

**Call for Proposals under the IMOS EIF Five Year Strategy:
Enhancement / extension of IMOS – July 2010 to June 2013**

Ship of Opportunity Program Biogeochemical (CO₂) Sampling

Project Plan for 2010-2013

Overview:

Proposed Infrastructure Investment:	SOOP Program Biogeochemistry
IMOS Facility:	Ship of Opportunity Program
Operating Institution:	CSIRO Marine and Atmospheric Research, Tasmania
Sub Facility Leader (for this Proposal):	Dr Bronte Tilbrook, CSIRO Marine and Atmospheric Research, PO box 1538, Hobart, TAS 7001; mob: 0407688832; bronte.tilbrook@csiro.au
Other(s) key people involved:	Dr Simon Wright, AAD, TAS, Dr Tom Trull, UTAS, Dr Richard Matear, CMAR
Co-investing / Collaborating Institutions:	CSIRO Marine and Atmospheric Research

Nature of Investment:

The investment is to extend an existing IMOS surface CO₂ biogeochemical measurement program in the Southern Ocean and in Australia's regional seas from mid 2010 to mid 2013.

The biogeochemical observations have already been established on the ships. The instrumentation used delivers high quality data from two ships; the Astrolabe in the Southern Ocean and the Southern Surveyor, which operates from the tropics to the 50°S. The data from the ships are helping to determine the regional uptake of CO₂ around Australia and in the Southern Ocean and providing data to evaluate the biogeochemical models of the region.

An enhancement is also requested to extend the measurements to Aurora Australis. This is one of the few ships that provide Southern Ocean data. While it is not a repeat line, there is good regional coverage for the Southern Ocean.

The sites proposed here will characterise changes down the east coast of Australia and the influence of the East Australian Current on CO₂ uptake and acidification and form the backbone of the IMOS biogeochemical sampling on ships of opportunity.

Implementation Strategy:

Summary

The proposal seeks to extend a program of carbon biogeochemical measurements on ships of opportunity to mid 2013. The program is already established and working well, delivering data to IMOS from the Southern Ocean (Astrolabe) and Australia's regional seas (Southern Surveyor). An enhancement is also requested for measurements to be made on Aurora Australis in the Southern Ocean. These observations provide broad regional coverage, and with higher frequency measurements made at moored sensors, will form the backbone of Australia's contribution to understanding air-sea exchange of CO₂ in our region, and the progress of acidification.

Objectives

The ships will deliver sustained observations of surface CO₂ in the Australian region and the critical Southern Ocean. The systems utilised are robust, and proven to work for extended periods with high data returns. Data generated from the moorings will complement and enhance existing observational programs at mooring sites and underway programs (figure 1). The Southern Surveyor is not a repeat line, but does provide wide geographic coverage. With the proposed offshore mooring in the Timor Sea (Flux reference site proposed through IMOS ABOS) and the Rottneest mooring, this is some of the only coverage available for the Western Australian region. The existing CO₂/acidification moorings (OA moorings) are proposed through a National Mooring Site subfacility for CO₂/acidification and contain pCO₂ sensors. The SOOP and mooring network are designed to capture the CO₂ system variability down the east and west coasts of Australia and in the Southern Ocean. The high frequency mooring measurements complement the 4-6 weekly coverage expected from the SOOP BGC measurements.

Applications for the SOOP data include:

- constraining estimates of CO₂ uptake in Australia's regional seas including some of the only sampling carried out in the Western and Eastern Boundary currents and the shelf waters around Australia,
- Using SOOP underway systems to tie together high frequency measurements of CO₂ made at mooring sites in IMOS.
- With ancillary underway data on alkalinity, total dissolved CO₂, SST and salinity deliver a network of sustained measurements that can be used to determine the regional gradients in carbonate chemistry and the evolution of the acidification of shelf and offshore waters around Australia. This information is a prerequisite for understanding the exposure and resilience of Australia's marine ecosystems to acidification.
- provide data to test biogeochemical models and predict the influence of climate drivers (stratification, warming, ENSO, SAM) and biological feedbacks on the future uptake and acidification of Australia's seas.
- make an Australian contribution to coordinated international programs on CO₂ uptake and acidification in the oceans, through the UNESCO/SCOR International Ocean Carbon Coordination Project (IOCCP <http://www.ioccp.org/>), and will deliver to international efforts to provide global gridded CO₂ products (e.g. SOCAT) and regional efforts (RECAPP), including the Southern, Indian and Pacific Ocean SOCAT groups.
- Provide data to support process studies on controls on air-sea CO₂ exchange (e.g. CO₂ uptake associated with cold core eddies off East Australia).

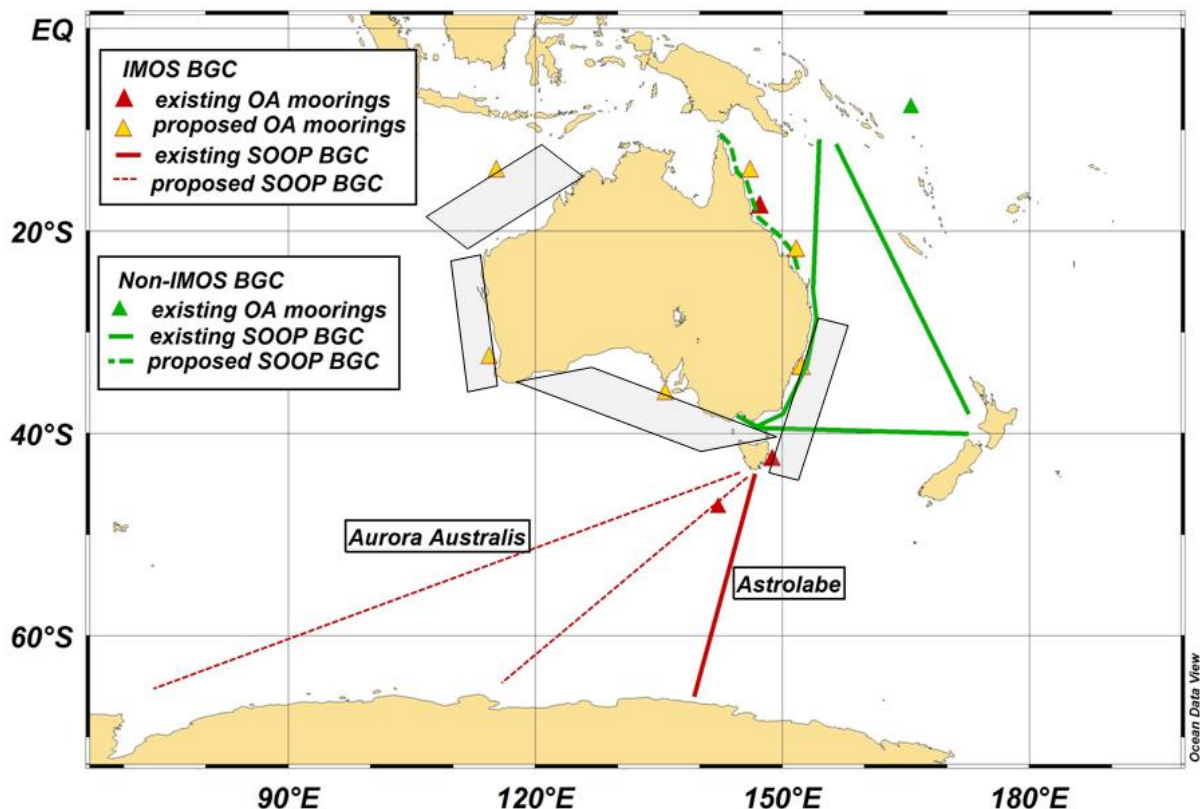


Figure 1. SOOP and mooring (existing and proposed) CO₂/acidification measurements with Australian involvement. The approximate area of operation for the Southern Surveyor is shown by the light grey areas. Ancillary measurements of carbonate parameters at mooring reference sites and on the SOOP BGC lines are used with the moored sensor data to describe the carbonate chemistry (saturation states, pH). The Tasman and Coral Sea underway SOOP line (green) sampling is done by NIES, Japan, and CSIRO have a collaboration to obtain some data on carbonate chemistry through discrete sampling. The mooring site at 8S 165E is a CSIRO-NOAA collaborative effort.

The CO₂ group at CSIRO, Hobart, will manage the work and are experienced in the instrument maintenance, calibration and data management. Collaboration with the mooring subfacility and the SOOP ecosystem groups will provide a cost-effective national network of observations that integrate across physical, chemical and biological systems.

List of major activities – including major party(s) involved, duration, start, finish

- 1) CSIRO, mid 2010 to early 2011: complete laboratory van and test on Astrolabe.
- 2) CSIRO, mid 2010 to 2013: prepare, calibrate and maintain instrumentation on ships of opportunity. CSIRO staff from the biogeochemistry/CO₂ group are trained in maintaining these systems and data QC.
- 3) CSIRO, mid 2010 to 2013: Maintain data stream and deliver near real-time and delayed-mode QC data products to IMOS. The Southern Surveyor is already being delivered in this way and daily delivery of data from Astrolabe is being trialled and should be available by early 2010;

Major activities for enhancement to include pCO₂ measurements on Aurora Australis.

- 1) CSIRO, mid 2010: purchase General Oceanics pCO₂ system for ship.
- 2) CSIRO, mid 2010 to 2013: prepare, calibrate and maintain instrumentation on Aurora Australis CSIRO staff from the biogeochemistry/CO₂ group are trained in maintaining these systems and data QC.
- 3) CSIRO, mid 2010 to 2013: Maintain data stream and deliver near real-time and delayed-mode QC data products to IMOS.

List of major equipment to be purchased

Most major equipment is already available. In 2010/11 funds are requested for three oxygen optodes (\$22K), a replacement laboratory van for Astrolabe (\$130K), and a new pCO₂ system for Aurora Australis (\$85K). The van is the only way to get laboratory space on Astrolabe. The existing van is on loan from Australian Antarctic Division and needs replacing to allow more efficient use of limited space, and safer and healthier conditions for people working in the van. The current van has poor air circulation and ventilation, the heating and cooling is inadequate, the layout poor, and the power regulation and wiring need fixing to handle the ships power. Odours from the ships septic system now fill the van regularly, and a thin layer of soot from the ship exhausts often covers the inside of the van. The use of liquid nitrogen in the enclosed van space for biological sampling is also a health hazard and needs correcting with a better ventilation system.

Access, pricing regimes:

- **How will data access be provided?**

Data are delivered daily from Southern Surveyor by file transfer. These data are updated every 1-2 hours and available publically with a web display. The data from Aurora Australis will be delivered in a similar way. For Astrolabe, communications from the ship are limited and in early 2010 an iridium based file transfer system is being installed and tested. This will deliver the data from the ship each day and will be available publically through IMOS. A delayed mode QC product with data reports and final sensor calibrations applied will be available at IMOS for both ships within 3-6 months.

- **How will data and products be managed?**

The collection, QC and delivery of CO₂ and related data, and data reporting are already established. The daily raw data for these systems will be received at CSIRO, Hobart, and be available the same day through IMOS.

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

The instrumentation and observational program is managed by CSIRO. On Astrolabe we also work with EU scientists from the Universite Pierre et Marie Curie and Universite of Perpignan. The French collaboration provides access to the ship, which is a French charter, and both Australia and France send a person to operate equipment on each Astrolabe voyages. We have worked collaboratively with this group for many years and expect that to continue.

- **Collaborative structures for allocation of priorities**

The biogeochemical measurements and priority setting is managed within the project. For Astrolabe we collaborate with the SOOP XBT group, including working with them to improve the ships seawater supply, which they use to monitor surface salinity temperature.

The XBT section is valuable for understanding the upper ocean structure, which affects the variability in biogeochemical parameters measured. This collaboration has worked well, there is a mutual benefit to both groups, and will continue into the future. An array of biological or ecosystem sampling on Astrolabe has also been supported in the past by the SOOP biogeochemistry group. The support has included providing infrastructure, coordination with overseas collaborators, organising personnel for the ships, worked with the SOOP XBT group to upgrade the ships monitoring capability and water supply to research standards, and collection of samples. The biological sampling has resulted in more diverse measurements, but added to an already sizeable workload without extra funding, and it is difficult to sustain. The biological groups are now coordinating their own efforts and submitting an enhancement proposal for SOOP on ecosystems. They will organise their own efforts and be solely responsible for data delivery of biooptical and other data they collect. The groups will still be linked, delivering an observing system integrated across biology, chemistry, and physics, but each group will be able to focus on its core business leading to greater efficiencies and maximising data delivery and quality.

Table 1: List of equipment to be purchased for extend and enhancement options:

Equipment	Requirement	Source	Date to be purchased /developed
Oxygen Optodes (Extension)	Underway Dissolved Oxygen	AAD, Norway	mid 2010
Lab van (extension)	Replacement for existing van on loan	CSIRO, Hobart	mid 2010
pCO2 system (enhancement)	Replacement for old system on Aurora Australis	CSIRO, Hobart	mid 2010

Governance

Performance indicators

- Data delivered to IMOS in near real time and delayed mode for all ships by February 2011.
- Incorporation of data into international and national CO2 flux products for model validation and estimation of global and regional carbon budgets by Dec 2011.

Describe key risks and risk management strategies

Key risks are defined in Table .

Table 2: Key risks and mitigation strategies.

Risk	Risk mitigation
<i>Common risks</i>	
Ship moves	<p>The Southern Surveyor is in service until mid 2013 where it will be replaced by a new ship. The equipment will be installed and used until then. The Aurora Australis should also be in operation until mid 2013.</p> <p>The Astrolabe is used to resupply the French Base, Dumont D'Urville. The size of Astrolabe means it needs to make a number of repeat trips from Hobart to Antarctica for resupply, making it an ideal ship for Southern Ocean observations. The contract for the ship was recently re-signed and it is expected to remain on the line past mid-2013.</p>
System failure	<p>The equipment was chosen because it is robust, delivers high quality data, and is proven to work for long periods in harsh conditions at sea. Regular checks and maintenance procedures are carried out on the ships and almost all data lost to date has been through failure of ship's equipment (pumps, thermosalinographs). The work in the last two years has resulted in identifying and correcting a number of issues on the ships and data returns of about 95% are routine. Six hourly data downloads</p>

	<p>from Southern Surveyor allow problems to be identified from shore and personnel on the ships notified. The communications on Astrolabe is currently limited to small emails with no attachments .A data transmission system is being installed on Astrolabe in collaboration with the SOOP XBT group in 2009/2010. Craig Neill works in the CO₂ group and he developed the prototype instruments used on the ships and now commercialised, and he wrote the software that controls the systems. We are as well equipped to make repairs as any group in the world.</p>
Loss of key staff	<p>Staff are not expected to leave the project. The CO₂ group in Hobart have ensured there are a number of people trained in the maintenance and repair of the equipment. Any loss of a staff member from the group could be covered by others. The CSIRO electronics group in Hobart are familiar with the software.</p>

Budget:

Extension of existing facility

EIF Funds

- Capital funds are sought to add oxygen optodes for underway dissolved oxygen measurements, and to purchase a laboratory van for Astrolabe. The Astrolabe provides one of the best sampling platforms in the Southern Ocean, but has poor infrastructure. The van on Astrolabe is the only lab space available on the ship and is needed to provide a safe working environment. This provides needed infrastructure for the Astrolabe work, is an important component of the collaboration with French scientists on CO₂ system observations in the Southern Ocean that facilitates our use of the ship, and it allows for phytoplankton sampling for the ecosystem proposal.

Co-investments – source and nature

- The primary co-investment is CSIRO staff time in project management, support and data delivery. In-kind co-investments are the supply of a complete underway CO₂ measuring system on Astrolabe, support from French colleagues who send a person on each voyage to do their own measurements on the CO₂ system and interact with the French science agency that leases the ship, and support (estimated) from the Marine National Facility who allow the Southern Surveyor to be used as a platform for underway CO₂ measurements and whose electronics group operate the underway system at sea.

Staffing details

- Staff required include: a 0.5FTE data manager/QC person that also handles the project management, and a 0.5FTE person to maintain the instrumentation on both ships. The biogeochemistry group have experienced people for the work. The budget also includes 0.2FTE support for the mechanical workshop and 0.1FTE for an electronics technician. The workshop support is required for maintaining the underway lines and communications on Astrolabe and maintenance on both ships.

Enhancement: CO₂ measurements on Aurora Australis

EIF Funds

- Capital funds are sought for underway pCO₂ system (\$85K). In the past pCO₂ measurements have been made on Aurora Australis and the system is now 7 years old and in need of repair. The infrastructure is in place for a direct addition of a General Oceanics pCO₂ system, including the wall brackets and interfacing with the ships logging system.

Co-investments – source and nature

- Co-investment is through salary support. The linked enhancement project for SOOP ecosystems contains information on the Australian Antarctic Divisions co-investment for ship time and science support and is not duplicated here.

Staffing details

- Provided the Australian Antarctic Division find volunteers to run the equipment on the voyages and provide calibrated SST and salinity data and an adequate ships seawater supply the staffing costs will require 0.25FTE for maintenance, training and QC. This is because of the core support and expertise provided through the extend option.

Budget for Extend SOOP Biogeochemical sampling 2010-2011

		2010/11	2011/12	2012/13
EIF Funding				
Capital	Laboratory Van, optode	162,000	0	
Salaries	Maintain SOOP systems, data management/QC	187,917	197,155	
Operating	freight, consumables, project travel,boat time	42,000	28,000	
EIF Funding Total		391,917	225,155	
Cash Co-investment (b)				
CSIRO	Staff time, confirmed	159,396	167,366	
Cash Co-investment Total		159,396	167,366	
In-Kind Co-investment (b)				
CSIRO	Underway CO2 measuring system, confirmed	100,000	0	
French access to Astrolabe(es	Joint sampling on ship and logistic support, provision	50,000	50,000	
Sth Surveyor use (est)	Engineering support, access ships seawater, confirr	50,000	50,000	
Cash Co-investment Total		200,000	100,000	
TOTAL Resources		751,313	492,521	

NOTES:

- (a) If any amounts included in Future column for Cash or In-Kind Co-investment, please provide detail of the time-frame of the investment.
- (b) For amounts included in Cash and In-Kind Co-investments, please include the likelihood of these resources being made available (eg confirmed, provisional, possible)

Budget for Enhancement of SOOP Biogeochemical sampling 2010-2013: pCO2 on AU

		2010/11	2011/12	2012/13
EIF Funding				
Capital	Laboratory Van, optode	85,000	0	0
Salaries	Maintain SOOP systems, data management/QC	28,600	30,020	31,500
Operating	freight, consumables, project travel,boat time	15,000	10,000	5,000
EIF Funding Total		128,600	40,020	36,500
Cash Co-investment (b)				
CSIRO	Staff time, confirmed	26,500	27,800	29,200
Cash Co-investment Total		26,500	27,800	29,200
In-Kind Co-investment (b)				
TOTAL Resources		155,100	67,820	65,700

NOTES:

- (a) If any amounts included in Future column for Cash or In-Kind Co-investment, please provide detail of the time-frame of these res
- (b) For amounts included in Cash and In-Kind Co-investments, please include the likelihood of these resources being made available (eg confirmed, provisional, possible)