:

System	Station	Status	Commissioning
Heron Island	Tannum Sands	Operating; uncalibrated data to archive	1 Nov 2007
	Lady Elliot Island	Operating; uncalibrated data to archive	1 Nov 2007
Perth Canyon	Leighton Beach	Site approval from Fremantle City pending; ACMA licence pending; CODAR Station has been delivered	April 2008
	Seabird	Site approval from WA Govt pending; ACMA licence pending; CODAR Station has been delivered	April 2008
	Cervantes	Site approval from Dandaragan Shire pending; ACMA licence pending; CODAR Station has been delivered	April 2008
Rottnest Island	Leighton Beach	Site approval from Fremantle City pending; ACMA licence pending; WERA Station has been ordered	May 2008
	Guilderton	Site approval OK; ACMA licence pending; WERA station has been ordered.	May 2008
SA Gulfs	Cape Spencer	Site approvals from SA Govt pending; ACMA licence pending; SA Govt acquisition documents pending;	
	Cape Wiles	Site approvals from SA Govt pending; ACMA licence pending; SA Govt acquisition documents pending;	

Coffs Harbour	Red Rock	Site identified	31 Dec 2009
	N. Nambucca	Site identified	31 Dec 2009
SA Bonney Coast			30 Jun 2010

## Budget

Figure 1 shows the salaries expenditure compared with the budget allocation. Staffing has been less than the planned level since the beginning of the project. This is partly due to the delayed start: note that the time axis in Figure 1 starts at 1 Jan 2007.

Delays in approvals from Local and State Governments, and from the Australian Communications and Media Authority have delayed the radar installation programme. Staff levels have been managed, in the large scale, to match the tasks at hand.

At the time of reporting our staff complement is:

Mal Heron 50%EFT Science Leader;

Arnstein Prytz 100% Radar Technician with responsibility for data and archiving;

Geoffrey Page 100% Radar Technician with special responsibility for WERA systems;

Daniel Atwater 100% Radar Technician with special responsibility for CODAR system;

Robyn Nickalls 50% Administrative Officer.

The last two are in the process of appointment and are not reflected on Fig.1. When all staff are included, the actual spending rate will be above the budget rate. Assuming complete stability, the projection from cycle 23 (Oct 08) to cycle 59 (June 2011) gives a finishing estimate about \$60,000 below the approved budget. Salary increments will account for most of the difference.

Figure 2 shows the capital expenditure compared with the budget allocation. At 3 Oct 2008, the cumulative total is \$1,200,945. The forward projection for capital items is:

Actual at 3 October 2008	\$1,200,945
WERA Spares (ordered)	\$ 123,000
WA WERA System (ordered)	\$ 533,560
Coffs Harbour WERA	\$ 533,560
SA Bonney Coast CODAR	\$ 537,681
Environmental power SA Gulfs	\$ 70,000
Site accommodation containers (x10)	\$ 80,000
Estimated Position at 30 June 2011	\$3,078,746

This estimated capital cost is \$444,759 in excess of the approved capital budget of \$2,633,991.

Figure 3 shows the Operational Expenditure compared with the budget allocation. At 3 Oct the cumulative total expenditure is about 30% of the budget, and the difference is approximately \$360,000. This difference, at this stage of the project, is completely due to the delays in the installations, and will disappear when the installation costs are eventually met. Offsetting this to some extent is that the installation costs for the SA Gulfs deployment were not included in the approved budget. The difference in the later stages of the project will again increase because the initial plan included re-deployments, which are not required under the revised plan. The amount of this non-re-deployments difference is estimated to be \$200K (for 4 re-deployments).

Budget-Conclusion: Present actual spending and forward estimates indicate that the overall ACORN budget will be approximately \$240K in deficit at 30 June 2008.

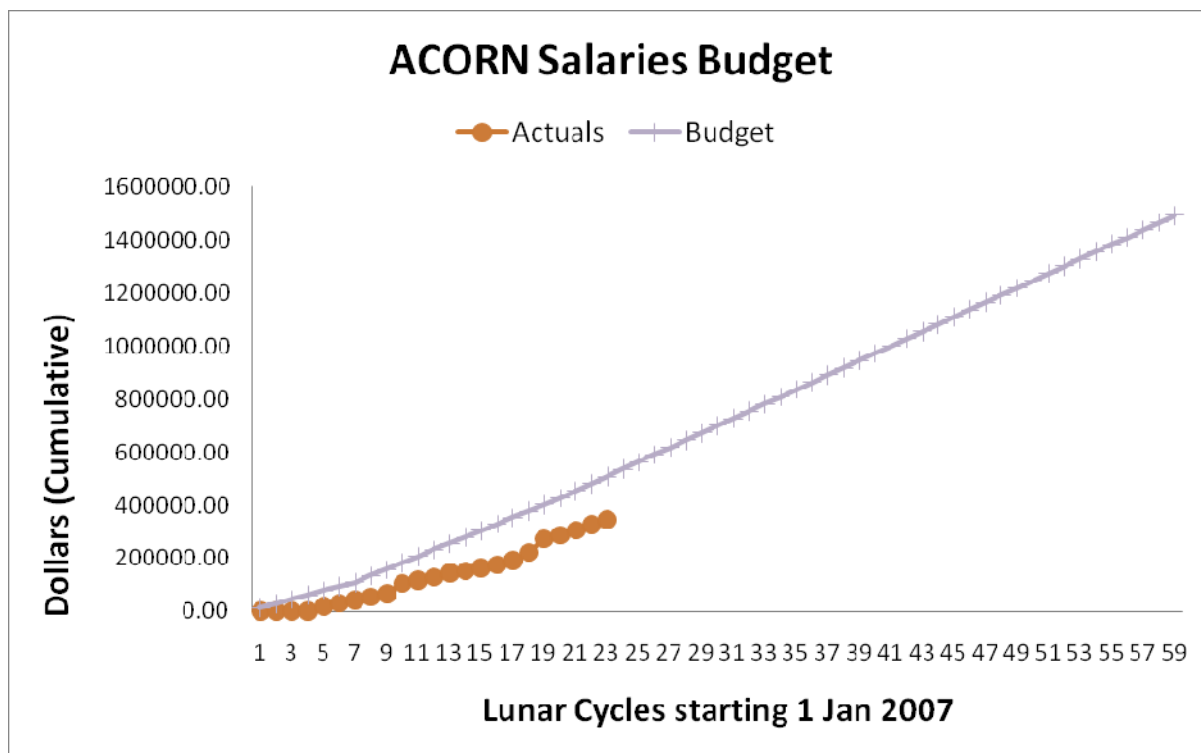


Figure 1. Progressive actual salaries against budget for the ACORN Facility to 3 Oct 08. Cycle #59 coincides with 30 June 2011. Our forward estimates, based on present staff and those being appointed, is that the two lines will approximately converge at 30 June 2011.

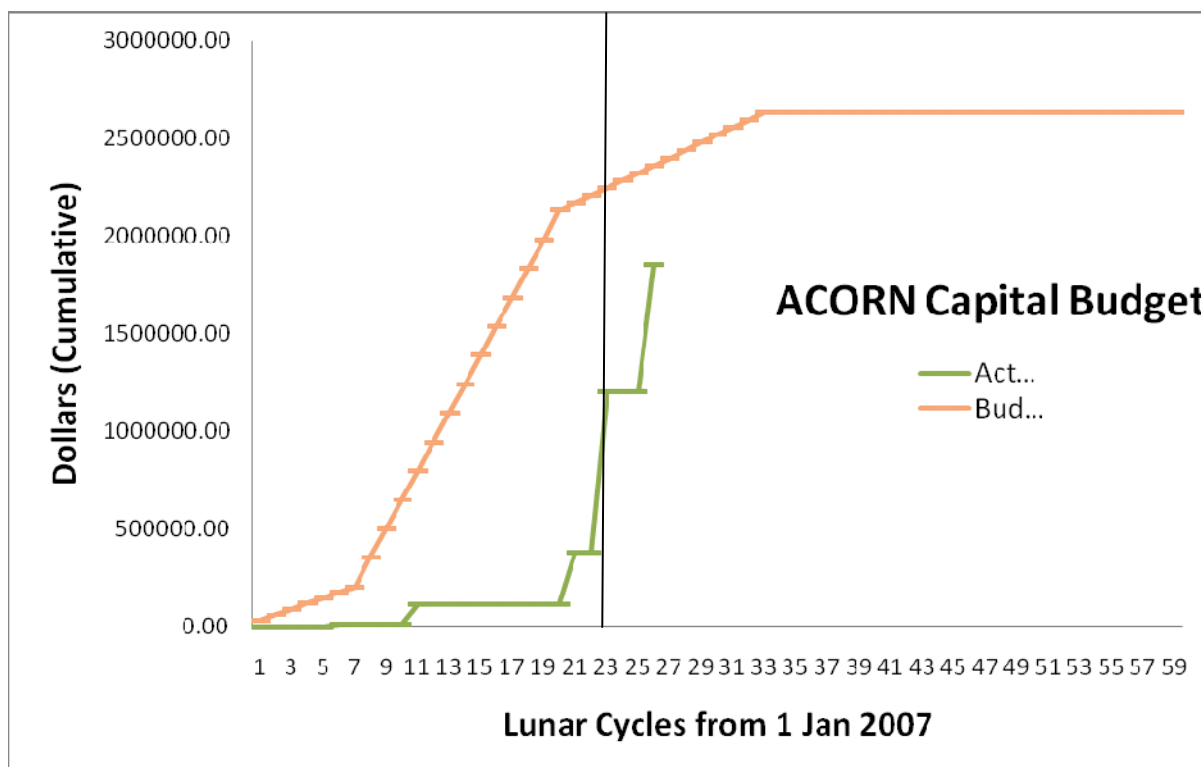


Figure 2. Progressive actual capital spending against budget for the ACORN Facility to 3 Oct 2008 (the vertical marker line), with ordered items up to cycle #26.

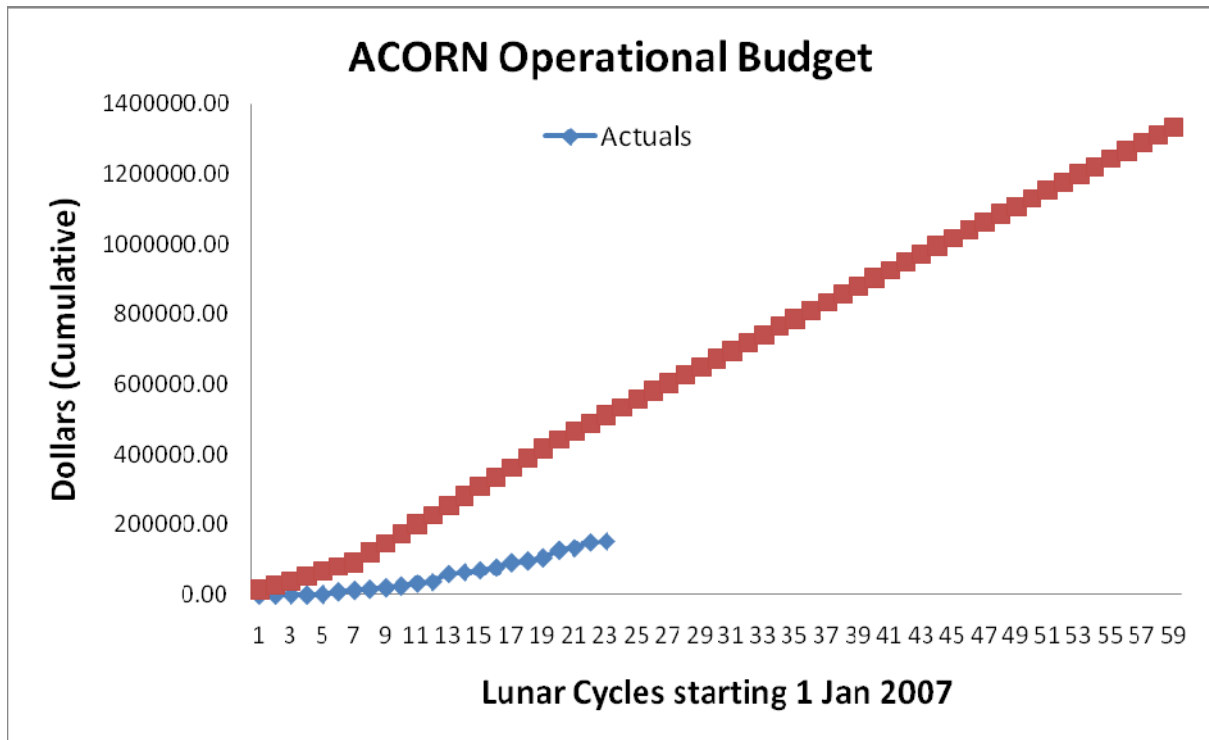


Figure 3. Progressive actual Operational spending against budget for the ACORN Facility to 3 Oct 2008.

## 2. Consistency with principles

- Service - IMOS is a national system and will provide a data-service that broadly supports marine research to maximise the contributions of R&D to economic development, national security, social wellbeing and environmental sustainability.**

As ACORN (and other Facilities) provide the data streams required, there is an obvious gap between the data and their conversion into the social and economic outcomes of economic development, national security, social well-being and environmental sustainability. The applications R&D needs to have a special boost if Australia is to get the best benefit from the IMOS data archive. An example of this is the Lagrangian tracking of surface drifting particles using the HF radar. In principle it is an easy calculation to take a notional drifting particle and follow its track over days or weeks. In practice the research is unclear about the physics involved and the errors that accumulate when such a process is followed. Yet the Search and Rescue community would benefit a huge amount by having such a tool.

- Data streams - IMOS data will be delivered freely, openly, in a timely manner, preferably in near real time. Success will be measured in terms of the quality and quantity of data that IMOS delivers, the number of users and the quality of research-results produced with IMOS data.**

Quality Control processes for the ACORN data are being developed with expected completion by 31 Dec 2008. In the meantime there have been some requests for access to un-calibrated ACORN data from the Heron Island deployment in the Great Barrier Reef. This is being provided through eMII as a temporary measure.

ACORN and eMII staff have conferred on the data archiving requirements for ACORN. There will be three levels of archived data and they are described in detail in an Appendix. Level 1 are Processed Data at fixed grid points at hourly intervals, available in near-real time. ACORN will deliver the Level 1 data to eMII with metadata and quality indices. eMII will develop access tools to enable users to get

easy access to visualisations or summaries of Level 1 data. Level 0 are Raw Data at the fixed grid points at 10-minute intervals, delivered by ACORN with metadata and quality indices. These data are intended for experienced users who will have their own access tools. Level -1 data consist of very large files with signal time series from each individual antenna at each radar station. The format for Level -1 data is proprietary (but open in the case of WERA systems) and ACORN will hold the software licence so that any user at this level can gain access.

The Appendix refers to access tools at different levels. eMII will develop the Production Level tools. Developmental tools require some knowledge of HF radar technology and will be developed jointly by ACORN and eMII. The Research Level access tools are effectively applied research and will be developed on an opportunistic basis. This work is important for the uptake and continued use of HF radar technology and should be directly supported under the IMOS umbrella beyond the present project term.

For relatively new technologies like the HF radar there is some responsibility to carry out validation and demonstration testing. To some extent this is done under 'Integration'

In preparation for adding radar data to the archive we have investigated and settled on netCDF as the common file format for all files submitted for archiving. All data produced by manufacturers of the radar systems (WERA/Helzel and SeaSonde/Codar) will be converted to netCDF. Because the structure of SeaSonde files is not yet known, there is still work to be done to make those files suitable for the archive; no SeaSonde installations are yet complete so there is no data flowing to ACORN at this time.

In order to use netCDF files by existing programs netCDF files generally should follow conventions that make data discovery possible. There are numerous netCDF conventions that one can follow. In the case of ACORN data no one convention meets all our needs. This is, in part, due to the nature of the proprietary data, with even the large SeaSonde network in USA not yet at the stage where standardisation is complete. At a ROWG workshop in San Diego last year ACORN was told that because IMOS was heading in the right direction that they would be likely to follow our lead.

At the same time we need to make the netCDF convention we use be compatible with the metadata standard defined by ISO19115 and the AODC Marine Community Profile based on that standard. It is impractical to manually enter metadata records into MEST for each of our files; these are produced every 10 min per station, with at least 3 files per 10 min interval. Our files thus need to be in a format that allows the relevant metadata to be harvested automatically when the files are uploaded to the archive. Work is underway by eMII to define the necessary elements so that we can make our data conform.

- ***Integration - IMOS will deploy a nationally coordinated, multi-platform system to take advantage of the synergies between instruments, and to provide a comprehensive description of the ocean, as a contribution to national and international programs.***

ACORN is very well integrated into the national system of marine observations, not only because it is operated as a single National Facility, but also because the locations for deployments have been wisely chosen by IMOS to maximise the overlaps. For example the deployment of the HF radar at Coff's Harbour will be centred on the

wave and current moorings off Coffs Harbour. Here the concept of integration was stronger than the local requirement to focus on the Solitary Islands Marine Park, and consequential compromises had to be made.

- ***Sustainability* - The real value of IMOS will only emerge if systematic, repeated data collection continues for a long time to see the full range of climate variation and change. Sustained streams of data are integrally related to conservation and sustainable development of the marine environment.**

The ACORN installations are made on a 5-year plan. This is done to avoid the regulatory burden of permanent structures. It does mean that there has to be a review of each installation every five years with a case made to the regulatory authorities about its value to the community. Because of the fixed nature of this IMOS term, all contracts undertaken by ACORN expire on or before 30 June 2011. ACMA radio licences are secondary licences and have to be applied for and justified on an annual basis.

The radar installations will need an overhaul after five years to replace exposed cables, connectors and other key components affected by the salt and sand environment. After a further five years the radar units should be assessed for obsolescence.

### **3. Relevance to the IMOS science-goal**

- **Streams of data that support research on the role of the oceans in the climate system and the impact of major boundary currents on shelf-ecosystems**

The justifications for this goal are built in to earlier IMOS proposals. One area where ACORN and IMOS are not doing so well is in our clients winning research grants in the National Competitive Research Grants structure. I have encountered ARC Panel members who do not know what IMOS or NCRIS are, and certainly were unaware of the deliberate policy to provide research infrastructure. This is a particularly acute problem for the University sector (rather than CSIRO or AIMS).

One way to address this, in a future version of IMOS, may be to offer PhD augmentation scholarships for students who draw upon the IMOS archive for their project work.

### **4. Contribution to national capability building**

ACORN has attracted a technical person from the Californian CODAR Network. Daniel Atwater will commence with ACORN in early November and will be the lead person in the CODAR technology area. This is a significant step in national capacity building and coincides with the first deployment of that radar genre over the next few months.

Associate Professor Eric Gill from Memorial University New Foundland spent a 12-month sabbatical in the Marine Geophysical Laboratory at James Cook University during 2007/8.

### **5. Demonstrated user community / meeting researcher needs**

We expect this to move more quickly when QC and metadata-ed files are flowing into the archive.

A new ARC Linkage proposal is being prepared titled 'Wave climate in the Southern Great Barrier Reef'.

## OTHER INFORMATION

*The Review Panel will have access to the detail provided in the 2006/07 and 2007/08 Annual Progress Reports – available at <http://imos.org.au/reports0.html>. Detailed below are any significant changes / additions since June 2008.*

### **A. Changes to the original agreed level of co-investment**

1. The Queensland Department of Tourism, Regional Development and Industry have agreed on terms with James Cook University to provide co-investment for ‘IMOS Sub-capability – The Great Barrier Reef Ocean Observing System at a level of \$100,000 per year, with an Agreement in process of execution for work commencing 1 July 2008 and ending 30 June 2012.

This has already been registered as a co-investment and this update confirms that the Agreement has now being executed but, because of delays in getting started, the term now extends past the present IMOS term to 30 June 2012.

These funds will be used for the Applications R & D identified elsewhere in this report as a critical need. This will provide access tools for users of the eMII archive of ACORN data. Examples are: Lagrangian tracking; empirical modelling to forecast surface currents up to 72 hours ahead of real time; use of HF radar data to determine mixing in the water column on the continental shelf.

### 2. Host Institution

Earlier problems of management of ACORN within JCU have been fixed to a level of operational expediency, and we have shown that this arrangement will work for the life of the present contract. Co-investment input from the host institution is to some extent offset by the bureaucratic burden imposed on ACORN staff.

## MILESTONES

Below are:

- the Milestones transferred from 2007/08 to 2008/09 (as reported in the 2007/08 Annual Progress Report)
- the 2008/09 Milestones, as provided for the 2008/09 Annual Business Plan
- The post July 2009 planned activities, as provided for the 2008/09 Annual Business Plan

Please review, and amend the tables as necessary for any changes, and note any potential barriers to achievement.

### **MILESTONES TRANSFERRED FROM 2007/08 to 2008/09 (being those Milestones from the 2007/08 Annual Progress Report, recorded as either 'In Progress', or 'Transfer to 2008/09')**

<b>Party(s)</b>	<b><u>Due / Status</u></b>	<b><u>Milestone / Achievements / [Comments]</u></b>	<b><u>Update / Potential Barriers to Achievement</u></b>
7.1 JCU	<b><i>Jun08</i></b> In progress	<b><i>Three installations operating</i></b> GBR operating from 1 Jan 08; WA installations (2) ordered; SA installation delayed by site approval <i>[WA installations expect completion 31 Dec 08. SA installation remains uncertain.]</i>	WA site and ACMA approvals still pending ; We will install in steps as approvals come through (as demonstrators) ; SA agreed work plan for completion by June 2009
7.3 JCU SARDI	<b><i>Jun08</i></b> In progress	<b><i>Freely available streams of ACORN Data</i></b> Delayed <i>[GBR and SA be operational by 31 Dec08]</i>	GBR uncalibrated data being made available; QC processes completed by 31 Dec 2008.

### **2008/09 MILESTONES (as provided in the 2008/09 Annual Business Plan)**

<b>Party(s)</b>	<b><u>Due</u></b>	<b><u>Milestone</u></b>	<b><u>Update / Potential Barriers to Achievement</u></b>
7.1 JCU SARDI	Dec08	Radar systems operating in Qld, WA and SA	QLD operational 1 Nov 2007 Orders placed for WA radars; WA will be installed in steps; completion by Jun 09; SA work plan to complete by Jun 09
7.2 JCU	Feb09	Radar systems ordered for NSW, SA/Vic	Ordering delayed until ACMA licence 13 MHz Coffs Harbour; Site approvals process early for Coffs Harbour; Not commenced for SA/Vic. Earliest completion Dec 2009

<b>Party(s)</b>	<b>Due</b>		<b>Milestone</b>	<b>Update / Potential Barriers to Achievement</b>
<b>Party(s)</b>	<b>Start</b>	<b>Finish</b>	<b>Activity</b>	<b>Update / Potential Barriers to Achievement</b>
JCU / SIMS		Dec09	Install WERA for Coffs NSW; installed and operating	Earliest completion Dec 2009
JCU SARDI		Dec09	Install CODAR SeaSonde at Bonney SA/VIC; installed and operating	Earliest completion Dec 2009
JCU		Jun11	Maintain system	
JCU		Jun11	Assist users	



### ACORN Archive Access Tools

MLH 18 July 2008.  
revised 4,8 Sep 08; 2 Oct

#### Summary: ACORN eMII Archive: WERA Data

08

#### **Level 1 Processed Data** Fixed grid points, hourly values:

Surface Current speed and direction  
Significant wave height (ratio algorithm)  
Wind Directions (ratio algorithm)  
Period of swell peak (Second order peak frequency offset)  
Directional wave spectra (Seaview algorithm) (reduced grid)

#### **Level 0 Raw Data** Fixed grid points, 10-minute values

Radial components of surface currents  
1<sup>st</sup> order peak heights  
2<sup>nd</sup> order integrals  
2<sup>nd</sup> order peak frequencies  
Signal/Noise ratios (noise floor)

#### **Level -1 Proprietary Format Data** 10-minute values

Raw SORT/RFI data (WERA systems time series for each Receive Antenna Element)

#### **ACORN Access Tools:**

##### **1. Production Level:**

- (a) Access to numerical values in the archive at Level 1 and Level 0
- (b) Access to visualisations of Level 1 data

#### Maps:

Surface current map - selected site and time ;  
Significant wave height map – selected site and time;  
Wind direction map – selected site and time;  
Swell peak period - selected site and time;  
Directional wave spectra - display on map

#### Movies:

Use hourly maps to construct movie loops for selected site, time and duration.

#### Time Series:

Surface Currents at selected grid points, and selected periods  
Significant wave heights at selected grid points, and selected periods  
Wind direction at selected grid points, and selected periods  
Swell peak period at selected grid points, and selected periods

Capacity to superpose on GoogleEarth maps

Capacity to introduce some BoM data

## 2. Developmental Level

selectively enhance convergence/divergence areas (DIV);

selectively enhance eddies (CURL);

selectively enhance jets.

## 3. Research Level

(a) Lagrangian drift simulation:

Select start position and time - single point

Select time and group of points - spatial bunch

Select position and period - stream from a point source

(b) Tidal ellipses at grid points: these need to be calculated on (say) successive monthly periods and put into an archive as processed data - this is in the nature of a research project.

(c) Optimise spatial averaging for directional wave spectrum analysis.

(d) Optimise spatial and temporal averaging for general analysis of spectra.

(e) Evaluate procedures for averaging spectra (over 1 hour) and averaging parameters.

Appendix 2: Installation work plan devised in conjunction with SA Govt approval agencies

Table 1. Time line for the acquisition and installation of the SA WERA radars. Against each task we identify an IMOS project officer who is responsible for that task (but not necessarily doing it!), using the following abbreviations:

MH = Mal Heron; GP = Geoff Page; JM = John Middleton; JL = John Luick; AP = Arnstein Prytz

Task Completion Date	Approval Process	Acquisition of Equipment	Site Preparation
31 October 08	Native Vegetation Reports – Spencer & Wiles [MH]	Design parameters for environmental power - Wiles [GP] Helzel to quote separately for capital items (SARDI) and installation costs (JCU) [JM]	Detailed site surveys – Spencer & Wiles [MH]
30 November 08	Heritage approval – Wiles [JM] Final approval - Wiles Licence to occupy site – Spencer (DEH & SARDI) [MH] Final approval – Spencer [JM]	Source suppliers for environmental power – Wiles (quotes) [GP] All quotes and documentation for SARDI [JM]	Agreement for access, rent and caretaking – Wiles (Theakestone & JCU) [MH]
31 December 08	ACMA licences [MH]	Dongas ordered – Wiles [GP] Donga ordered – Spencer [GP] WERA radar ordered -capital [JM] Installation [MH]	
31 January 09			

28 February 09			
31 March 09		WERA radar delivered to store in Adelaide [JL]	Dongas delivered and installed [GP]
30 April 09			Environmental power installed – Wiles [GP] Power and phone connected – Spencer [GP] WERA radars installed – Wiles & Spencer [MH]
31 May 09			Calibrations and commissioning [MH]
30 Jun 09	Real time data flowing to archive [AP]	Real time data flowing to archive [AP]	Real time data flowing to archive [AP]

# INTEGRATED MARINE OBSERVING SYSTEM (IMOS)

## IMOS FACILITIES Information for the IMOS 2009 Review

**Name of Facility:** Australian Acoustic Tagging and Monitoring System (AATAMS)

**Facility Leader:** A/Prof Rob Harcourt, Phone 02 9850 7970, Email [rharcourt@gse.mq.edu.au](mailto:rharcourt@gse.mq.edu.au)

**Technical Officer:** Dr Charlie Huveneers, Email [charlie.huveneers@sims.org.au](mailto:charlie.huveneers@sims.org.au)

### 1. Quality of implementation so far, and soundness of forward plan

The deployed infrastructure has provided the research community with quality data that is already being used through many different projects nationally (see Part D). The general interest and positive feedback obtained from the user community illustrates the quality of the data and adequacy of the forward plan.

### 2. Consistency with principles

- **Service - IMOS is a national system and will provide a data-service that broadly supports marine research to maximise the contributions of R&D to economic development, national security, social wellbeing and environmental sustainability.**

AATAMS has been providing data from acoustic receivers deployed nationally in areas identified by the marine research community as requiring further studies and research infrastructure. By providing continuous data of fish movement and migrations, AATAMS is delivering data required to ensure the sustainability of the ecosystem and that enables fishery managers to ensure sustainable fishing practice.

- **Data streams - IMOS data will be delivered freely, openly, in a timely manner, preferably in near real time. Success will be measured in terms of the quality and quantity of data that IMOS delivers, the number of users and the quality of research-results produced with IMOS data.**

About 300 deployments of 210 AATAMS receivers have already taken place all around Australia. The successful downloading of data from these receivers has provided over 400,000 detections from 340 tagged sharks, rays, and fishes. Furthermore, the user community has simultaneously been deploying, servicing, and downloading acoustic receivers funded and in use by other institutions. The data downloaded from these approximately 600 receivers has been offered to AATAMS and will be uploaded to eMII once that facility is up and running. This network of acoustic telemetry users created by AATAMS is composed of over 100 research scientists from 34 different institutions located nationally. Furthermore, research results derived from AATAMS receivers have already been presented at national and international conferences (see Other Information D).

- **Integration - IMOS will deploy a nationally coordinated, multi-platform system to take advantage of the synergies between instruments, and to provide a comprehensive description of the ocean, as a contribution to national and international programs.**

The AATAMS receivers have been deployed in areas where oceanographic moorings from IMOS and other institutions have also been deployed allowing biological and oceanographical information to be integrated. This is a basic requirement by the user community to facilitate interpretation of fish movements and migration, and plays an integral part of the AATAMS facility.

Furthermore, new collaborations are planned and are described under points 5, and Other Information C. These new developments propose new innovative ways to integrate several of the IMOS facilities. AATAMS is proposing to:

- Deploy new technology not yet available on a coastal glider from the Australian National Facility for Ocean Gliders (ANFOG) and test its capability in detecting tagged marine organisms during glider deployment;
- Collaborate with the Facility for Automated Intelligent Monitoring of Marine Systems (FAIMMS) and Tasmanian Marine Analysis Network (TasMAN) to improve current acoustic receiver technology and allow real-time detections to be obtained through the Sensor network.

- ***Sustainability* - The real value of IMOS will only emerge if systematic, repeated data collection continues for a long time to see the full range of climate variation and change. Sustained streams of data are integrally related to conservation and sustainable development of the marine environment.**

The infrastructure deployed by AATAMS has been designed to be permanent and was deployed in collaboration with various institutions that have gained ownership of the project. AATAMS was intended to provide acoustic receivers to the community which would service and maintain the infrastructure. This allows AATAMS to be maintained efficiently and collect continuous data through large temporal scale. The full development and availability of eMII is essential to the community and in particular the Co-Investors for sustained support of the facility.

### **3. Relevance to the IMOS science-goal**

- **Streams of data that support research on the role of the oceans in the climate system and the impact of major boundary currents on shelf-ecosystems**

As stated above, AATAMS has deployed permanent infrastructure that is being serviced by collaborative institutions and agencies allowing long-term data to be collected. These will enable continuous monitoring of fish migrations and movements through time and climatic changes. The receivers are also deployed within major boundary currents such as the Eastern Australian Current off Sydney, the Leeuwin Current off Ningaloo Reef and Perth, and the Flinders Current off South Australia. Furthermore, the locations of the deployments in proximity to oceanographic moorings allow monitoring of movements and migrations of fishes through fluctuations of these major boundary currents.

New collaborations with James Cook University (JCU), the Australian Institute of Marine Science (AIMS), University of Tasmania (UTAS) and CSIRO are also currently being planned to monitor the connectivity between tropical islands and trophic interactions between fish species within the shelf-ecosystem and movement of marine organisms within coastal systems that are impacted by urban and industrial development.

### **4. Contribution to national capability building**

From the initial business plan, AATAMS initiated strong national collaborations with a range of institutions including universities, state and federal agencies to create a network of acoustic receivers and scientists which is now being used as an example to follow by the international project Ocean Tracking Network (OTN).

Furthermore, AATAMS recently identified several areas requiring capability building and initiated new collaborations with ANFOG, GBROOS/AIMS, and UTAS, CSIRO, TasMAN to increase capability building.

## 5. Demonstrated user community / meeting researcher needs

Many students and established researchers nationally are already using infrastructure provided by AATAMS. Whereas AATAMS contributes to many existing projects, other studies are entirely based on data obtained through AATAMS. Projects using some of AATAMS receivers or being entirely supported by AATAMS include:

- Habitat utilisation of fish Ningaloo Reef Marine Park; data and tools for understanding spatial dynamics of ecological processes (Russ Babcock, Richard Pillans – CSIRO)
- Habitat use of sharks and rays in Ningaloo Reef (John Stevens, Rory McAuley, William White – CSIRO MAR, WA Fisheries)
- Movement, feeding and behaviour of reef sharks at Ningaloo Reef, Western Australia (Conrad Speed, Corey Bradshaw, Mark Meekan, Iain Field – CDU, AIMS)
- Movement of Southern Bluefin Tuna in Southwest Australia (Alistair Hobday – CSIRO MAR)
- Movement and residence times of batoids within Ningaloo Reef, Western Australia (Florencia Cerutti, Mark Meekan – CDU, AIMS)
- Residence time, site fidelity in relation to foraging behaviour of Manta Rays (Frazer McGregor, Mike van Keulen – Murdoch University)
- Site Fidelity, localised movement patterns and migrations of manta rays along the Queensland coast (Mike Bennett, Kathy Townsend – University of Queensland)
- The effects of predator release within marine protected areas (Kate Lee, Charlie Huveneers, Rob Harcourt, Vic Peddemors – Sydney Institute of Marine Science, Macquarie University, NSW DPI)
- Habitat use and migration patterns of silvertip and grey reef sharks at the Rowley Shoals, Western Australia (Iain Field, Mark Meekan, Corey Bradshaw)
- Movement patterns, habitat use and species interactions of key shark and finfish species in coastal systems (Adam Barnett, Jeremy Lyle, Jayson Semmens – TAFI, UTAS)
- Post release behaviour of juvenile mulloway: Effects of stocking density (Andrew Fairfax, Matt Taylor, Iain Suthers – UNSW)
- The Yongala Halo of Holes – Who’s digging it? (Thomas Stieglitz, Rhondda Jones – JCU)
- Coral Sea Nautilus tracking project (Andrew Dunstan, Jamie Seymour – JCU)
- Movement patterns and habitat use of rabbit fishes (F: Siganidae) on the Great Barrier Reef as a link to ecosystem function (Rebecca Fox, David Bellwood, JCU)
- What size do Marine Protected Area Sanctuary Zones need to be in order to protect the Near-Threatened Western Blue Groper and Harlequin Fish? (Simon Bryars, Paul Rogers – Department of Environment and Heritage, SARDI)
- The effect of abiotic variables on the field diving behaviour of the Arafura Filesnake (*Acrochordus arafurae*) (Kirstin Pratt, Craig Franklin – University of Queensland)

Furthermore, the network created by AATAMS also enables researchers to obtain further information not available through the use of their institutions arrays. For example, Barry Bruce (CSIRO MAR) and Will Robbins (NSW DPI) have both obtained detections of organisms that they tagged in one region from receivers outside of their arrays thanks to the centralisation of the transmitter id codes and detections that is now possible through AATAMS.

However, the user community has highlighted some major regions as requiring increased coverage. AATAMS worked in close association with the community to design and propose locations for new deployments to fill in the gaps identified.

## OTHER INFORMATION

*The Review Panel will have access to the detail provided in the 2006/07 and 2007/08 Annual Progress Reports – available at <http://imos.org.au/reports0.html>. Detailed below are any significant changes / additions since June 2008*

### **A. Changes to the original agreed level of co-investment**

In addition to the minor changes of the received co-investment which are described in the progress report, AATAMS established new collaborations and gained further in-kind support from WA Fisheries and SARDI/MAFFRI to deploy, service and maintain the receivers obtained from the OTN co-investments. This in-kind support has been preliminarily valued at about \$180,000 per institution.

VEMCO (Amirex Canada) also provided 20% of tags for detection testing being conducted by the AATAMS technical officer.

Furthermore, the proposed new deployments in Queensland and Tasmania would also be supported by GBROOS/AIMS and UTAS/CSIRO. As co-investments, GBROOS/AIMS has already offered to:

- Provide logistic support for four areas of deployments as well as future receiver servicing and downloads;
- Support R&D to enable real-time downloads through the sensor arrays;
- \$50,000 project costs in addition to logistics towards a project in their region to ensure that fish are being tagged and that receivers obtain detections.
- CSIRO to provide \$350,000 for biogeochemical sensors
- CSIRO Wealth of Oceans Flagship providing \$200,000/yr for INFORMD network
- CSIRO ICT providing 5 people and significant infrastructure to develop TasMAN, including R&D for this project
- UTAS to provide logistic support for deployments, receiver servicing and R&D
- Myriax to provide logistical support for data visualisation software (EON Fusion)

### **B. Promotional activities**

AATAMS spent a lot of time at a National scale promoting the facility and the deployed infrastructure to scientists using acoustic telemetry to create a national network of acoustic telemetry users. AATAMS has also been promoted to national and international scientists to inform them of the innovative work undertaken in Australia. AATAMS represented the Eastern Indian and Western Pacific region at the Ocean Tracking Network 1<sup>st</sup> conference during which AATAMS was identified as an example that the other region should follow with emphasis on its current success. The success of these promotional activities is demonstrated by the network created and positive feedback from all stakeholders.

The AATAMS Technical Officer (TO) Dr Charlie Huveneers and Dr Jayson Semmens, a member of the AATAMS scientific committee, recently attended the Ocean Tacking Network first conference in Halifax, Canada. Dr Huveneers and Facility Leader Assoc Prof Rob Harcourt presented a talk on AATAMS/IMOS at the Third Biologging Symposium in Monterey Bay, California. Dr Huveneers and Assoc Prof Rob Harcourt also attended the Oceania Chondrichthyan Society conference in Sydney where three papers using AATAMS' data were presented.

Media activity has been persistent. For example one project using acoustic telemetry and part of the AATAMS network received extensive media attention nationally and

internationally including about 20 radio interviews, 15 internet articles, five stories in the news and ten stories in newspapers.

### **C. Fostering collaborative development of infrastructure**

AATAMS initiated new collaboration with other IMOS facilities and nodes to expand the AATAMS coverage, develop infrastructure and improve the current technology. AATAMS recently contacted ANFOG to deploy a new transmitter not yet available on the market (business card tag) on one of the ANFOG gliders. This deployment would test a new way of deploying acoustic receivers in areas not available using common deployment methods. Furthermore, AATAMS has also been in contact with FAIMMS and technicians from AIMS/JCU and UTAS/CSIRO to enable real-time detections of the VR2Ws to be obtained through the Sensor network deployed by FAIMMS.

### **D. Scientific publications using IMOS data / participation in scientific seminars and conferences**

*Since July 2008*

#### **Presentation**

Speed, C.W., Meekan, M.G., Field, I.C., Bradshaw, C.J.A. (2008) Reef shark movement patterns at Ningaloo Reef, WA. Coast to Coast, 21 August 2008, Darwin Convention Centre, Darwin, Northern Territory.

[https://www.coast2coast.org.au/pdfs/DRAFT\\_C2C8\\_Timetable.xls](https://www.coast2coast.org.au/pdfs/DRAFT_C2C8_Timetable.xls)

Huveneers, C. and Harcourt, R.G. (2008) The Australian Acoustic Tagging and Monitoring System (AATAMS) – A national network for the investigation of migratory marine species. *Biologging III*, 1–5 September 2008, Asilomar Conference Centre, Pacific Grove, California, USA.

Speed, C.W., Meekan, M.G., Field, I.C., Huveneers, C., Harcourt, R.G., Stevens, J.D., White, W.T., McAuley, R.B., Chidlow, J., McGregor, F., Pillans, R. and Bradshaw, C.J.A. (2008) Reef shark movement patterns at Ningaloo Reef, Western Australia. *Oceania Chondrichthyan Society Conference*. 22–24 September 2008, Australian Museum, Sydney, NSW, Australia.

Stevens, J., McAuley, R., Last, P., White, W., Chidlow, J., Pillans, R., Meekan, M., Huveneers, C., Speed, C., McGregor, F. and Sugden, M. (2008) Sharks and rays of Ningaloo Reef. *Oceania Chondrichthyan Society Conference*. 22–24 September 2008, Australian Museum, Sydney, NSW, Australia.

#### **Conferences**

*Coast to Coast*, 21 August 2008, Darwin Convention Centre, Darwin, Northern Territory, Australia.

*Biologging III*, 1–5 September 2008, Asilomar Conference Centre, Pacific Grove, California, USA.

*Oceania Chondrichthyan Society Conference*. 22–24 September 2008, Australian Museum, Sydney, NSW, Australia.

## MILESTONES

Below are:

- the Milestones transferred from 2007/08 to 2008/09 (as reported in the 2007/08 Annual Progress Report)
- the 2008/09 Milestones, as provided for the 2008/09 Annual Business Plan
- The post July 2009 planned activities, as provided for the 2008/09 Annual Business Plan

Please review, and amend the tables as necessary for any changes, and note any potential barriers to achievement.

**MILESTONES TRANSFERRED FROM 2007/08 to 2008/09 (being those Milestones from the 2007/08 Annual Progress Report, recorded as either ‘In Progress’, or ‘Transfer to 2008/09’)**

<b>Party(s)</b>	<b><i>Due / Status</i></b>	<b><i>Milestone / Achievements / [Comments]</i></b>	<b>Update / Potential Barriers to Achievement</b>
8.3 SIMS	<b><i>Jun08</i></b> In progress	<b><i>Establish the three IMOS Curtains: at Ningaloo (April 2008), East Coast (April 2008) and South Australia (June 2008)</i></b> South Australian curtain deployed, Ningaloo Reef Ecosystem Tracking Array deployed, East Coast curtains not deployed yet. <i>[Delays in the deployment of the East Coast curtain is due the extreme conditions (currents and swell) occurring at these locations. New stronger mooring design had to be developed to ensure retrieval of equipment.]</i>	

**2008/09 MILESTONES (as provided in the 2008/09 Annual Business Plan)**

<b>Party(s)</b>	<b>Due</b>	<b>Milestone</b>	<b>Update / Potential Barriers to Achievement</b>
8.1 SIMS	Jun09	Complete all acoustic tracking installations	Depending on arrival times of OTN receivers and ordered mooring equipment
8.2 SIMS	Jan09	User access of tracking data from eMII	Depending on eMII user friendly database search

**POST JULY 2009 PLANNED ACTIVITIES (for the period July 2009 to June 2011, as listed in the 2008/09 Annual Business Plan)**

<b>Party(s)</b>	<b>Start</b>	<b>Finish</b>	<b>Activity</b>	<b>Update / Potential Barriers to Achievement</b>
SIMS WAFisheries PIRVIC	Jul08	Jul09	Completion of OTN deployment	Depending on arrival time of OTN receivers
SIMS WAFisheries	Jun09	Jun11	Data retrieval and receiver servicing of West Coast Deployments	
SIMS	Jun09	Jun11	Data retrieval and receiver servicing of East Coast Deployment	
SIMS	Dec07	Jun11	Continued Deployment of mobile receiver pool	
SIMS	Jan08	Jun11	Upload of Data to eMII	Depending on eMII progress
SIMS eMII	Jan08	Jun11	User access of Data from eMII portal	Depending on eMII user friendly database search

# INTEGRATED MARINE OBSERVING SYSTEM (IMOS)

## IMOS FACILITIES Information for the IMOS 2009 Review

**Name of Facility:** Automated Intelligent Monitoring of Marine Systems (FAIMMS)

**Facility Leader contact details:**

Dr. Peter Doherty:	07 – 4753 4282	<a href="mailto:p.doherty@aims.gov.au">p.doherty@aims.gov.au</a>
Mr. Scott Bainbridge	07 – 4753 4377	<a href="mailto:s.bainbridge@aims.gov.au">s.bainbridge@aims.gov.au</a>

### 1. Quality of implementation so far, and soundness of forward plan

The Facility is on-track with regard to the implementation plan with the following deployments and work completed:

- Development and testing of field packages including sensor platforms, communication systems, enclosures, poles, buoys and moorings;
- Permits and approvals for all deployments obtained;
- Sensor deployments completed at Heron Island, One Tree Island and Davies Reef, that is three of the seven sites selected. Deployments at Rib Reef are underway with Orpheus Island due for May 2009 leaving only Lizard Island to be completed in late 2009.
- Communication links have been installed at three of the sites (Heron, One Tree and Davies Reef) with plans underway for the remaining sites with the exception of Lizard Island for which a feasibility study will be required;
- The Moreton Bay work, being done in conjunction with the University of Queensland, is underway with the deployments planned for early 2009;
- A number of presentations and publications completed including presentations at a number of international conferences;
- Initial data streams are now available via a number of mechanisms.

The Facility has a comprehensive implementation plan especially for the period covering the initial deployments. The forward view is that while there are some lessons to be learnt in the design of the deployed equipment the success of the deployments so far indicates that there are no major issues. The majority of the work is now in refining the design and in working through the particular issues with each of the deployments.

The deployments themselves have been done to the standards that AIMS uses for all of its oceanographic deployments and the considerable expertise of the Institute has been used to ensure that the systems deployed are reliable and will produce high quality data.

The Facility has also moved to deploy standard oceanographic grade instruments rather than cheaper sensors. These give higher quality data and require less servicing so increasing the quality of the overall implementation. The project has developed a quality control framework that it is applying to the data which includes regular manual checks of the data to again ensure the delivery of quality data.

The Facility has a dedicated Project Manager, via the GBROOS Node, along with dedicated financial and support staff. There has been no staff turnover to date and all positions have been filled. Governance arrangements are also in place, again via the GBROOS Node, that FAIMMS sits within. All invoicing is up to date and so far the in-kind contributions have been forth coming from the various partners. All of this ensures that, at the project level, the implementation is being done to the expected standards and that there are no organisational and resourcing issues that will impact the implementation.

The Facility is one of the few that is producing real-time instrument data and a lot of work has been put into developing data systems to deal with this. Sensor networks are an emerging technology and much of the standards and tools are still being developed so the Facility has needed to invest heavily in data management. This has a benefit in that this work can be transferred to other parts of IMOS and it works to establish IMOS as a contributor in this area.

The main potential issue is with the higher level data management. The emerging set of standards for streaming sensor data use a framework that is very different to that for traditional data files. While the Facility has been very aggressive in working with these there is a need for an equivalent set of expertise and investment at the eMII level to support and facilitate the work done in the Facility.

The risk is, that if this is not forthcoming, that the Facility will not be able to deliver to the set of standards and products that it could and that a lower set of outcomes may be achieved. The delay in eMII starting and the range of issues that eMII has to deal with means that there is a risk that eMII will not be able to deliver the outcomes required for the Facility in turn to fully deliver.

## 2. Consistency with principles

- ***Service - IMOS is a national system and will provide a data-service that broadly supports marine research to maximise the contributions of R&D to economic development, national security, social wellbeing and environmental sustainability.***

The FAIMMS Facility is deploying one of the first marine sensor network deployments in Australia and one of a few around the world. This will provide real-time monitoring of the Great Barrier Reef at a range of scales. These data streams will provide a unique set of data to a range of researchers and will be a major advance in the data available for coral reef systems.

The FAIMMS data will be a key component of the data provided to the Great Barrier Reef Marine Park Authority (GBRMPA) in helping them to better understand some of the environmental threats such as coral bleaching and ocean acidification. The data will be made available to GBRMPA in a form, such as bleaching indices, that provides them with real-time information about the state of the Great Barrier Reef at the designated locations. The FAIMMS data will therefore directly support the Marine Park Authority in managing and sustaining the Great Barrier Reef Marine Park.

The Facility is working with a number of research and development groups by providing the infrastructure and logistics to support their research work. This includes work on underwater wireless communications with the University of Queensland, work on sensor optimisation with the University of Melbourne (via ISSNIP), work on new sensor platforms with CSIRO, work on self discovery architectures for sensors with James Cook University, support for a radiance reference station at Heron Island with NOAA and work on over the horizon microwave systems also with James Cook University. There are also projects to support new sensor types such as pCO<sub>2</sub> and underwater video and new applications such as jellyfish monitoring for Surf Lifesaving Australia.

The Facility is also advancing the use of real-time sensor data for management and monitoring of marine systems and the set of underlying standards and tools to support the use and discovery of real-time data. The Facility is working with a number of open

source software projects both as a 'Use Case' for their development and to directly develop the tools required for managing sensor data. The projects currently engaged with include the Data Turbine middleware, the Kepler work flow software, the Deegree web map service software and the EonFusion visualisation software.

- ***Data streams - IMOS data will be delivered freely, openly, in a timely manner, preferably in near real time. Success will be measured in terms of the quality and quantity of data that IMOS delivers, the number of users and the quality of research-results produced with IMOS data.***

The Facility currently has over thirty data streams coming in to AIMS in real-time; this will grow to almost one hundred by the end of 2008 and then will expand from there as more deployments are completed.

All data streams will consist of a non quality controlled real-time stream and a corresponding delayed quality controlled stream. The quality control process will be rigorous and will deliver high quality data suitable for use in a range of applications. All data will be freely available via a range of mechanisms using open community standards.

All of the FAIMMS data streams will be real time and openly available. The project is developing a range of middleware, such as Data Turbine, to deliver data in real time to any person who wishes to subscribe to the data streams. This makes the use of the data open and easily accessible. Platforms such as the iPhone and desktop widgets will be used to make it easier to access and use the real time data streams.

At this stage the data streams are new and so there has not been an opportunity to strongly engage with end users but as these streams come on line there will be a major push to make these available to a range of researchers. The focus of this work will be to provide real-time streams available in a format that can be directly used by specific communities such as the modelling and management communities. Technologies such as Google Earth, desktop widgets and GIS (via WFS, WCS) integration will be used to deliver targeted products to particular user communities.

- ***Integration - IMOS will deploy a nationally coordinated, multi-platform system to take advantage of the synergies between instruments, and to provide a comprehensive description of the ocean, as a contribution to national and international programs.***

The FAIMMS facility is managed under the umbrella of the Great Barrier Reef Ocean Observing System (GBROOS) Node of IMOS and the deployments are designed to compliment the other components of GBROOS, especially the mooring array. The ability to mix long term deep water moorings with smaller shallow water sensors that are easier to re-deploy allows for phenomena to be studied at a range of scales in both time and space. This results in a very powerful set of systems that can be used synergistically to study some of the fundamental ocean / reef dynamics and interactions.

The Facility will provide real-time data streams in standards compliant format allowing the data to be very easily integrated into other data systems. Unlike data that is in simple files, all of the data from the Facility will be available as web services so that programs from Excel to GIS software to models can access the data via simple URL's. The focus on standards by the Facility will ensure that the data can be integrated into other systems and that new types of instruments can be supported within the one infrastructure.

FAIMMS is part of an international network called the Coral Reef Ecological Observing Network (CREON) that is establishing sensor networks at a number of coral reef sites around the world. The Facility is working with CREON to develop a set of standards for deployments and to deliver a set of standardised data streams for at least three sites around the world by mid 2009.

- **Sustainability - The real value of IMOS will only emerge if systematic, repeated data collection continues for a long time to see the full range of climate variation and change. Sustained streams of data are integrally related to conservation and sustainable development of the marine environment.**

The design of the Facility has a number of fixed systems and a number of re-deployable systems. The fixed units will provide long term records suitable for climate change and other studies and will serve as essential inputs to our understanding of the natural and longer term variability in coral reef systems. The integration of these fixed units with the mooring component of GBROOS allows for data at a range of scales to be obtained.

The Facility has a large support contribution from a range of University and other partners including the Australian Institute of Marine Science (AIMS) that manages the Facility. This combination of agencies ensures that the Facility has a high level of current in-kind support and that it has ownership by the partners and so will be supported into the future.

The linkage between the research agencies and the management of the Great Barrier Reef, overseen by GBRMPA, means that the Facility will have a series of Users who will rely on the data for their day to day operational work. The requirement to provide long term operational type data to resource management agencies will ensure that the project delivers long term sustained data and that this data will be focused on the conservation and sustained use of coastal systems and the Great Barrier Reef in particular.

In the larger context through collaborations such as CREON, the Facility is engaged with the international coral reef community and so is in a position to contribute to the conservation of tropical coastal systems at an international level. A presentation on GBROOS was given at the International Coral Reef Society conference in Florida in 2008 and from this a range of potential collaborations are being developed. Facilities such as FAIMMS are increasingly being seen as essential components to managing the continued sustainability of coral reefs and other tropical coastal ecosystems.

### 3. Relevance to the IMOS science-goal

- **Streams of data that support research on the role of the oceans in the climate system and the impact of major boundary currents on shelf-ecosystems**

The sensor networks provide real time data streams from a range of sensors and so provide the only real-time data for much of the Great Barrier Reef. As such they form critical input into modelling and monitoring efforts and can be used to give the current conditions actually on the reef itself. The system is designed to compliment remote sensing and other data sources that provide large but often only limited set of measurements; the sensor network provides a high resolution three dimensional view of key parts of reef systems. The sensor data can therefore be used to calibrate and validate the larger scale data as well as providing other dimensions to the remote data collected.

In the Townsville region the sensors are designed to monitor the intrusion of oceanic water from off the shelf into the reef matrix and so for this key area the design serves as an early warning system for the movement of ocean water into the reef system. These intrusions have been linked to coral bleaching and other environmental stressors and so monitoring these is an important part of monitoring and managing the health of the reef itself.

In the Capricorn Bunkers group the FAIMMS data will compliment the deeper mooring data in characterising the flow of water around the southern part of the Great Barrier Reef where it forms into the main East Australian Current that flows southward. This area forms a critical part of how the southward current forms and the complex series of jets and eddies in this region have an effect on localised fisheries as well as downstream systems.

There is a concentrated effort in the southern GBR region that includes moorings, coastal HF radar, sensor networks and satellite based modelling giving a range of scales of data that together increase our understanding of the variability and functioning of this region. The data will feed into modelling work being done by the University of Queensland and AIMS looking at the fine scale variability of the water movement in the southern part of the GBR.

Around Lizard Island the sensors will be used to better link ecosystem events such as spawning and heat stress events into the local environmental conditions. This will allow the examination of how the small scale environment links into the larger scale processes and how these in turn link into ecological responses. The understanding of these linkages is an important component of understanding the larger impacts of climate and boundary currents.

#### **4. Contribution to national capability building**

The sensor network technology being deployed by the FAIMS Facility is relatively novel, certainly the deployment of this technology in the marine environment is. This Facility therefore has an important role in building national capacity in marine and coastal sensor networks. Given the size and complexity of Australia's marine jurisdiction, sensor networks have an important role in providing a range of spatially dense real-time information about coastal systems. The Facility is building and developing this capacity in a 'plug and play' form that can be used in almost any location or application.

The other area of capacity building is in the management and processing of sensor data. Sensor networks are an emerging area and there is little current expertise on how to manage process and present the large amounts of real time data that are produced. The Facility is working at the national and international level on the standards, middle-ware and tools for accessing and using sensor data.

This expertise will be transferred into the environmental information management community as well as the more general computing community including the super computing and grid computing areas. Examples of this include the Data Turbine, Kepler and Deegree software, the SWE set of OGC standards, the WaterML XML standard and the use of Google Earth and other GIS type tools for data presentation and visualisation.

Finally the provision of high quality real time data will be an important asset to the modelling and visualisation communities. The development of sophisticated models and data visualisation products requires data to validate and seed them, the FAIMMS Facility

produces real time data that is perfect for such applications and so the Facility will facilitate the development of capacity in these areas.

## **5. Demonstrated user community / meeting researcher needs**

At this stage of the project the data streams are still coming on line and so it has not been possible to tightly engage with the research or user community. Even so there have been a number of people interested in using the data; the main focus is still to make more data streams available but then to deliver these to the research and user community.

One main User will be the Great Barrier Reef Marine Park Authority and in particular their climate change group. We have started engaging with them and this process will continue as more data is available. The intention is to deliver to them operational style data products that allow them to know what is happening at key locations on the reef and to work with them to develop monitoring indices and other derived data products to meet their needs.

The project is also working with a number of other communities. The first is the international coral reef community where participation in groups such as CREON and presentations at a number of conferences is facilitating interest in the use of the FAIMMS systems to do new research and to extend this into new areas. The second is the eco-informatics community where the Facility is working to develop and deploy the standards, software and tools to deliver real-time sensor data to environmental managers and scientists. Finally the Facility is working with the modelling community to deliver data streams that will allow them to validate and develop new types of small and medium scale models.

## **OTHER INFORMATION**

*The Review Panel will have access to the detail provided in the 2006/07 and 2007/08 Annual Progress Reports – available at <http://imos.org.au/reports0.html>. Detailed below are any significant changes / additions since June 2008.*

### **A. Changes to the original agreed level of co-investment**

There have been no changes to the agreed to level of co-investment.

### **B. Promotional activities**

Presentation to representatives from IFRAMER, the French marine science agency, based in New Caledonia. They are interested in the development of monitoring systems for mining activity in New Caledonia.

Presentation on GBROOS to the Chinese SOA delegation looking at implementing a coastal and oceanic observing system for China.

### **C. Fostering collaborative development of infrastructure**

The work with the University of Queensland in Moreton Bay is to provide the infrastructure to support the development of underwater wireless communication technologies and a range of new sensor designs as part of the SEAMAT project. The Facility will provide the above water communications, data management and deployment expertise to support this work.

FAIMMS is working with NOAA to develop a proposal to measure light at two reef based reference stations along the Great Barrier Reef, this proposal will be submitted to IMOS.

#### **D. Scientific publications using IMOS data / participation in scientific seminars and conferences**

The following additional papers and conferences have been participated in:

Title: **GBROOS – An Ocean Observing System for the Great Barrier Reef**  
Authors: Scott Bainbridge  
Presented: International Coral Reef Symposium, Fort Lauderdale, Florida, July 2008.  
Audience: Conference attendees, International coral reef community

Title: **Sensor Networks on the Great Barrier Reef – managing marine sensor data**  
Authors: Scott Bainbridge, Gavin Feather and Damien Eggeling.  
Published: Proceedings of the Environmental Information Management Conference 2008. Pages 19-25, University of New Mexico, 2008.  
Presented: Environmental Information Management Conference, New Mexico, September 2008.  
Presenter: Scott Bainbridge  
Audience: Conference attendees, International environmental data managers

## MILESTONES

Below are:

- the Milestones transferred from 2007/08 to 2008/09 (as reported in the 2007/08 Annual Progress Report)
- the 2008/09 Milestones, as provided for the 2008/09 Annual Business Plan
- The post July 2009 planned activities, as provided for the 2008/09 Annual Business Plan

**MILESTONES TRANSFERRED FROM 2007/08 to 2008/09 (being those Milestones from the 2007/08 Annual Progress Report, recorded as either ‘In Progress’, or ‘Transfer to 2008/09’)**

<b>Party(s)</b>	<b><i>Due / Status</i></b>	<b><i>Milestone / Achievements / [Comments]</i></b>	<b>Update / Potential Barriers to Achievement</b>
9.5 AIMS	<i>Nov07</i> In progress	<b><i>Survey field sites to finalise deployment designs</i></b> Site surveys have been done at Heron and One-Tree Islands and at Davies and Rib Reefs. The remaining sites include Orpheus Island which is scheduled for October 2008, Myrmidon Reef (August 2008) and Lizard Island (mid 2009). <i>[Lack of time has delayed some sites and it is hoped that these will be picked up early in the 2008/09 year.]</i>	The Myrmidon Reef site visit has been completed but the Orpheus Island site visit has been moved to early 2009 due to staff commitments.
9.6 AIMS	<i>Oct07</i> In progress	<b><i>Install communications links at 2-3 sites</i></b> Links are operational at one site (Davies Reef) with those at Heron and One-Tree Islands due to be installed in mid July 2008. <i>[Site visits have tested the communications designs and it was decided to install the links with the sensor deployments which in turn have been delayed by one month due to supplier issues.]</i>	The links on Heron and One Tree Island are operational and data is coming back through them.  The link on Davies Reef is also operational and currently is supporting an on-reef weather station.

<b>Party(s)</b>	<b><u>Due / Status</u></b>	<b><u>Milestone / Achievements / [Comments]</u></b>	<b><u>Update / Potential Barriers to Achievement</u></b>
9.7 AIMS	<b>May08</b> Transfer 08/09	<b><i>Deploy sensors at 1-2 sites depending on timing</i></b> Delays in equipment arriving and logistical issues have delayed the planned deployments at Heron and One-Tree Islands from late May to mid July. <i>[These issues have been resolved and the equipment is currently being delivered to the research stations for the July deployments. The delay has pushed back the other deployments with Davies Reef now scheduled for September 2008 and Rib Reef soon after.]</i>	The initial deployments have been completed at Heron and One Tree Islands with the infrastructure in place. Additional instruments will be added in early 2009 to bring these two sites up to their full compliment of instruments.  The Davies Reef deployments have been started and these will be rolled out between the larger deployments as sea-time permits.
9.8 AIMS	<b>Sep07</b> Transfer to 08/09	<b><i>Establish standards for data exchange and integration with the eMII project</i></b> A number of data management components initiated including data schemas, data management systems, software and data outputs but these have not been done in the context of eMII due to the late start to the eMII facility. <i>[The delay in the eMII project being operational has resulted in the delay of the development of standards for data exchange and integration with eMII.]</i>	The project is moving forward in developing and deploying its own data management systems as there has still been no obvious progress from the eMII project.  Currently metadata records are available for each of the data streams and the data is available via XML services and via the Data Turbine middle ware.  It is hoped that more interaction with the eMII project will occur once the project is fully staffed and operational.
9.10 AIMS	<b>Jun08</b> Transfer to 08/09	<b><i>Deposit data (at least one site) with eMII by Jul08</i></b> Due to the late start to the eMII project there is no current capacity for eMII to deal with streaming sensor data and so this milestone has been delayed. <i>[Metadata from the facility will be lodged with the MEST software when this becomes operational.]</i>	Again the lack of progress with eMII has not allowed any data streams to be lodged with eMII. Metadata records have been created for all of the current data streams and these will be made available to eMII for quality control and harvesting into their central system.

<b>Party(s)</b>	<b><u>Due / Status</u></b>	<b><u>Milestone / Achievements / [Comments]</u></b>	<b><u>Update / Potential Barriers to Achievement</u></b>
9.11 AIMS	<b>Oct08</b> In progress	<b><i>Develop website and settle hosting arrangements</i></b> The FAIMMS IMOS hosted web site has been developed and is operational, as well as this the facility has set up a dedicated data web site that is also operational. <i>[The work that has been done has raised a number of issues that are with IMOS for clarification and these have stopped progress on this milestone for the moment.]</i>	The issue of web sites and hosting arrangements have been brought up but not fully resolved. This is a potential barrier as FAIMMS has a number of participants and funding agencies and needs to recognise these in any web sites and data products.
9.13 AIMS	<b>Dec07</b> In progress	<b><i>Gain recognition from CREON and ILTER</i></b> A joint project proposal is under development between the Moorea ILTER site and the FAIMMS facility to look at the deployment of a number of near-identical stations around the world and to work on issues of data management as well as the exchange of technical expertise. <i>[The FAIMMS work will be presented at a CREON meeting in early July which will include the main representatives from the ILTER project.]</i>	The FAIMMS work was presented at the June CREON meeting in Florida and it was decided that it will be possible to deploy equivalent installations at three or more sites and to present the data from these sites as an integrated data product. A proposal has been developed to take this further and a meeting is planned for December 2008 to progress this.

**2008/09 MILESTONES (as provided in the 2008/09 Annual Business Plan)**

<b>Party(s)</b>	<b>Due</b>	<b>Milestone</b>	<b><u>Update / Potential Barriers to Achievement</u></b>
AIMS	Mar09	Wireless sensor network operating at all GBR Locations	Three sites are operational and by mid 2009 all except one site will be operational with Lizard Island to come on line in late 2009.
AIMS	Dec08	Data management jointly developed with eMII	The late start with eMII has delayed this and while the eMII project now has some staff there has been no real ability for eMII to work with FAIMMS to develop data management components. FAIMMS is waiting for eMII to develop implementation plans against which the Facility can plan any development activities.

**POST JULY 2009 PLANNED ACTIVITIES (for the period July 2009 to June 2011, as listed in the 2008/09 Annual Business Plan)**

<b>Party(s)</b>	<b>Start</b>	<b>Finish</b>	<b>Activity</b>	<b>Update / Potential Barriers to Achievement</b>
AIMS	Apr 09	Sept 09	Second generation data management systems	On track, will still rely on eMII being up to speed and able to accept the data.
AIMS	Sept 09	Oct 09	Maintenance of Equipment	On track, no issues
AIMS/Others	Mar 10	Apr 10	Roll out of second generation sensor at Heron Island	At this stage still on-track but this depends on a number of agencies outside of AIMS and the results of their work so there may be barriers if their work is not successful or delayed.
AIMS	Mar 10	Apr 2010	Maintenance of Equipment	On track, no issues
AIMS	Sept 10	Oct 10	Maintenance of Equipment	On track, no issues
AIMS	Mar 11	Apr 11	Maintenance of Equipment	On track, no issues

# INTEGRATED MARINE OBSERVING SYSTEM (IMOS)

## IMOS FACILITIES Information for the IMOS 2009 Review

**Name of Facility:** electronic Marine Information Infrastructure (eMII)

**Facility Leader:** Dr Roger Proctor, Ph: 03 6226 1977, Email [roger.proctor@utas.edu.au](mailto:roger.proctor@utas.edu.au)

### 1. Quality of implementation so far, and soundness of forward plan

Nothing additional to report

### 2. Consistency with principles

- ***Service*** - IMOS is a national system and will provide a data-service that broadly supports marine research to maximise the contributions of R&D to economic development, national security, social wellbeing and environmental sustainability.
- ***Data streams*** - IMOS data will be delivered freely, openly, in a timely manner, preferably in near real time. Success will be measured in terms of the quality and quantity of data that IMOS delivers, the number of users and the quality of research-results produced with IMOS data.
- ***Integration*** - IMOS will deploy a nationally coordinated, multi-platform system to take advantage of the synergies between instruments, and to provide a comprehensive description of the ocean, as a contribution to national and international programs.
- ***Sustainability*** - The real value of IMOS will only emerge if systematic, repeated data collection continues for a long time to see the full range of climate variation and change. Sustained streams of data are integrally related to conservation and sustainable development of the marine environment.

Nothing additional to report

### 3. Relevance to the IMOS science-goal

- **Streams of data that support research on the role of the oceans in the climate system and the impact of major boundary currents on shelf-ecosystems**

Nothing additional to report

### 4. Contribution to national capability building

Nothing additional to report

### 5. Demonstrated user community / meeting researcher needs

Nothing additional to report

## OTHER INFORMATION

*The Review Panel will have access to the detail provided in the 2006/07 and 2007/08 Annual Progress Reports – available at <http://imos.org.au/reports0.html>. Detailed below are any significant changes / additions since June 2008.*

### **A. Changes to the original agreed level of co-investment**

Nil

### **B. Promotional activities**

- UTAS ICT Committee, July 2008. eMII talk – R Proctor. Promoting e-research at UTAS.
- SOOP poster at the UK FerryBox workshop, NOC, Southampton, September 2008
- IMOS/eMII exhibition at e-Research'08, Melbourne, October 2008
- iVEC, WAMSI, WASTAC Data management workshop, Perth, October 2008

### **C. Fostering collaborative development of infrastructure**

- IMOS/CSIRO/GA 2-day workshop on data management infrastructure, Hadley's Hotel, Hobart, July 2008
- NSW-IMOS day, SIMS, Sydney, August 2008. eMII talk – R Proctor
- CSIRO Data Management Review, CMAR, August 2008
- Preliminary formation of Australian MEST Development Group, September 2008
- At the AODCJF Board meeting in August 2008 the decision was taken, following a report from the Oceans Portal Working Group, to terminate ongoing development of the Oceans Portal. It was also decided that the GeoNetwork MEST (the BlueNet/eMII Metadata Entry and Search Tool) was a better Catalogue tool than presently under development in AODCJF. Consequently it was decided that the AODCJF should adopt the IMOS/eMII GeoNetwork MEST as the data management infrastructure for AODN and that a new Portal Working Group should be established to provide the 'window' to the MEST. The eMII Implementation Plan would provide the roadmap for future co-investment by AODCJF.
- JCU/AIMS data management visit, August 2008. (R Magierewski, K Tattersall, E Strain) eMII/metadata talk – R Magierewski
- SA-IMOS data management visit, September 2008, SARDI. (R Proctor, R Magierewski, K Tattersall, E Strain, S Mancini). IMOS/eMII talk – R Proctor, MEST/metadata talk – R Magierewski.
- WA-IMOS Data Management visit, October 2008. iVEC, Curtin, CSIRO-Floreat, UWA-SESE, WAMSI (E Strain, S Mancini, R Proctor, K Tattersall).

### **D. Scientific publications using IMOS data / participation in scientific seminars and conferences**

- AMSA Conference, July 2008, Christchurch, NZ. IMOS/eMII talk – R Proctor
- EuroGOOS AGM, October 2008, Galway, Ireland. IMOS/eMII talk – R Proctor
- NOOS AGM, October 2008, Brest, France. IMOS/eMII talk – R Proctor
- WAMSI 2<sup>nd</sup> Marine Data Management Seminar: "One year on... Marine data management in Western Australia", WAMSI, Perth, October 2008. Presentation: National and international data management developments – R Proctor

## MILESTONES

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**MILESTONES TRANSFERRED FROM 2007/08 to 2008/09 (being those Milestones from the 2007/08 Annual Progress Report, recorded as either ‘In Progress’, or ‘Transfer to 2008/09’)**

<b>Party(s)</b>	<b><i>Due / Status</i></b>	<b><i>Milestone / Achievements / [Comments]</i></b>	<b><i>Update / Potential Barriers to Achievement</i></b>
10.1 UTAS	<i>Jul07</i> In progress	<p><i>Establishment of eMII Office and employ staff</i> Recruitment effort to fill positions has been extensive. By 30 June 2008, eMII has 6 staff working on the project (all part-time), with the eMII Project Director to commence (fulltime) on 1/7, and the Executive Officer to commence on 15/9.</p> <p><b>June 2008 - Oct</b>  <b>By 31<sup>st</sup> October 2008 eMII will have a full-time Director (commenced 1/7), a part-time (25%) Assistant Director, an Executive Officer (commenced 15/9), a part-time (60%) admin assistant, a part-time (50%) systems architect (on secondment from CSIRO), a full-time data programmer, a full-time systems programmer (commenced 15/9), a full-time web portal developer (on secondment from CSIRO), 2 part-time (80%) and 1 full-time (commenced August) project officers. Thus the eMII Office consists of 8.95 FTE out of a full complement of 13.5 (as per funding agreement). Recruiting still on-going.</b></p>	<p>In addition to the Systems Architect appointment, BlueNet Project Office staff have been seconded part-time to eMII activities. Additionally, new appointments have been made for 5 staff to commence in August/September. In May, the Systems Architect resigned, to take up a permanent position elsewhere, with part-time secondment back to eMII for a further 6 months. Current Office status is: Full-time Director, part-time Assistant Director, part-time Outreach Officer, 80% Administration Assistant, Executive Officer due to start September, part-time Systems Architect (on secondment), one programmer and one expected to start in September.</p> <p><b>June 2008 – Oct</b>  <b>The Outreach Officer (R Magierewski) resigned on 15<sup>th</sup> October to take up a post-doctoral research position in the University. This is especially unfortunate as Dr Magierewski was the main eMII specialist in metadata. Steps were taken prior to departure to transfer metadata skills. The contract for the part-time secondment of the systems architect ends on 31 October 2008, continued association yet to be negotiated but expected through the MEST development group.</b></p>

<b>Party(s)</b>	<b><i>Due / Status</i></b>	<b><i>Milestone / Achievements / [Comments]</i></b>	<b>Update / Potential Barriers to Achievement</b>
<p>10.2 UTAS</p>	<p><i>Oct07</i> In progress</p>	<p><i>Employment of other eMII staff members associated with particular data streams</i> Staff working in the Project Office have been working with particular data streams. 2 Project Officers commenced in April. <b>June 2008 - Oct</b> A 3<sup>rd</sup> project officer started full-time in August. The Data Programmer has produced a data management system for the AATAMS data stream.</p>	<p>The two project officers have commenced a detailed analysis of all data streams and a full inventory of methods, equipment and current data delivery status. A third will start in August. <b>June 2008 - Oct</b> All three project officers have been actively engaged in developing the data formats. They have also been working on the links between data streams (SOOP, ARGO, ACORN, AUV, ANMN, SOTS, AATAMS) and the metadata records so that the metadata conforms to ISO 19115/19139 and can be extracted from the datastreams automatically. The Systems Programmer has been looking at methods for the automatic retrieval of data streams from FTP sites and DACs. The Data Programmer has produced a data management system for the AATAMS data stream, which allows the automatic processing of the data. The system consists of a Microsoft Access relational database to assist with field collection of the 'metadata' stream; a browser based data search and retrieval client; a Web Feature Service (WFS) server product called 'deegree' (version 2.1) and an Oracle RDBMS, with spatial enablement to allow spatial searches via deegree.  As a result of the Moorings Data Management guidelines (see 10.3) a proposal is under consideration to employ an eMII-funded data scientist within the Moorings Group (based at CMAR).</p>

<b>Party(s)</b>	<b><i>Due / Status</i></b>	<b><i>Milestone / Achievements / [Comments]</i></b>	<b>Update / Potential Barriers to Achievement</b>
10.3 UTAS	<i>Dec07</i> In Progress	<b><i>Identification, documentation and communication of Data Management guidelines</i></b> Have identified, arranged and communicated a short-term data upload, describe, store and deliver workflow. Data management guidelines for data providers have been developed in draft form. Data management guidelines for data hosts have been developed in draft form and circulated to AODCJF Data standards being formulated.	Considerable effort has been directed towards identifying current practice across communities (in collection, description, processing, versioning, naming, and formats available). Have advised Facilities that this is iterative process, and initial focus is to acquire, store, describe deliver using current practice – where this exists. For new data streams - have engaged with Facilities to identify dataflow and most practicable option for short-term solution. <b>June 2008 – Oct</b> <b>A report on Data Management guidelines for the Moorings Data has been produced by the Moorings Facility with assistance from eMII. This defines the data formats as well as management practice.</b>
10.4 UTAS	<i>Dec07</i> In Progress	<b><i>Refinement of the MEST (metadata entry and search tool)</i></b> Improved functionality of the MEST has been implemented to allow more flexible search options, upload and download of datasets. Some visual/graphical tools have been developed to display search results because of the Oceans Portal delays (see below). <b>June 2008 - Oct</b> <b>Following the AODCJF Board decision to adopt the MEST for the AODN, a Portal Working Group has been established to evaluate the current options for portal design and interface to the MEST.</b>	The MEST is still under development. Staff issues have impacted on deliverables. Some data streams are approaching ‘well-defined’, some have yet to start. Efforts are now in place to establish a robust MEST through collaborative activity. Issues with the Oceans Portal have resulted in MEST development of web services to deliver results of MEST search and discovery. <b>June 2008 - Oct</b> <b>The different versions of the MEST were consolidated by the systems architect in October 2008. A rigorous error reporting mechanism has been developed by the systems programmer. Future development of the MEST will continue (via the MEST development group) but updates will occur infrequently and at well defined points. Further work continues on linking the MEST with the metadata records.</b>

<b>Party(s)</b>	<b><i>Due / Status</i></b>	<b><i>Milestone / Achievements / [Comments]</i></b>	<b>Update / Potential Barriers to Achievement</b>
10.5 UTAS	<i>Jul07</i> In Progress	<p><b><i>Basic level deployment and integration of the IMOS data outputs into the Marine Catalogue and the Oceans Portal</i></b></p> <p>Due to Ocean Portal issue, the BlueNet “Central MEST” is deemed the point of centralised delivery.</p> <p>eMII has not yet been advised of any IMOS data being delivered by data-hosts as WMS or WFS; however, eMII has taken AATAMS data as a use-case – and is in the process of delivering AATAMS data as WFS.</p>	<p>Oceans Portal has not been delivered as an infrastructure platform, has been reviewed, and part of the frontend software is now under revision, with a view to retaining the Marine Catalogue component, and discarding the Oceans Portal software frontend.</p> <p>For expediency, eMII has asked data hosts to advise eMII once data is available so the MEST can be a delivery point for WMS or WFS delivery options. Until the Oceans Portal is available, the MEST is the sole integrating point, resulting in eMII staff effort being deployed in this area.</p> <p><b>June 2008 - Oct</b></p> <p><b>At the AODCJF Board meeting in August 2008 the decision was taken, following a report from the Oceans Portal Working Group, to terminate ongoing development of the Oceans Portal. It was also decided that the GeoNetwork MEST (the BlueNet/eMII Metadata Entry and Search Tool) was a better Catalogue tool than presently under development in AODCJF. Consequently it was decided that the AODCJF should adopt the BlueNet/eMII GeoNetwork MEST as the data management infrastructure for AODN and that a new Portal Working Group should be established to provide the ‘window’ to the MEST. The eMII Implementation Plan would provide the roadmap for future co-investment by AODCJF.</b></p> <p><b>See above (10.2) for progress on the AATAMS data management system.</b></p>
10.6 UTAS	<i>Aug07</i> Transfer 08/09	<b><i>Develop agreements to underpin management of archiving data by members of AODC-JF</i></b>	Draft agreements have been circulated within AODCJF - eMII awaits feedback.

<b>Party(s)</b>	<b><i>Due / Status</i></b>	<b><i>Milestone / Achievements / [Comments]</i></b>	<b>Update / Potential Barriers to Achievement</b>
10.7 UTAS	<b><i>Dec07</i></b> Transfer to 2008/09	<b><i>Successful archiving and recovery of initial data from Investment Areas Areas 1, 3, 4, 6, 7, 8, and 11</i></b>	<p>Argo - Links being created  SOOP - Procedures for uploading the near real-time SOOP data are in development  SOTS - No data yet collected  ANFOG - Test data set received  AUV - Procedures for uploading the large image datasets are in development  Moorings (ANMN)- No data yet collected but imminent  Radar (ACORN) - Initial dataset obtained and archived  AATAMS - Initial dataset obtained and archived  FAIMMS - No data yet collected  Remote Sensing - Links being created</p> <p><b>June 2008 - Oct</b>  <b>SOOP – SST and air/sea flux data now available from BoM in near-real time</b>  <b>SOOP – Data from the Spirit of Tasmania</b>  <b>SOTS – sample data set received (only engineering data)</b>  <b>ANFOG – first deployment data received, process for routine retrieval (via OpenDap) in discussion.</b>  <b>AUV – first data received</b>  <b>ACORN – first deployment product dataset received, tools developed to display outputs</b>  <b>FAIMMS - data collected but not available yet (remote data upload technical problems)</b>  <b>ANMN- Maria Island NRS WQM data received</b>  <b>ANMN – Sydney water data (2-years) received</b>  <b>SOOP – XBT data is available</b>  <b>SOOP – CO2 sample data received</b>  <b>SOOP – CPR sample data received</b>  <b>SOOP – Sensors on Tropical Research Vessels sample data received</b>  <b>AATAMS – Data from deployments Dec 07 – August 08 has been uploaded and available via the MEST and query interface</b></p>

**2008/09 MILESTONES (as provided in the 2008/09 Annual Business Plan)**

<b>Party(s)</b>	<b>Due</b>	<b>Milestone</b>	<b>Update / Potential Barriers to Achievement</b>
10.1 UTAS	May09	All IMOS data streams including SRS data are reliably discoverable and available in a timely manner, dataflow processes fully communicated, and monitoring established to address blockages	June 2008 - Oct This is still in progress, due partly to staffing issues and partly to data availability. SRS data portal is in final stages of testing, when finalised the link to eMII will be made.
10.2 UTAS	Sep08	Finalise recruitment of staff	June 2008 - Oct Set back due to the resignation of the Outreach Officer. An additional programmer starts on 5 <sup>th</sup> November.
10.3 UTAS	Jul08	Prepare work-plan and initiate NeAT project	June 2008 - Oct NeAT project MACCDAP started in September 2008. A 2-year position has been advertised. First project meeting arranged for early November.

**POST JULY 2009 PLANNED ACTIVITIES (for the period July 2009 to June 2011, as listed in the 2008/09 Annual Business Plan)**

Party(s)	Start	Finish	Activity	Update / Potential Barriers to Achievement
UTAS	Jul09	Jan10	Facilitation of successful archiving and recovery of data from Investment Areas. <ul style="list-style-type: none"> <li>▪ <u>Phase2 (versions of data, and changes in stakeholder capacity)</u></li> </ul> <p><i>Longterm overarching solution not yet finalised, and will continue into 2009 (to provide a streamlined solution for versioning, etc.).</i></p>	
UTAS	Jul08	Jul09	<b>SUMMARY MEST activities for completion by Jul09:</b> Some highlights include: Improved User-Interface; Automation of metadata creation and update where feasible; Further integration of lookup tables and links to tools; Improved logging of data use (improve this for the range of emerging use-cases: technical, design); Establish harvesting regimes; Incorporation of machine-to-machine automated transfer processes.	
UTAS	Feb08	Dec09	Refinement of the MEST and related infrastructure -designed and streamlined for each IMOS datastream.	
UTAS	Oct07	Dec10	Deployment of and integration of the IMOS data outputs into the Marine Catalogue and the Oceans Portal, and the MEST.	
UTAS	Jan07	Jan10	Legal – IP Issues	
UTAS	Jul08	Jun10	<ul style="list-style-type: none"> <li>• Development/improvement of sample records, in the MEST <ul style="list-style-type: none"> <li>▪ Expand range of sample records to cover needs; and iteratively improve content/model;</li> </ul> </li> </ul>	

UTAS	Mar07	Jun11	Needs analysis: (including group and individual surveying, liaising, via workshops, discussion-lists, meetings, etc), and iterative response	
UTAS	Sep08  Ongoing  Oct07 Oct08	Jun11 Jul09	<u>Tool and interface (web-tool) development; and integration</u> of data, tools and products with the AODN infrastructure, and with other access-points and systems, as appropriate <ul style="list-style-type: none"> <li>• Authentication and access</li> <li>• Data integration and data product development <ul style="list-style-type: none"> <li>○ Product- planning and development</li> <li>○ Initial product development (commenced by Oct.2008)</li> </ul> </li> </ul>	June 2008 - Oct Initial product list for ACORN agreed. AATAMS Access tool for metadata entry provided and product demonstrator produced. Initial data products (via Matlab scripts) placing ACORN and SOTS outputs into a geospatial (Google earth) setting demonstrated.
UTAS	Jun07	Jun11	Monitor, QC, review adequacy of, and improve processes; Standards developed and adopted; Hosting practice and implementation; Dataflow; Versioning; Discovery; Usage; as well as Support (tools, services and structures) provided by eMII.	

# INTEGRATED MARINE OBSERVING SYSTEM (IMOS)

## IMOS FACILITIES Information for the IMOS 2009 Review

**Name of Facility:** Satellite Remote Sensing

**Facility Leader:** Dr. Peter Turner – phone 03 6232 5094, email [peter.turner@csiro.au](mailto:peter.turner@csiro.au)

### Sub-facility Leaders and contact details:

No	Sub-facilities	Leader	Phone	Email
11a	Australian Satellite SST L2P Products	Helen Beggs	03 9669 4394	<a href="mailto:h.beggs@bom.gov.au">h.beggs@bom.gov.au</a>
11b	Australian Oceans DAAC (AO-DAAC)	Peter Turner	03 6232 5094	<a href="mailto:Peter.Turner@csiro.au">Peter.Turner@csiro.au</a>
11c	Hobart Ground Station Townsville X band upgrade	Stuart Barr Craig Steinberg	02 6249 9131 07 4753 4345	<a href="mailto:Stuart.Barr@ga.gov.au">Stuart.Barr@ga.gov.au</a> <a href="mailto:c.steinberg@aims.gov.au">c.steinberg@aims.gov.au</a>

### 1. Quality of implementation so far, and soundness of forward plan

Satellite Remote Sensing information is critical to the understanding and management of the Australian Marine environment. Satellite Remote Sensing is the only way to get the big picture of what is happening around our coasts and on the surface of our oceans.

The purpose of the Satellite Remote Sensing Facility is to provide easy and immediate access to a number of satellite derived marine data products with national spatial coverage both programmatically and through a simple web interface (Australian Oceans Distributed Active Archive Center, AO-DAAC). The underlying structures to support this goal include maintaining and expanding our national satellite receiving network and developing processing systems to supply standard products to which access is provided.

#### Current Status

- L3P SST data is available as 14 day composites but due to staff movement there is a delay in providing daily data in this format.
- The pilot (beta) AO-DAAC software has been deployed and provides access to a limited dataset (see <http://imos.org.au/srs.html> Satellite Remote Sensing Facility for link).
- Deployment of the reception system at AIMS although slightly delayed has gone according to plan, the system is operational, and data is being received.
- The upgrade of certain components at TERSS has gone according to plan with some delays. The installation of new motor controllers has been more problematic with more work required to reconfigure the antenna control system required. The antenna is still working and receiving data.
- All work has been done to conform to relevant standards and software has been written, rewritten and documented to allow proper future maintenance.

#### Forward Plan

- SST products will be improved for mesoscale and coral reef studies by producing an additional single day and single night, 0.01 degree resolution, composite AVHRR SST GHRSSST L3P product for IMOS.
- Incremental increases will be made in online data and capability for the AO-DAAC from now until June 2009.

- Installation of the AO-DAAC software on an ARCS server along with the use of ARCS for code management will be performed.
- Profiling of the AO-DAAC operation to improve performance is being undertaken.
- The AIMS antenna will continue to run operationally and supply data.
- Installation of the new synthesizer and motor controllers at TERSS will be carried out before June 2009.

### Future Needs

In the present funding round sub-facilities 11a and 11c received adequate funding to complete the tasks as specified. The AO-DAAC facility 11b was initially under funded. The IMOS AO-DAAC funding from 09/10 and 10/11 has been brought forward to allow enough momentum to be developed to deliver a result. Additional funds have been found from the National eResearch Architecture Taskforce (NeAT) to allow maximum effort in developing the AO-DAAC in 08/09. These NeAT funds continue through to 10/11. However, the NeAT funds do not cover travel expenses to promote the AO-DAAC, minor equipment requirements, and organisational efforts to make sure the system is properly managed. Additional top up funding from IMOS of the order of \$30K pa would be desirable to allow proper continued development of the AO-DAAC and support integration with eMII. Any additional funds that would help with the TERSS upgrade would also be valuable (see below)

In IMOS II, provision should be made to replace and upgrade storage facilities for the AO-DAAC and to do some software re-engineering to bring the system up to date. TERSS will need a further upgrade to allow data flow to continue and allow upgrade to receive data from new advanced satellite instruments. Funds will be required to bring new products online. As a rough estimate similar funding of the order of \$2 million over the IMOS II period should be considered to maintain and extend the Satellite Remote Sensing Capability.

## 2. Consistency with principles

- ***Service* - IMOS is a national system and will provide a data-service that broadly supports marine research to maximise the contributions of R&D to economic development, national security, social wellbeing and environmental sustainability.**

The AO-DAAC provides national access to a national sea surface temperature product and will be expanded to include a number of ocean colour products. The AO-DAAC packages the data the user wants in one file and delivers that data to the user in seconds of the request. Satellite sea surface temperature and “ocean colour” data provide a snap shot the state of all Australian waters which no other measurements can provide. Easy access to these datasets via a number of interface layers meets the service requirement for a wide variety of groups, and agencies. The Bureau has received feedback from users of the IMOS data product (ReefTemp, GBRMPA and UWA) on the types of satellite SST products they need. Future IMOS products will be designed to satisfy these requirements.

- ***Data streams* - IMOS data will be delivered freely, openly, in a timely manner, preferably in near real time. Success will be measured in terms of the quality and quantity of data that IMOS delivers, the number of users and the quality of research-results produced with IMOS data.**

The AO-DAAC system is only just online as a pilot (beta) version and it will take some months to build the number of data sets available and generate usage statistics. In addition a range of MODIS derived ocean colour products will be made available using the AO-DAAC.

The high-resolution AVHRR L3P SST data will be made available via AO-DAAC and internationally via the GHRSSST archive at NASA JPL PO.DAAC and NODC in the U.S. Metadata will be held by eMII.

- **Integration - IMOS will deploy a nationally coordinated, multi-platform system to take advantage of the synergies between instruments, and to provide a comprehensive description of the ocean, as a contribution to national and international programs.**

The AO-DAAC data streams are derived from a national network of satellite receiving stations as well as internet data feeds from the USA and Europe.

The AO-DAAC has a layered interface based on international standards allowing eMII to access data in a number of ways. eMII is charged with integrating the satellite data with other data systems and the AO-DAAC team will work with eMII to ensure this happens..

- **Sustainability - The real value of IMOS will only emerge if systematic, repeated data collection continues for a long time to see the full range of climate variation and change. Sustained streams of data are integrally related to conservation and sustainable development of the marine environment.**

The Satellite Remote Sensing Facility will provide access to current and time series data for a range of marine data products derived from satellite measurements. SST time series data will start in the early 1990s and ocean colour data will be available from 2000 onwards.

### **3. Relevance to the IMOS science-goal**

- **Streams of data that support research on the role of the oceans in the climate system and the impact of major boundary currents on shelf-ecosystems**

Satellite derived sea surface temperature and ocean colour products are critical to the understanding of the large scale behaviour of the ocean. These data are used to initialise and validate ocean circulation models. Measurements of algal blooms can be used to determine the productivity of the ocean and estimate the likely effect on more sophisticated organisms. Satellite measurements provide the context for many of the point measurements made by other data collection facilities.

### **4. Contribution to national capability building**

The Satellite Remote Sensing Facility has encouraged the idea and implementation of a national satellite data receiving network for environmental data. A national sea surface temperature product has been established and a national system for access to the data is nearly complete (presently in beta). The data access technology has been designed for reuse and the components maybe adapted for other data access applications.

### **5. Demonstrated user community / meeting researcher needs**

The Bureau of Meteorology, BLUElink Ocean Forecasting Australia Project, ReefTemp Project and University of WA's Transient Coastal Upwelling Along Ningaloo Reef Project all ready or are planning to use the IMOS satellite SST products in research and operational systems. The products will also be supplied to the International Group for High Resolution Sea Surface Temperature (GHRSSST) for use in their research projects and global distribution.

The AO-DAAC is not yet fully functional and although some promotion has occurred through conference presentations the impact of data from this system has not been felt by the marine research community.

## OTHER INFORMATION

The Review Panel will have access to the detail provided in the 2006/07 and 2007/08 Annual Progress Reports – available at <http://imos.org.au/reports0.html>. Detailed below are any significant changes / additions since June 2008.

### A. Changes to the original agreed level of co-investment

The level of co-investment is higher than anticipated with considerable resources being contributed to get MODIS data products processed and online by iVEC and Curtin University in Western Australia. Investment from NeAT of \$70K pa for 2008/2011 has increased direct investment in the AO-DAAC technology.

### B. Promotional activities

There have been a number of talks given on the AO-DAAC including most recently one at eResearch in Melbourne (September 2008) and a poster presentation at the 14 Australian Remote Sensing and Photogrammetry conference in Darwin (September 2008).

### C. Fostering collaborative development of infrastructure

The Satellite Remote Sensing Facility encompasses a large number of groups collaborating on a national basis. The Bureau of Meteorology, CSIRO, GeoScience Australia, AIMS, Curtin University and the University of Tasmania are all working together to deliver a data stream to the Australian Marine community.

The AO-DAAC team is also now working with ARCS and ANDS to deploy the system nationally.

The Bureau of Meteorology is also collaborating with NOAA to improve the processing of polar orbiting and geostationary satellite derived SST.

### D. Scientific publications using IMOS data / participation in scientific seminars and conferences

Data from the AO-DAAC is only just starting to become available and so there are no papers reflecting the use of the data. However, there are a few conference presentations and a thesis which have been produced:

King, E.A., P.P.Y.Mak, P.J.Turner *et al*, 2008, **Distributed Gridded Data Delivery for Marine Research**, eResearch, Melbourne September 2008 reviewed conference paper.

King, E.A., P.P.Y.Mak, P.J.Turner *et al*, 2008, **Distributed Gridded Data Delivery for Marine Research**, 14<sup>th</sup> Australian Remote Sensing and Photogrammetry Conference, Darwin, September 2008 poster presentation.

Beggs, Helen, 2008, Diurnal Variation of Sea Surface Temperature over the Western Pacific Tropical Warm Pool, Western Pacific Geophysics Meeting, Cairns, 29 July to 1 August 2008

Jackett, Chris, 2008, Spatio-Temporal Database Search Algorithms for Rapid Access to Satellite Images and Derived Products, University of Tasmania Honours Thesis, November 2008

## MILESTONES

Below are:

- the Milestones transferred from 2007/08 to 2008/09 (as reported in the 2007/08 Annual Progress Report)
- the 2008/09 Milestones, as provided for the 2008/09 Annual Business Plan
- The post July 2009 planned activities, as provided for the 2008/09 Annual Business Plan

Please review, and amend the tables as necessary for any changes, and note any potential barriers to achievement.

**MILESTONES TRANSFERRED FROM 2007/08 to 2008/09 (being those Milestones from the 2007/08 Annual Progress Report, recorded as either ‘In Progress’, or ‘Transfer to 2008/09’)**

<b>Party(s)</b>	<b><u>Due / Status</u></b>	<b><u>Milestone / Achievements / [Comments]</u></b>	<b><u>Update / Potential Barriers to Achievement</u></b>
11.4 BOM CSIRO	<b><i>Jun08</i></b>  Transfer to 08/09	<b><i>Report on operational test of the distributed archive and access system at Bureau</i></b>  The deployment of the pilot AO- DAAC has been delayed by approximately 2 months. The AO- DAAC software has been completed to a stage where it works and can be deployed once the hardware is properly configured. <i>[We anticipate getting the pilot system running in the next few weeks.]</i>	The AO-DAAC beta pilot has been deployed. There have been some further delays in getting the main Melbourne and Canberra file servers operational. The fileservers are waiting a final IP address change before data can start the flow of onto them.
11.5 AIMS GA	<b><i>Jun08</i></b>  In progress	<b><i>Report on the impact of ground-station upgrades</i></b>  TERSS – The new demodulator has been received and installed in conjunction with the new ingest system. The new servo system is partially installed. A replacement synthesizer and the dehumidifier have been received but are not yet installed. <i>[The synthesizer was shipped to the wrong address and was unavailable for installation when personnel were on-site. No difficulties are anticipated in its installation.]</i> AIMS (Townsville) - X band antenna installed and receiving data as planned. <i>[L-band reception to be implemented.]</i>	The initial attempt at installing the servo was unsuccessful due to difficulties with the original software performing loop control calculations. Resolution of how to incorporate two control loops is being investigated. The TERSS antenna is still operating on the old servo controllers and supplying data from the newly installed demodulator and computers.

**2008/09 MILESTONES (as provided in the 2008/09 Annual Business Plan)**

<b>Party(s)</b>	<b>Due</b>	<b>Milestone</b>	<b>Update / Potential Barriers to Achievement</b>
11.1 BOM	Jun09	Develop system to generate real-time regional skin SST AVHRR L2P files	
11.2 CSIRO	Jun09	AODAAC software and user interface enhancement and development of operational systems	A pilot system is presently running and the software development is on schedule. The system should be fully operational by June 2009
11.3 AIMS	Jun09	Produce near real-time data streams from the Townsville X band station	Achieved with an operational system supplying MODIS data.

**POST JULY 2009 PLANNED ACTIVITIES (for the period July 2009 to June 2011, as listed in the 2008/09 Annual Business Plan)**

<b>Party(s)</b>	<b>Start</b>	<b>Finish</b>	<b>Activity</b>	<b>Update / Potential Barriers to Achievement</b>
BOM	Jul09	Jun11	Ongoing supervision, data management, documentation and quality control.	
BOM	Jul09	Jun11	Reprocess archived AVHRR raw data from NOAA satellites to L2P SST	This process is yet to be undertaken
	Jul09	Jun10	Develop operational system to generate real-time regional skin AVHRR SST L2P files	
BOM	Jul09	Jun11	Operational management of the AO-DAAC	Waiting for the development team to hand over.
CSIRO	Jul09	Jun11	Enhancements to the AO-DAAC as funded through NeAT. IMOS funding was brought forward to complete the AO-DAAC by June 09	
Geoscience Australia	Jul09	Jun11	Continuing minor upgrades and management of the TERSS facility and supply of data.	Significant breakdown
AIMS	Jul09	Jun11	Management of the reception facility and data provision	Significant breakdown