IMOS Integrated Marine Observing System

Australian Bluewater Observing System

(ABOS)

Facility Project Plan

Overview:

Proposed Infrastructure Investment:	Extension , Enhancement, and Coordination of Bluewater moored observatory programs
IMOS Facility:	Australian Bluewater Observing System Facility, incorporating 3 sub-facilities: i) Southern Ocean Time Series (SOTS) sub-facility leader Tom Trull , UTAS/CMAR ii) Air-Sea Flux Stations sub-facility leader Eric Schulz, BOM iii) Deepwater Arrays (DA) sub-facility leader Bernadette Sloyan, CMAR
Operating Institution:	UTAS-CMAR-BOM
Facility Leader (for this Proposal):	Tom Trull CMAR-UTAS 03 6226 2988, 03 5232 5069, 0447 795 735, Tom.Trull@csiro.au, Tom.Trull@utas.edu.au
Other(s) key people involved:	Eric Schulz (BOM), Bernadette Sloyan (CMAR), Bronte Tilbrook (CMAR), Susan Wijfells (CMAR), Steve Rintoul (CMAR), Ken Ridgeway (CMAR), Mike McPhadden (PMEL)
Collaborating Institutions:	Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC), Pacific Marine Environmental Laboratory

Attachments:

1. **Operating and Collaborating Institution Support Letters**
   Tony Press, ACE CRC
   Michael Stoddart, UTAS
   Toni Moate, CMAR
   Sue Barrell, BOM

2. **Facility and Sub-facility Leader CVs**
   Tom Trull
   Eric Schulz
   Bernadette Sloyan

<u>Nature of Investment</u>:

The proposed Australian Bluewater Observing System Facility targets the coordination of national efforts in the sustained observation of open ocean properties to meet the needs of the Bluewater and Climate Node and various Coastal Node plans, with particular emphasis on observations important to climate and carbon cycle studies.

The Facility will consist of three sub-facilities

i) the Southern Ocean Time Series sub-facility (SOTS)
This is an extension of the NCRIS funded SOTS facility and is based on multiple moorings deployed in the Subantarctic Zone southwest of Tasmania. The emphasis is on inter-annual variations of upper ocean properties and their influence on exchange with the deep ocean. The program is highly interdisciplinary and includes physical, chemical, and biogeochemical observations. Resolution of high amplitude seasonal variations beyond those achievable from ship-based observations (e.g. via SOOP facility observations) is an important characteristic. SOTS also coordinates with other observations in this region, including glider missions provided via ANFOG, and SOOP facility observations.

ii) the Air-Sea Flux Stations sub-facility (ASFS)
This is an extension and enhancement of the NCRIS funded Southern Ocean Flux Station (SOFS) (previously a component of SOTS) into a larger sub-facility. Specifically, deployment of SOFSt at the SOTS site will be extended, and this effort will be enhanced by the additional deployment of the Timor Sea Flux Station (TSFS) mooring at a site in the Timor Sea. This work is important to climate, seasonal variability and weather science.

iii) the Deepwater Arrays sub-facility (DA)
This is a new sub-facility that targets observations of deep ocean currents and properties needed to monitor and understand the role of the ocean on climate and climate variability. The deepwater arrays will monitor ocean circulation and property variability in the ocean surrounding Australia and provide estimates of the ocean contribution to the regional and global circulation, heat and freshwater content and change. They will contribute to improved estimates of the regional and global sea level budget, improvements to the climate model simulations via direct comparison with observations, assimilation and development of improved model physics and parameterisations.

This sub-facility includes observational programs based on moored conductivity-temperature-depth sensors and current meter arrays in deep waters that are specifically targeted to monitor formation of Antarctic Bottom Water (AABW), interbasin exchange, major boundary currents, and the Southern Ocean global overturning circulation. The Deepwater array sites include :
a) the Adelie Land Coast deep shelf to observe outflows of newly forming Antarctic Bottom water – *the Polyna array.*
b) adjacent to the Kerguelen Plateau to monitor the deep western boundary current which is part of the deep limb of the global overturning circulation – *the Kerguelen array*
c) Timor Passage and Ombia Strait, to monitor the interbasin Indian-Pacific Ocean exchange and the upper limb of the global overturning circulation – *the Indonesian Throughflow (ITF) array*
d) east coast of Australia, near Brisbane, to monitor the East Australian Current transport – *the EAC array*
e) the southern entrance of the Perth Basin to monitor the deep ocean property fluxes of the global overturning circulation – *the Perth Basin Array .*

Implementation strategies for the sub-facilities and their components are described separately and sequentially below, and in the associated EIF budget spreadsheets, so that their objectives, deliverables, and costs are individually clear. But, in the operation of the Facility emphasis is on coordination for maximum research delivery and maximum economies of scale. For this reason, the sub-facility sections are followed by a single combined section on governance.

Implementation Strategy (SOTS):

The request for extension funding for SOTS emphasises continuation of the successful SAZ sediment trap mooring and developing Pulse biogeochemical mooring platforms. The Air-Sea Flux Station component of SOTS (known as SOFS for Southern Ocean Flux Station) will also continue but under the aegis of the ASFS sub-facility.

i) ***the SAZ deep ocean sediment trap mooring***
annual deployments to continue delivery of particulate carbon flux estimates and deep ocean sinking particle samples from the Subantarctic Zone. This platform has been the most successful of the SOTS moorings, and has had strong uptake leading to published work on paleo-oceanographic proxies, evaluation of ecosystem models, quantification of ocean carbon cycle processes, study of the impacts of ocean acidification on organisms, nutrient cycling and the role of the Subantarctic Zone in global carbon budgets, e.g. publications [1-14].

This platform is currently (2009/10) deployed with 3 classical conical sediment traps at ~1000, 2000, and 3800m depth, and a fourth innovative zooplankton excluding sediment trap at ~1000m depth. This platform is wholly sub-surface, serviced annually, and provides data and samples only on recovery. ***The EIF investment for this platform is on maintenance and operating costs***

ii) ***the Pulse surface mixed layer mooring***
to deliver upper ocean biogeochemical property measurements with full seasonal resolution to inform understanding of how upper ocean processes regulate biological carbon sequestration. The need for this missing seasonal information has been emphasized in modelling studies and budget calculations, e.g. publications [15-20].

This platform has been through 5 rounds of engineering development and successfully completed a 6 month test deployment for platform robustness in 2008/9. It is currently deployed with its full complement of scientific sensors (waves, currents, temperature, salinity, oxygen, total gas tension, phytoplankton fluorescence, particulate backscatter, photosynthetically active radiation) and a sampler for the collection of 24 pairs of weekly samples for dissolved inorganic carbon, alkalinity, nitrate, silicate, and phytoplankton identification measurements. It presently requires twice annual servicing and reports only wave data from the surface float in real-time mode, with the other data and samples that are collected within the surface mixed layer near 40m depth obtained only on recovery. ***The investment for this platform is on maintenance and operating (including sensor/sampler replacement scheduled for 2011/12) and implementation of acoustic modem communication of the subsurface observations to the surface float to allow real-time delivery via Iridium satellite telemetry.***

iii) ***the SOFS air-sea flux mooring***
to deliver:

a) heat and freshwater air-sea flux measurements for use in climate studies (this aspect is described in the Air-Sea Flux Observatory sub-facility documents under the leadership of Eric Shulz, BOM) and

b) biogeochemical measurements that either provide redundancy with the Pulse mooring (temperature, salinity, oxygen, phytoplankton fluorescence, particulate backscatter, PAR) or extend those measurements (pCO_2).

This platform is currently under construction by contract to the Woods Hole Oceanographic Institution for deployment in March or September 2010, and this includes addition of the sensors noted at iii-b. If the platform proves to be robust, and is also in later engineering evaluations determined to be able to carry the sub-surface Pulse instruments, then this platform will supersede the Pulse platform, with transfer of the Pulse instruments to that platform. ***Investment for extension of this platform is detailed in the Air-Sea Flux Observatory sub-facility section.***

iv)bio-optical and oxygen profilers
to quantify phytoplankton biomass and production. Development of the originally proposed tethered profiler has been superseded by advances in glider mission duration and cost reductions. But, the purchased profiling floats with O2 and bio-optical sensors will be deployed using shallow (300m) rapid profiling (4x per day) modes to estimate biomass and production, followed by the progression to use of gliders funded via ANFOG for missions at the SOTS site.

***v)* the application of ocean gliders**
to deliver physical (temperature, salinity) and biogeochemical (oxygen, phytoplankton fluorescence, particulate backscatter) measurements on transects to the SOTS site to provide:
i) spatial context for the larger set of biogeochemical observations obtained from the moored observations to allow assessment of their regional representivity.
ii) transects across the Tasman Outflow and Zeehan Current between Hobart and the SOTS site as a contribution to characterizing boundary currents that influence climate and marine ecosystems.
The gliders have been funded by an EIF award to the ANFOG facility, and no additional investment is requested here, although in-kind contributions of personnel and shiptime for their deployment are noted.

<u>List of major activities – including major party(s) involved, duration, start, finish</u>
1. Annual deployment/recovery of SAZ mooring in spring – to provide full annual samples and records of sedimenting particle fluxes with weekly resolution in spring/summer and monthly resolution in autumn winter.
2. Annual deployment of Pulse mooring in spring, with recovery in autumn in 2010/11 – to provide daily resolution of upper water column properties in spring/summer, progressing to full annual records (via redeployment in autumn annually) in 2012/13

<u>List of major equipment to be purchased / developed</u>
1. annual refurbishment of SAZ and Pulse mooring platforms
2. one-off replacement of Pulse instruments
3. one-off replacement of SAZ instruments
4. development of acoustic modem data transfer from subsurface instruments to enable movement from delayed mode (after mooring recovery) to real-time (via Iridium telemetry) data delivery
5. either continued use of profiler floats, or further support of glider missions depending on success of ANFOG supported glider missions

<u>List of deliverables (performance indicators)</u>
1. Continuing provision of annual updates to the ongoing time-series database of deep ocean particulate carbon flux values, as obtained by successful deployment of the SAZ sediment trap mooring.
2. Continuing provision of a core set of analyses of the SAZ sediment trap samples including total dry mass, particulate organic carbon (POC), particulate inorganic carbon (PIC), biogenic silica (BSi).
3. Continuing processing, curation, and availability for distribution of samples from the SAZ sediment trap mooring to support development of paleo-oceanographic proxies, evaluation of ecosystem models, quantification of ocean carbon cycle processes, study of the impacts of ocean acidification on organisms, etc.
4. Delivery of upper ocean biogeochemical property measurements with full seasonal resolution from the Pulse biogeochemical mooring, including T,S,O2, PAR, phytoplankton fluorescence, and particulate backscatter from sensors, and DIC, alkalinity, phosphate, and phytoplankton identification from water samples.

5. Delivery of upper ocean carbon system parameter measurements with full seasonal resolution from the ASFS mooring, including pCO2, O2, PAR, and phytoplankton fluorescence.
6. Delivery of wave height and period statistics from the Pulse surface float motion reference units, in delayed mode in 2009 and 2010, moving to real-time mode in 2011.

Implementation Strategy (ASFS):

Air-Sea Flux Stations (ASFS) at two sites: the Southern Ocean Flux Station (SOFS) at 47S, 140E, and; the Timor Sea Flux Station (TSFS) at 15S, 114E. The flux stations consist of a large surface float with instrument tower, tethered to the sea floor and measure marine meteorology to the standard required to obtain climate quality fluxes, as well as CO2, PAR, and sub-surface temperature, salinity and currents. SOFS also carries a number of bio-geo-chemical sensors and is strongly integrated with SOTS.

A CO2 sensor package will also be deployed on the Timor Sea Flux mooring. In contrast to the system on SOFS, provided by NOAA PMEL, the TSFS CO2 system will be provided by CMAR scientists. The system will provide information on the air-sea flux of CO2 in the region offshore of the NW shelf. The observations will cover a major gap in CO2 observations for the NE Indian Ocean, and will deliver information on the changes in carbonate chemistry (acidification) of source waters for the Australian NW region. These data will contribute to international efforts to determine the air-sea flux of CO2 (http://www.ioccp.org) and the network of CO2/flux moorings that are planned for deployment in other locations of the Indian Ocean. The sensors are robust and proven to work for up to 14 months on open ocean deployments, delivering data each day. The sensors will be maintained and data managed from CSIRO, Hobart, using experienced staff.

Summary of Platforms and Assocated Objectives
SOFS. The Southern Ocean Flux Station is primarily tasked with obtaining meteorological and carbon flux observations at the quality required to resolve climate scale variability. SOFS is being designed and constructed by Woods Hole Oceanographic Institution. SOFS consists of a large surface float carrying a tower with meteorological sensors. The mooring is a slack-line system consisting of chain, wire and rope, with acoustic releases. Subsurface instruments are concentrated in the upper 200m of the water column and are tasked with resolving the mixed layer depth and light attenuation profile. The surface float carries a number of bio-geo-chemical sensors in support of the SOTS science objectives. Meteorological observations will be telemetered daily or better frequency. The mooring has a large surface expression and is strongly influenced by the wind and wave conditions at the site. Therefore the design has been carefully and conservatively tuned by WHOI Institution for the conditions at the SOTS site via static and dynamic analysis with engineering safety factor of 4x the 12 month planned deployment time. The 1-year deployment is scheduled to commence in March 2010. ***NCRIS funding was for one mooring, and EIF funding is requested to enable the construction of a second near identical SOFS mooring – SOFS#2, to enable back-to-back deployments at the site. This will allow a continuous occupation and hence create an uninterrupted flux time-series at the site.***

Construction and payment of SOFS#2 will only commence once SOFS#1 has been deployed for a period of time and proved to be suitable for the conditions. If SOFS#1 deployment is not successful, then funds will be diverted to reengineer it rather than constructing SOFS#2.

TSFS. The Timor Sea Flux Station performs the same observational function as SOTS, but with no biogeochemical sensors. Main science drivers centre around understanding climate variability and predictability on the 3-month to intra seasonal time scales, as well as filling gaps in the CO2 flux network. The TSFS site is at a latitude of 15S in the East Indian Ocean where conditions are much calmer that the SOTS site. For this reason a more lightly engineered standard design PMEL “Flux Reference Station” provided by PMEL will be used.

List of major activities – including major party(s) involved, duration, start, finish
SOFS
Construction completion and delivery of SOFS#1 Febuary 2010 (WHOI)
Deployment of SOFS#1 March 2010 (If delivery is delayed then deployment will be delayed by ~6 months until the September SOTS cruise). WHOI, BOM, CMAR, UTAS
Establishment of real-time data feed, processing, QC and dissemination March 2010-March2011 BOM
Retrieval of SOFS#1 March 2011 BOM, CMAR, UTAS
Engineering evaluation of SOFS#1 and design modification for SOFS#2 March 2011- May 2011 CMAR BOM, WHOI
Construction of SOFS#2 May 2011- September 2012 WHOI
Refurbishment of SOFS#1 March 2011-September 2011 CMAR
Deployment of SOFS#1 September 2011 BOM, CMAR, UTAS
Retrieval of SOFS#1 & deployment of SOFS#2 September 2012 BOM, CMAR, UTAS
Refurbish SOFS#1 September 2012-Sept 2013 CMAR
Turnaround SOFS Sept 2013 BOM, CMAR, UTAS

TSFS
Purchase standard flux reference station (2 moorings) from PMEL July 2010-June 2011
Deploy TSFS in conjunction with BOM ATWS DART cruise early 2011
Turnaround TSFS ~ January 2012 via MNF vessel research cruise
TSFS#1 freighted back to PMEL for refurbishment, then back to BOM 2012
Turnaround TSFS in conjunction with BOM ATWS DART cruise early 2013
TSFS#2 freighted back to PMEL for refurbishment, then back to BOM 2013

List of major equipment to be purchased / developed
SOFS#2 will be designed and fabricated by WHOI. Design will build on SOFS#1 performance. SOFS observing instruments are tstandard, robust and field proven systems used by WHOI and have operated unattended for 12-month periods over multi-year occupations at a number of locations.

TSFS – two identical moorings complete with meteorological and physical oceanographic sensor systems will be purchased from PMLE. These systems are the standard PMEL Atlas buoy design which are well proven in the tropical environment.

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List of deliverables (performance indicators)
Continuous real-time observation data stream, delivered daily to EMII and international partners for surface meteorology and CO2 (SOFS and TSFS), and coarse resolution subsurface physical oceanography (TSFS).
Delayed mode delivery (post cruise) of QC's high-esolution data, including sub-surface SOFS observations.

<u>Implementation Strategy (DA):</u>

The request for a new Deepwater Arrays (DA) sub-facility addressed the lack of Bluewater ocean current and property monitoring sites in the current IMOS. Deepwater arrays will remain in the water for a period 18 month to 2 year per deployment, apart from the Polyna array that will be recovered and redeployed every 12 months. The work plan schedule is to build, deploy and recover a mooring array each year. We will stagger the initial build and deployment plan to enable the sub-facility to be fully functioning within three years.

i) Polyna Array

This mooring array will measure the export of dense Antarctic Bottom Water from the Adélie Land coast. Sinking of dense water near Antarctica supplies the deep branch of the global overturning circulation, a pattern of ocean currents that strongly influences climate. Several studies have recently shown that the properties of the bottom water in the Australian Antarctic Basin are changing. Aoki et al. (2005) showed that the bottom water at 140E had freshened between the 1970s and 2003. Rintoul (2007) demonstrated that rapid freshening of AABW was observed both up- and down-stream of 140E, resulting in a basin-wide shift of the deep potential temperature – salinity (T – S) relationship. Both the Adélie Land and Ross Sea sources of bottom water were observed to have freshened during this period. Jacobs (2004, 2006) also discussed changes in AABW between the Ross Sea and 140°E. Monitoring the temperature, salinity and oxygen of bottom water will provide observations to detect how the Southern Ocean limb of the overturning circulation is responding to changes in high latitude climate forcing.

This array will re-continue the time series of bottom water export begun in 2008, using observation strategy, modified as required following recovery of the array in 2009. The array will consist of three moorings of similar design – profiles 75kHZ ADCP and Seabird SBE39s. The array will collect a time series of full-depth profiles of water velocity and discrete temperature and salinity measurement at four depth on each mooring, between the sea-floor and 300m depth (the mooring are limited to this depth to avoid contact with icebergs). This array will be built during 2010 and deployed during the austral summer 2010/2011, with annual recover and redeploy thereafter. ***The EIF investment for this platform is on maintenance, operating costs and delivery of climate quality data IMOS eMII.***

ii) Kerguelen Array

The abyssal distribution of CFCs shows that AABW is exported to lower latitudes by two DWBC systems: AABW formed in the Weddell Sea is exported in a DWBC along the Antarctic Peninsula and South Sandwich Island arc to ultimately ventilate the deep waters of the Atlantic and western Indian Ocean (Fahrbach et al., 2001); AABW formed in the Ross Sea and Adelie Land coast is carried north in a DWBC east of the Kerguelen Plateau before passing through fracture zones in the mid-ocean ridge systems to supply the abyssal layers of the eastern Indian and Pacific Oceans (Rintoul, 1998; Nakano and Suginohara, 2002).

Previous ship-based studies had found evidence of the Kerguelen DWBC in the distribution of water properties and velocity (Speer and Forbes, 1994; McCartney and Donohue, 2007; Aoki et al., 2008). A joint Japanese and Australian two-year long mooring program determined the mean transport and structure of the DWBC (Fukamachi et al. in prep). The current measurements reveal a narrow and intense equatorward flow extending throughout the water column. Two-year mean velocities in the core of the DWBC exceed 0.20 m s^{-1} at depths of 3500-4500 m, the largest mean flows yet observed at similar depths. The DWBC carries a mean equatorward transport of 12.3±1.0 Sv, roughly half of the total export of AABW to lower latitudes, confirming the Kerguelen DWBC is a primary pathway of the deep overturning circulation.

The mooring array, based on the previous design, will be built and deployed adjacent to the Kerguelen Plateau in 2012/2013. The array will consist of 9 current meter and property moorings extending eastward from the Kerguelen Plateau shelf to the deep ocean. Instrumentation on the moorings will include profiles 75kHz ADCPs, Seabird SBE39s and discrete current meters at 500-600 m intervals near the Kerguelen Plateau and increasing to 800-1000 m in the deep ocean. ***The EIF investment for this platform is on purchase of some current meters, and Seabird 39's, note that instruments will also be sourced from CMAR gear pool and ongoing CMAR CAPEX instrument acquisitions. EIF invest will also purchase maintenance, operating costs and delivery of climate quality data IMOS eMII.***

iii) ITF Array

The Indonesian seas are the only major low-latitude connection in the global oceans. This connection permits the transfer of Pacific waters into the Indian Ocean, known as the Indonesian Throughflow (ITF). The ITF actually consists of several filaments of flow that occupy different depth levels and weave their way through the complex island geometry comprised of broad shallow shelves and deep basins. The largest Indonesian seas are: the shallow Java Sea, the deeper Flores, Banda and Timor Seas, and the shallow Arafura Sea.

Recently, Sprintall et al (2009) have provided direct estimates of the Indonesian Throughflow from current meters in all major passages in the Indonesian seas. They find that a total mean transport from 2004-2006 of -2.6 Sv (1Sv=10^6 m^3 s^{-1}) in Lombok Strait (i.e. toward the Indian Ocean), -4.9 Sv in Ombai Strait and -7.5 Sv in Timor Passage. The transport in Timor Passage is nearly twice as large as historical estimates, and represents half of the –15 Sv full-depth Indonesian Throughflow transport that enters the Indian Ocean. Therefore the proposed mooring array in the Timor Passage and Ombai Strait will monitor more than 50% of the total Indonesian Throughflow. We note that international colleagues (USA, Korea) do and are interested in monitoring the remaining major passages of the Indonesian Throughflow.

The mooring array, based on the previous design, will be built and deployed in 2010/2011. The mooring array will consist of three moorings – two in Timor Passage and one in Ombai Strait. Instrumentation on the moorings will include profiles 150 kHz and 75kHz ADCPs, Seabird SBE39s, discrete current meters and Pressure Inverted Echo Sounders (PIES). The deepwater mooring array will intergrate at the Australian continental shelf with the northern mooring coastal array. The deepwater moorings will provide profile velocity data above 500 m and point source velocity between 500 m and 1200 m (depth of controlling sill). Temperature and salinity data will be collected for the entire water column. ***The EIF investment for this platform is on purchase of 3 75kHz ADCPs and 3 PIES, note that all other instruments will be sourced from CMAR gear pool and ongoing CMAR CAPEX instrument acquisitions. EIF invest will also purchase maintenance, operating costs and delivery of climate quality data IMOS eMII.***

iv) EAC Array

The East Australian Current (EAC) is the major western boundary current of the south Pacific Ocean. It plays a critical role in the ocean re-distribution of global heat from the equator to the mid-and-high latitudes. The EAC is relatively stable north of Brisbane, but as the current moves south 2-3 large eddies are pinched off every year. These eddies frequently move onto the continental shelf and close inshore and influence the local circulation patterns. At prominent coastal features the EAC moves away from the coast, driving upwelling which draws nutrient-rich water from a depth of 200-m or more.

The mooring array will be built in FY 2011/2012 and deployed in austral spring 2013. The array will consist of 9 current meter and property moorings extending eastward from the Queensland Coastal Node shelf mooring array near Brisane to the deep ocean. Instrumentation on the moorings will include profiles 75kHz ADCPs, Seabird SBE39s and discrete current meters at 500-600 m intervals across the Continental Slope and increasing to 800-1000 m in the deep ocean. ***The EIF investment for this platform is on purchase of some current meters, and Seabird 39's, note that instruments will also be sourced from CMAR gear pool and ongoing CMAR CAPEX instrument acquisitions. EIF invest will also purchase maintenance, operating costs and delivery of climate quality data IMOS eMII.***

v) Perth Basin

Accurate estimates of the total sea level budget must include all components of the earth system that contribute to sea level rise. The deep ocean component (below 2000m) of the observed sea level budget is highly uncertain. Comparison of repeat hydrographic sections has revealed statistically significant warming of the entire abyssal Indian, Pacific and Southern Oceans. While the sparse data makes quantification of these changes difficult, they do appear large enough to be significant contributors to global heat, freshwater and sea level budgets. The deep mooring arrays will provide sustained observations of the deep ocean heat and freshwater changes that will be an important component of a deep ocean observing system.

The Perth Basin mooring array will monitor properties and transport of the abyssal ocean. The mooring array will be built and deployed in 2011/2012. The mooring array is located in a region where the deep western boundary current is topographically constricted thereby allowing the mooring array to efficiently monitor the abyssal basin. The mooring array will consist of 6 current meter and property moorings at the western and eastern boundary, and 3 temperature and salinity moorings in the interior of the basin. ***The EIF investment for this platform is on purchase of some current meters, and Seabird 39's, note that instruments will also be sourced from CMAR gear pool and ongoing CMAR CAPEX instrument acquisitions. EIF invest will also purchase maintenance, operating costs and delivery of climate quality data IMOS eMII.***

<u>List of major activities – including major party(s) involved, duration, start, finish</u>

Build and deployment plans are staggered such that sub-facility becomes fully operational by 2012/2013. All construction and deployment of moorings will be undertaken by ABOS mooring specialists.

1. 2009/2010 Purchase RDI 75 kHz and Pressure Inverted Echo Sounders (PIES) for Indonesian Throughflow array from EIF-I Northern Mooring Array 2009/2010.
2. 2010/2011, 2011/2012, 2012/2013, Construction and deployment of Polyna mooring array – construction July-September 2010, deployment austral summer 2010/2011. Annual mooring construction and refurbishment of instrumentations will be undertaken in 2011/2012 and 2012/2013. The array will be re-covered and re-deployed every Austral summer.
3. 2010/2011 Construction and deployment of Indonesian Throughflow mooring array – construction will begin in last quarter of 2010 and completed by March 2011, deployment austral winter 2011. Mooring array will be deployed for 18 to 24 months, with recovery and re-deployment planned for 2012/2013
4. 2011/2012 Construction and deployment to Perth Basin array, and build of EAC mooring array. Exact timing of deployment of Perth Basin Mooring array depends on NMF ship schedule. Mooring arrays will be deployed for 2 years. Recovery and redeployment is planned for 2013/2014
5. 2012/2013 Recovery and redeployment of Indonesian Throughflow. Deployment of EAC mooring array. Construction of Kerguelen Plateau mooring array and deployment of array in austral summer. Mooring arrays will be deployed for 2 years. Recovery and redeployment is planned for 2014/2015

<u>List of major equipment to be purchased / developed</u>
All instruments to be deployed are commercial available and have been used within the ocean community for a many of years. CMAR deepwater pool gear and future CSIRO CAPEX expenditure will be used to substantially offset the need to purchase new instrumentation. However, we envisage that EIF budget will be required to supplement the purchase of additional instruments.

Instruments that will be purchased include:

RDI 75 kHz ADCP
Pressure Inverted Echo Sounders (PIES)
Single point current meters
Seabird SBE39
Floatation
Acoustic Release

<u>List of deliverables (performance indicators)</u>

1. Build and successful deployment of deepwater arrays.
2. Recovery and re-deployment of deepwater arrays.
3. Provision of quality assured/controlled current and temperature and salinity time series data to EMII and OceanSITES within approximately six months of the moorings recovery

ABOS Facility Access, pricing regimes:

- How will data access be provided?

  Data will be provided on-line, free of charge, via the IMOS eMII servers, the GTS server, and deposited with the Australian Antarctic Data Centre. The data will also be available to the internationally through the OceanSITES data portal.

- How will data and products be managed?

  The provision of quality assured/controlled time series data to EMII and OceanSITES in a timely manner after the recover voyages is a major deliverable of ABOS. We will employ appropriately skilled data analysts in each of the sub-facilities to ensure high quality climate data is provided to IMOS eMII and international data servers.

  Data will be managed by EMII and AADC after provision to those bodies. Samples will be held by the ACE CRC for distribution on request via the IMOS SOTS Sample Manager (S.Bray, ACE CRC)

- What are the dependencies on external / other facilities (national and international)?

  The main dependency is on ship logistics for mooring service.
  For SOTS (and SOFS), ship logistics are obtained by proposals to the Australian Antarctic Sciences (AAS) program for support using Aurora Australis and the Australian Marine National Facility (MNF) for support using Southern Surveyor. AAS has provided support annually since 1997 and there is in-principle approval through 2014 for its continuation subject to annual review. This support is also a component of the successful ACE CRC extension contract through 30 June 2014. MNF has provided annual support since 2005, subject to annual review.

  For the ASFS Timor Sea site, ship logistics are obtained by:

  1. Biennial piggyback on Australian Tsunami Warning System DART mooring service cruises using chartered vessels. The TSFS is located between the two Australian DART buoys in the region. Funding is requested to cover the cost of 2 additional days per piggyback cruise.
  2. Biennial request to MNF for ~10day cruise to service ASFS. This will be coordinated with other mooring and research cruises in the area planned for ~ January 2012 (CINDY)

  For the DA arrays, ship logistics are obtained by:

  1. proposals to Australian Antarctic Sciences (AAS) program for support using Aurora Australis for Polyna mooring deployments and recovery. However, when the new MNF

vessel is available will submit a proposal to use this vessel as the area of mooring array is ice free during austral summer;
2. co-investment from AIMS will provided the RV Solander to deploy and maintain Indonesian Throughflow mooring array;
3. other mooring array deployment logistics will be obtained by proposals to the Australian MNF

ABOS and ANMN will have common dependencies with respect to instrument and material procurement, workforce planning at mooring build, shipping and deployment, and instrument refurbishment. ABOS and ANMN will each provide 50% support to a Project Officer to ensure the smooth day-to-day running of each facility. This position will also be part of the at-sea deployment and recovery team.

ABOS and ANMN will also share a data analyst (1 FTE) to ensure quality assured./controlled current meter data from similar instrumentation used across these facilities.

- Collaborative structures for allocation of priorities

Priority allocation has been primarily set by the P.I.s via informal consultation with research collaborators and via discussions with the IMOS Bluewater and Climate Node and coastal Nodes. A call for use of the mooring platforms for additional projects was formally issued via IMOS in 2008, and this will be repeated annually for all sub-facilities. Informal discussions have led to additional use of the platforms for RAFOS float communication tests, current studies, and passive acoustic recording of marine mammals. We anticipate similar use of the moored observing infra-structure in the future and are in discussions with Rudy Kloser regarding passive acoustic measurements on small fish and zooplankton.

Governance

- Performance indicators

Detailed Deliverables are described separately for each sub-facility. Here we emphasise the overall program of output delivery. The ABOS facility will concentrate Australian expertise and experience of Bluewater mooring construction, deployment and recovery into a cohesive national unit. This will enable the facility to plan work flow such that all personnel in the facility are fully utilized across the many skills required by a successful mooring group. A key performance indicator of the ABOS facility will be the successful provision of climate quality data to IMOS eMII and other international data servers (GTS, OceanSITES). The ultimate provision of data for national and international climate research requires successful management through all stages that lead to the data retrieval, including instrument procurement, mechanical and physical mooring design, construction, instrument preparation, at-sea safety, deployment, and recovery and data retrieval and quality control and assurance procedures and instrument maintenance. Therefore key ABOS performance indicators will be on-time, on-budget mooring deployments, recovery of moorings, and retrieval and provision of climate quality to the research community.

- Describe key risks and risk management strategies

The key risk is partial or complete loss of mooring hardware. This is managed by i) a careful program of platform development and testing, ii) working with leading engineers from the ABOS and within the international community, iii) building in observational redundancy within and among the separate mooring platforms whenever possible, iv) planning for loss by funding replacements, v) insuring the mooring equipment.

Budget:
The ABOS facility consists of three sub-facilities, as follows:
i) SOTS which extends the carbon cycle and biogeochemistry observations started under the NCRIS-SOTS facility
ii) ASFS which extends the air-sea flux observations started under NCRIS-SOTS facility and enhances them by the addition of a second air-sea flux station in the Timor Sea
iii) DA which received an initial allocation of EIF funds in 2009/2010 for observations of currents in the Indonesian Throughflow region, and will enhance these with new arrays to measure boundary currents in multiple locations in southern, northern, eastern, and western Australia waters.
The budget workbook provides separate spreadsheets for each sub-facility (further separated into their extension and enhancement components) as well as a summary sheet for the overall ABOS facility. Please see the budget workbook for the full details. Here we provide only financial and staffing overviews:

BUDGET OVERVIEW

	2009/10 (NCRIS/EIF)	**2010/11** (NCRIS/EIF)	**2011/12** (EIF)	**2012/13** (EIF)	**Total** (NCRIS+EIF)
SOTS Extension					
NCRIS/EIF	1,356,961	694,417	940,059	502,517	3,493,955
Cash Co-investment	958,000	850,000	2,081,863	1,467,995	5,249,858
In-kind Co-investment	64,000	64,000	248,740	257,392	634,132
ASFS Extension					
NCRIS/EIF	1,159,916	184,378	1,514,681	269,042	3,128,017
Cash Co-investment	0	0	533,213	534,874	1,068,087
In-kind Co-investment	0	0	36,759	37,862	74,621
ASFS Enhancement					
NCRIS/EIF	0	902,827	281,054	285,198	1,095,079
Cash Co-investment	0	726,000	726,000	726,000	2,126,000
In-kind Co-investment	0	41,450	42,694	43,975	128,119
DA Extension					
NCRIS/EIF	258,744	0	0	0	258,744
Cash Co-investment	0	0	0	0	0
In-kind Co-investment	0	0	0	0	0
DA Enhancement					
NCRIS/EIF	0	425,773	2,515,892	1,740,483	3,286,206
Cash Co-investment	0	2,814,453	2,394,563	3,929,241	9,138,257
In-kind Co-investment	0	91,650	92,699	92,433	276,782
Total ABOS Facility					
NCRIS/EIF	2,775,621	2,207,395	5,251,686	2,797,240	11,262,001
Cash Co-investment	958,000	4,390,453	5,735,639	6,658,110	17,582,202
In-kind Co-investment	64,000	197,100	420,892	431,662	1,113,654

Increases in funding requests in years 2011/12 reflect the replacement of the SOTS and ASFS moorings at the SOTS site, and the initiation of Perth Basin and EAC arrays.

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- Co-investments – source and nature

Cash co-investment provided by CMAR, UTAS, ACE CRC and BoM, is primarily in the form of overhead support for EIF funded staff and provision of existing and replacement instruments for use on the SOTS and DA moorings.

In-kind co-investment provided by CMAR, UTAS, ACE CRC and BoM and international collaborators includes oversight and support staff, as well as shiptime resources provided from the Australian Antarctic Sciences program and the Marine National Facility via competitive grants. Full details are provided in the budget workbook.

- Staffing details

Staffing level of approximately 3.6 FTE's in 2009/10 will increase to 5.7 FTE's in 2010/11 with the addition of the Deepwater Array sub-facility A fully functioning ABOS facility requires approximately 6 FTEs, there are slight fluctuation around this effort depending on redesign and rebuild of different mooring components. Due to the similar nature of the Bluewater mooring construction the personnel employed by the ABOS facility will work across all sub-facilities, apart from the BoM data management person.

FTE Overview

	2009/10 (NCRIS/EIF)	**2010/11** (NCRIS/EIF)	**2011/12** (EIF)	**2012/13** (EIF)
SOTS Extension				
Pender (CMAR)	0.10	0.10	0.10	0.10
Sherlock (CMAR)	0.15	0.15	0.30	0.15
Hughes(CMAR)	0.15	0.15	0.50	0.15
McLaughlin (CMAR)	0.50	0.50	0.50	0.50
Cherry (CMAR)	0.20	0.20	0.20	0.20
Dirita (CMAR)	0.10	0.10	0.10	0.10
O2 tech (CAMR)	0.25	0.25	0.25	0.25
Adelstein (UTAS)	0.40	0.40	0.40	0.40
Sediment trap tech (UTAS)	0.50	0.50	0.50	0.50
Trull (UTAS)	0.10	0.10	0.10	0.10
TOTAL	**2.45**	**2.45**	**2.95**	**2.45**
ASFS Extension				
Data Management (BoM)	0.50	0.50	0.50	0.50
Deck Hand (BoM)	0.10	0.10	0.10	0.10
Mooring Tech	0.50	0.50	0.50	0.50
TOTAL	**1.10**	**1.10**	**1.10**	**1.10**
ASFS Enhancement				
Tech coordination (BoM)			0.25	0.25
TOTAL			**0.25**	**0.25**
DA Enhancement				
Marouchos (CMAR)		0.20	0.20	0.20
McLaughlin (CMAR)		0.30	0.30	0.30
Cherry (CMAR)		0.30	0.50	0.50
Instrument Tech (CAMR)		0.25	0.30	0.30
Data Analysis (CMAR)		0.50	0.50	0.50
Project Office (CAMR)		0.50	0.50	0.50
Sloyan (CMAR)		0.10	0.10	0.10
TOTAL		**2.15**	**2.40**	**2.40**
TOTAL (NCRIS/EIF) ABOS FTE	**3.55**	**5.70**	**6.70**	**6.20**

Facility	**Observations required by the Node**			
	NCRIS Funded (already allocated to Jun11) (see Appendix 1 of the Guidelines)	EIF first $8M funded (already allocated to Jun10)	Extension of existing facility infrastructure out to 2013.	Enhancements of existing Facilities / new infrastructure required 2010-2013
Bluewater & Climate	Air-sea fluxes (including CO2), and subsurface physical and BGC oceanography at SOTS site	Monitoring the Indonesian Throughflow via mooring array in Timor Passage and Ombai Strait	Continuous year-round observations of air-sea fluxes (including CO2), and subsurface physical and BGC oceanography at SOTS site	Continuous year-round observations of air-sea fluxes (including CO2), and subsurface physical oceanography in Timor Sea to monitor air-sea interactions for intra-seasonal variability, MJO, TC preconditioning and climate impacts. Contribution to RAMA. Deepwater Array will provide sustained monitoring of ocean currents and properties for: (1) Monitoring Pacific-Indian interocean exchange; (2) Formation and property variability of AABW near the Antarctica; (3) Deep Ocean transport and property variability in the Perth Basin; (4) Monitoring the transport and property variability of a branch of the deep limb on the Southern Ocean Overturning Circulation from the Kerguelen Plateau mooring array; (5) monitoring the EAC near Brisbane.
WAIMOS		Monitoring the Indonesian Throughflow via mooring array in Timor Passage and Ombai Strait		Continuous year-round observations of air-sea fluxes, and subsurface physical oceanography in Timor Sea to monitor air-sea interactions for

Facility	Observations required by the Node			
	NCRIS Funded (already allocated to Jun11)	EIF first $8M funded (already allocated to Jun10)	Extension of existing facility infrastructure out to 2013.	Enhancements of existing Facilities / new infrastructure required 2010-2013
	(see Appendix 1 of the Guidelines)			
				intra-seasonal variability, MJO, TC preconditioning
GBROOS		Monitoring the Indonesian Throughflow via mooring array in Timor Passage and Ombai Strait		Continuous year-round observations of air-sea fluxes, and subsurface physical oceanography in Timor Sea to monitor air-sea interactions for intra-seasonal variability, MJO, TC preconditioning
NSW-IMOS				
SAIMOS				

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