IMOS Integrated Marine Observing System

Assessment of IMOS EIF Node and Facility Proposals and Recommendations for Funding

21st December 2009

IMOS is supported by the Australian Government through the National Collaborative Research Infrastructure Strategy and the Super Science Initiative

IMOS is a national, collaborative project, led by the University of Tasmania on behalf of the Australian marine & climate science community

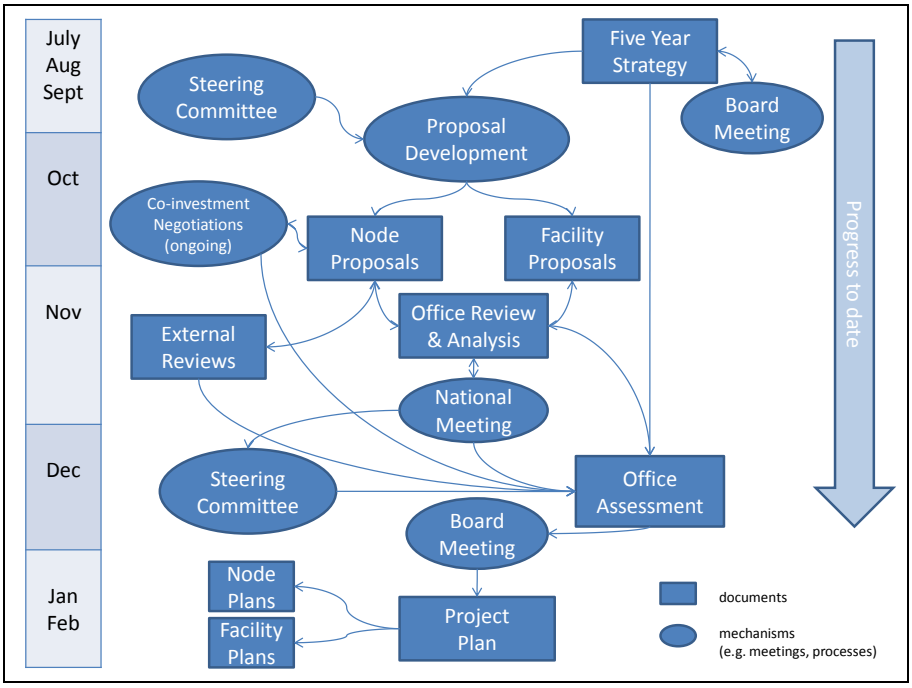
Australian Government
Department of Innovation Industry, Science and Research

UTAS

Introduction

This document provides a record of the assessment of IMOS EIF proposals by the Advisory Board and IMOS Office, which will underpin development of a Project Plan for submission to DIISR in February 2010. It outlines a package of Facility Proposals to be recommended for approval in line with available EIF and NCRIS funding, and co-investment as indicated by partners.

This assessment is the third last step in an intensive IMOS EIF planning process that commenced in July 2009. The penultimate step will be writing the Project Plan, and the final step will be DIISR's decision on the Plan in March 2010. A schematic of the IMOS EIF planning process is as follows:



The process began with development of a draft Five Year Strategy, national consultation, and approval of a final Strategy by the Advisory Board. The Node Leaders (who comprise a Steering Committee under the IMOS governance structure) were brought together early on to discuss integration across Nodes. Proposals were called for in mid-September and submitted at the end of October. Six Node Proposals (one new) and fifteen Facility Proposals (three new) were received, totalling 900 pages of documentation. The Bluewater & Climate and WAIMOS Node Proposals were sent for international peer review during November. A National Meeting was held on 26th November, guided by a review and analysis paper prepared by the IMOS Office which identified a range of issues to be considered. The National Meeting was attended by Node and Deputy Node Leaders, leaders of proposed new Nodes, Facility and Sub-Facility Leaders, and leaders of proposed new Facilities and Sub-Facilities, Operator Representatives, and Members of the Advisory Board and IMOS Office (~65 people). A second Steering Committee meeting was then held on 9th December to allow the Node Leaders to further discuss synthesis and prioritisation across the Nodes.

As a result, this assessment is well-informed by considerable intellectual input from the Australian marine and climate science community, provided at various stages of the process.

The document is structured into three sections.

Section 1 deals with the over-arching issues of
(a) Responding to the approved Five Year Strategy, and
(b) Responding to the international peer reviews.

Section 2 provides the detail of the assessment. The package of Proposals submitted is considered under the five major research themes that IMOS is addressing. For each theme there is:

- an introduction
- a summary of proposed observations (both NCRIS extension and EIF enhancement)
- discussion of issues arising
- an assessment of proposed observations as
    - **essential** – IMOS Strategy will not be achieved unless investment is made
    - **highly desirable** – in line with IMOS Strategy but insufficient funds to support without further co-investment
    - **next stage** – potentially suitable for IMOS investment but not on EIF timeframe, based on assessment of risk regarding maturity of technology, logistical constraints, operator delivery constraints etc
    - **unsuitable** – not suitable for funding by IMOS.
- a discussion of key points arising from the prioritisation, including the implications of cash co-investment.

Section 3 looks at portfolio balance, to ensure that the sum of decisions made at Facility/Sub-Facility level makes sense when judged against the overall Strategy.

1. Overarching Issues

(a) Five Year Strategy

In general, Node and Facility Proposals submitted address the goals of IMOS and respond constructively to the Five Year Strategy. However there is inevitably some heterogeneity across the Proposals, and key issues are highlighted in the following assessment against the strategic priorities:

IMOS Strategic Priorities	Assessment of Response
1. Ongoing development of a coherent, well-positioned Bluewater and Climate Node	This priority has been well-addressed. Southern Ocean and northern Australian waters are given due consideration, biophysical integration improved (noting that this is global challenge for the next decade), and much clearer priorities articulated in monitoring boundary currents and interbasin flows – a key linkage point between the Bluewater and Climate Node and the Regional Nodes. The Node Proposal includes an explicit prioritisation. Governance (of all Nodes) does need to be strengthened, and will be addressed in 2010.
2. Impact and delivery through improving model output	This priority has been well-addressed. The Node Proposals in general, and the Regional Node Proposals in particular, have a much stronger emphasis on links between the observing programs and modelling frameworks.
3. Providing a national backbone for observing boundary currents	The boundary current priorities are clearer as noted above, but Proposals relating to development of the national backbone require substantial adjustment. Plans for the National Reference Stations resulted in completely unrealistic budgets that have to be pared back. Proposals relating to Satellite Remote Sensing were not well-coordinated in some areas, and have limited if any support in the Regional Node Proposals. This IMOS strategic priority will need further work in 2010.
4. Ongoing development of Regional Nodes	The direction of Node development is as expected i.e. • extension of WAIMOS into northern Australia , with NT engaged • extension of GBROOS into SEQ (now QIMOS) • a proposed new Tasmanian Node, and • an opportunity provided for Victoria to engage with SAIMOS. However the rate and intensity of proposed development is overly ambitious, and needs to be scaled back in line with strategic priorities and further development of our national, collaborative approach. Governance (of all Nodes) does need to be strengthened, and will be addressed in 2010.
5. Continuing to build institutional strengths into national capability	This priority has been reasonably well-addressed, with all the Operators engaged. Issues have inevitably arisen around costs, co-investment, logistics (incl. vessel access), priorities, leadership and capacity to deliver. The issues will need to be addressed case by case.
6. Exploring the potential for whole-of-system approaches	This priority has been moderately well-addressed. There was a significant increase in "biological" Proposals, although whole-of-system integration is not always evident and needs attention. This IMOS strategic priority will need further work in 2010.

IMOS Strategic Priorities	Assessment of Response
7. Driving down the cost per observation	This priority has not been well-addressed, with few Proposals looking at more efficient ways of doing things. Value of observations relative to cost is the fundamental issue, but the heavy and growing emphasis on moorings, which generally have a high cost per observation, has emerged as a feature of IMOS. Also, some Facilities that are still under development, and yet to deliver their NCRIS-contracted observations, have sought enhancement prematurely. This IMOS strategic priority will need further work in 2010.
8. Creating and developing the information infrastructure	This priority has been well-addressed through the eMII Facility proposal.
9. Ensuring the data is used	This priority has been moderately well-addressed overall i.e. better in some Node proposals than others. Much greater emphasis on uptake and use of data is required. Also, the user base and potential impact of some proposed observational streams is too narrow. This IMOS strategic priority will need further work in 2010.
10. Partnering for sustained ocean observing	This priority has been reasonably well-addressed under the circumstances, given that the IMOS EIF planning timeframe is not particularly well-aligned with the planning and budgeting timeframes of some key partners e.g. State Governments. However additional co-investments will be required to ensure aspects of the envisaged capability are delivered. A number of observing technologies (e.g. Argo and SOOP XBT) are operationally mature and given the utility of observations from these technologies beyond the research community, consideration will need to be given to transitioning responsibility for these observing systems to an operational agency beyond the EIF funding period.

In summary, the framing of recommendations for funding will be strongly influenced by the assessment of how well Node and Facility Proposals responded to the Five Year Strategy.

(b) International peer review

All Node Proposals will be internationally peer reviewed on a rolling basis. The Bluewater and Climate and WAIMOS Nodes were chosen in the first stage, as they are most likely to be responding to the Federal Government imperative for enhanced monitoring capability in the Southern Ocean, and extended coverage in northern Australian waters.

Five reviews were undertaken for each Node. Seven reviewers were used, with three reviewers looking at both Proposals, and two looking at just Bluewater and Climate and two looking at just WAIMOS. This approach was designed to address both the breadth and depth of IMOS Nodes. The Advisory Board and relevant Node Leaders have been provided with full details of the reviewers' comments and summaries of key issues prepared by the IMOS Office.

Bluewater and Climate

- All of the reviews were very positive. There was strong agreement that the science questions posed are relevant and appropriate.
- In general the reviewers felt that the correlation between science questions and observations required was strong, though Reviewer 3 questioned the clarity and reasoning behind the prioritisation. While it is likely to have been discussed, the reasoning has not been articulated.
- Reviewer 1 noted that "Moorings are a relatively expensive tool and the IMOS plan is very ambitious in its use of moorings. The OceanSites Program is unhelpful for prioritizing among these because it simply incorporates all national plans for long time-series observations. In the event that not all of the planned moored arrays can be implemented and sustained, the tropical RAMA array mooring north of Australia, the EAC monitoring array, and the Indonesian Through Flow program all rate especially highly for cost effectiveness and for leveraging of international partner efforts and of other related program elements."
- However Reviewer 2 provided somewhat conflicting advice on the RAMA array - "I am not convinced, that under 4.2 the new installation of a RAMA buoy should receive the highest priority, but I am in support of a joint NOAA-PMEL pilot deployment. I would certainly object to the statement below that this would be "the first installation to…. Support seasonal prediction" you have Argo and support altimeter calibrations, both by now essential elements of modern forecast systems … (i.e. possibly downgrade to high priority)."
- There was strong support for satellite observations (SST, OST, OC) including in situ observations needed for cal/val. Increasing the value of satellite observations through modest investments was seen to be a highly cost-effective. Reviewer 4 felt that "The high priority given to developing the altimetry facility is of international importance, as altimetric data play a very powerful role in ocean assimilating models, sea-level problems and ocean circulation..."
- While generally supportive of IMOS investment in Gliders, four of the reviewers made cautionary comments about this technology from a sustained observing perspective.
- Two reviewers questioned whether links with the modelling community were addressed.
- Reviewer 1 noted "An important caution is that initiation of new observations to be sustained for decades into the future carries with it a strong responsibility and obligation. These expansions should be undertaken only if they can be sustained and if continuation of the valuable existing long time-series will receive top priority in potentially tightened future Australian budgets. Otherwise the present increased investment is at risk. "

WAIMOS

- Reviews were more mixed. Overall, the plan was considered to be comprehensive and its multi-disciplinary nature was acknowledged.
- Two of the reviewers identified that the plan was actually two plans, and one of the reviewers saw this as a serious problem.
- Three reviewers concluded that it was not clear how the observations proposed would help to answer the science questions posed, making it extremely difficult to prioritise observations. Reviewer 2 went on to suggest that no enhancements to the regional observations be approved without a significant re-write, and Reviewer 5 also recommended significant revisions.
- As a result, the Advisory Board requested that the WAIMOS Plan be rewritten in advance of the 21st December Board Meeting, and this has been done with the assistance of the IMOS Office.
- Reviewer 1 noted that "Some elements of the plan appear to be relatively costly in relation to their information content, and unlikely to be sustained, including the many AUV transects and the use of ADCP on NRS moorings."
- Reviewer 3 noted that "There is also no discussion on the specific requirements of physical and biogeochemical coastal models and how the IMOS data sets will be used in conjunction with modeling and data assimilation systems."
- Two reviewers again noted issues about use of Gliders for sustained observing.
- Reviewer 1 also recommended "A national planning process for the coastal ocean. There is a tendency in large nations for coastal observing systems to be designed piecemeal, as the sum of what the participating coastal institutions would each like to do in their patch. The Australian plan is not nearly as egregious as the US IOOS in this regard, but it is still an important issue."

In summary, the international peer reviews have been extremely helpful in:

1. Confirming where the IMOS Nodes are well on track.
2. Highlighting the need to strengthen the WAIMOS Proposal.
3. Providing comment on specific priorities and issues.
4. Raising general issues around the commitment to sustain, and the need for a national approach to the coastal oceans.

2. Assessment of Node and Facility Proposals

Six Node Proposals were submitted:

1. Bluewater and Climate
2. WAIMOS
3. QIMOS
4. NSW-IMOS
5. SAIMOS
6. TasIMOS

Significant developments in the scope of Nodes during the Proposal stage were as follows:

1. Response by the Bluewater and Climate Node to Federal Budget requirements for enhanced monitoring capability in the Southern Ocean and extended coverage in northern Australian waters, and a strong push for greater biophysical integration.
2. Expansion of the WAIMOS area of interest from SW WA/Ningaloo, to include NW WA and NT in line with the Federal Budget requirement for extended coverage in northern Australian waters.
3. Establishment of QIMOS to (a) build on the strengths of GBROOS, (b) extend into SEQ to leverage engagement opportunities with State and Local Government and the major research institutions in the region, and (c) create a platform for future expansion into Far North Queensland.
4. Clear messages from NSW State Government stakeholders that they are looking for opportunities to leverage the national strength of IMOS to address shelf-to-coastal impacts in the NSW region.
5. Ongoing interest from Southern Australian IMOS (SAIMOS) to better cover the region, and a strong push for a more "biologically-coloured" IMOS. A clear message from Victorian State Government Stakeholders that formal engagement with IMOS was a little premature and will need to build on a longer timeframe.
6. Proposed establishment a new Node in Tasmania (TasIMOS) to provide better coverage of the EAC and leverage engagement opportunities with State Government and the major research institutions in the region.

All 12 existing Facilities (including the IMOS Office) submitted Proposals to extend under EIF. All existing Facilities, other than FAIMMS, eMII and the IMOS Office, also proposed to enhance. Three new Facility proposals were received, bringing the total to 15. A number of new Sub-Facilities were also proposed, bringing the total number of Sub-Facilities to 23. These were concentrated in four Facilities - three in SOTS/ABOS, eight in SOOP, eight in ANMN and four in SRS. This meant there were in fact 34 "budget units" to consolidate i.e. 23 Sub-Facilities and 11 standalone Facilities.

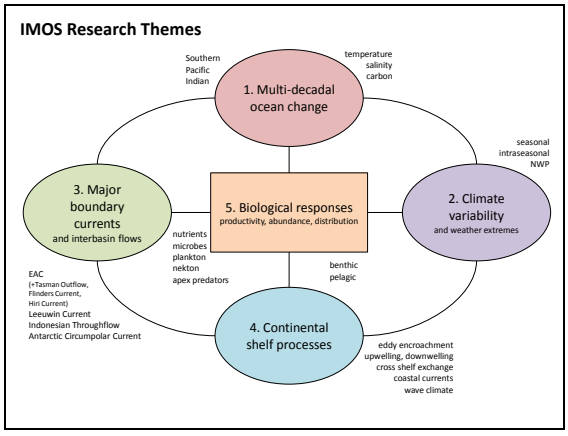
Significant Facility developments during the Proposal stage were as follows:

1. Extension of Argo, noting that enhancements for ice-capable and oxygen were approved in the EIF first $8M.
2. Proposed addition of five or six new SOOP CPR lines, three new SOOP radiometers for skin SST, and three new Sub-Facilities, in Bi-acoustics, Southern Ocean Ecosystem & Biological Observation, and Nutrient Mapping.

3. Proposed expansion of SOTS into a deepwater mooring Facility called Australian Bluewater Observing System (ABOS), with additional Sub-Facilities in Air Sea Flux Stations (ASFS) and Deepwater Arrays (DA).
4. Enhancement of ANFOG in the Southern Ocean and Coral Sea under the EIF first $8M, and further enhancement in WAIMOS (NW) and TasIMOS.
5. Proposed increase in the number of Sirius AUV missions per annum covering all Regional Nodes, and acquisition of a new faster RMUS AUV.
6. Massive enhancement of ANMN, including Stradbroke Island and NRS upgrades and the new Northern Australian Observing System under the EIF first $8M, as well as bio-optics on the NRS, more pCO2, more acoustic observatories, new shelf arrays in Northern Australia, SEQ and Tasmania, further enhancements in NSW and SA, and addition of sediment traps (NCOTS).
7. Extension of the current six ACORN installations, and further enhancement in NSW and SEQ.
8. Significant enhancement of AATAMS, including Southern Ocean creatures, GAB seals and OTN off the GBR under the EIF first $8M, plus further enhancement in multiple locations.
9. Extension of FAIMMS at current level.
10. Extension of eMII at current level.
11. In SRS, extension of SST and AODAAC-type activities, and proposed enhancement of the Lucinda Jetty Coastal Observatory (moved from ANMN) plus establishment of a national database on bio-data and regionally-validated ocean colour products, and an Altimetry Cal Val Sub-Facility.
12. Extension of the IMOS Office at current level.
13. Proposed establishment of a new Facility in Marine Molecular Observing (MMO).
14. Proposed establishment of a new drifter Facility for Lagrangian Ocean Currents (FLOC).
15. Proposed establishment of a new Fast Ice Facility, called Australian Fast Ice Monitoring (AFIM).

Each Node Proposal had up to four major research themes and, on average, a dozen or so more detailed research questions. At the whole-of-IMOS level, these have been synthesised into five research themes as follows:

1. Multi-decadal ocean change,
2. Climate variability
3. Major boundary currents & interbasin flows
4. Continental shelf processes, and
5. Biological responses (productivity, abundance and distribution).



To provide a nationally integrated view, the package of Node and Facility Proposals has been assessed against the five research themes, as outlined in the following sub-sections.

1. Multi-decadal ocean change – temperature, salinity, carbon

This theme is solely within the Bluewater and Climate Node, and the observing strategies are firmly embedded in the Global Ocean Observing System. Estimates of multi-decadal change are drawn from SOOP (e.g. XBT's in the upper 700m, over decades), Argo (down to 2000m, over the last five years), repeat Hydrography (at greater depths, on up to decadal timeframes N.B. non-IMOS, but an issue for the related MNF), and SST and OST satellites. SOTS is coming on stream as part of OceanSITES international network of deepwater moorings. The high latitudes (beyond the reach of core Argo) and the deep ocean (including Antarctic Bottom Water formation) are identified as key gaps of relevance to Australia's focus on the Southern Ocean.

The Node Proposal identifies priorities in broadscale ocean monitoring, global ocean circulation, global ocean carbon cycles and seasonal fast ice. A summary of proposed observations is as follows:

Node focus	NCRIS observations	EIF enhancements
BW&C – broadscale ocean monitoring	core Argo - Altimeter cal val x 1 SOOP SST SRS SST (GHRSST)	Argo in seasonal ice* Seals as samplers* Altimeter cal val + 3 3 x Radiometers (Solander, Surveyor, Spirit of Tas) -
BW&C – global ocean circulation	SOOP XBT - - -	- ITF Array Polynya Array (Adelie Coast) Kerguelen Array Perth Basin Array
BW&C – global ocean carbon cycles	SOTS • SOFS • SAZ, PULSE, profilers pCO2 on MNF + Astrolabe - - Improved global OC products (from it situ data)	 Sea gliders to PULSE* pCO2 on AA CO2 on NRS, Yongala + Maria* CO2 on NRS, other -
BW&C – seasonal fast ice	-	Monitoring seasonal build-up and decay of near-shore ice

* Approved under the EIF first $8M

Discussion of proposals to extend and enhance observations is as follows:

- Argo has been <u>the</u> outstanding success of global ocean observing over the last decade, and is a cornerstone for IMOS. The global design coverage of one float every 3 degrees (300 km) requires an array of 420-460 floats in the Australian region, 50% of which is being provided by our international partners. For Australia to sustain the other 50% (210-230 active floats), we need to deploy 50-60 floats pa, and the Node has proposed that IMOS fund half of this, with the balance of required investment provided by national partners – CSIRO, BOM, ACE CRC, RAN, DCC etc. N.B. Working with the partners to establish a national "game plan" for Argo is an essential follow-up action. It should also be noted that the ACE CRC co-investment (of ~11 floats pa) will

end in 2011-12, and this component is shown as a co-investment "to be advised" in the final year. In summary, the proposed IMOS contribution to the global array (~25% of design requirement in the Australian region) can be achieved within a reasonable financial parameter (thanks in part to a positive exchange rate), and provides excellent leverage. It should also be noted that EIF "first $8M" funding for ice and oxygen capable Argo is over and above the core mission.

- An investment of $600K was approved for Southern Ocean Seals as Samplers (SOSS) in 2009-10 under the EIF "first $8M". The AATAMS Facility proposal requested a further $600K pa to extend this in 2010-13 i.e. $1.8M in total. By reviewing the design density from 30 to 25 tags pa, this has been reduced to $500K pa i.e. $1.5M in 2010-13. Further savings of 10% ($50K pa, $150K in total) have been negotiated around satellite time/exchange rate savings. The revised cost is now $2.050M - $600K approved plus $450K pa for three years ($1.35M) plus $100K for deployment costs. This proposal continues to rank highly given the Advisory Board decision in May 2009, and the focus on Southern Ocean, high latitudes, and biophysical integration.
- IMOS is currently making a very modest contribution to a single Altimetry cal val site, and it is proposed that this be expanded to include one continuous mooring deployment (in Bass Strait) and two episodic deployments (in Storm Bay, and Melville Island or Lorne) along Altimeter Pass 088. Unfortunately, neither the Darwin NRS nor any of the proposed northern Australian mooring arrays align with this pass, though the Storm Bay location is in an area of interest for the proposed Tasmanian Node. It can be argued that IMOS is under-invested in satellite observing in general, and altimetry in particular. The direct users of the data will be the sea level rise community, which is small in Australia, though very influential and heavily relied on by others nationally.
- SST investments in SOOP cal val and SRS product development are well-integrated with the global effort via GHRSST. On that basis, they appear well-targeted. It has also been proposed to provide more accurate (<0.1^{o} C) skin SST by investing in four radiometers and deploying them onto the MNF, Solander and Spirit of Tasmania. At $0.9M the proposal is a fairly expensive increment on IMOS SST investment, and there are questions about what will actually be delivered from the MNF in 2011-13 given the vessel replacement project.
- SOOP XBT is another cornerstone of the global ocean observing system, and the IMOS contribution is strategically important in terms of Australia's international role. The proposal is to extend NCRIS investment for a further two years (2011-13).
- Responding to indentified gaps in monitoring upper and lower limbs of the global ocean circulation in areas of strategic interest to Australia, a new Deepwater (Mooring) Array Sub-Facility is proposed. It is recognised that "going deep" is a significant endeavour, and a staged approach is proposed, leveraging recent pilot deployments e.g. in the ITF (INSTANT) and Polynya (ACE CRC). The ITF Array will address multiple themes (principally Major boundary currents and interbasin flows – see next sub-section). The Polynya Array requires modest co-investment from IMOS. N.B. Issues about funding of capital vs operating have been resolved, and the nature of what is proposed to IMOS is now appropriate. The Kerguelen and Perth Basin Arrays require more substantial investment, but are considered lower priority in the IMOS EIF planning timeframe.
- SOTS has three major components –the surface flux component (SOFS), the below surface component (SAZ, PULSE, profilers), and the May 2009 Advisory Board-approved Sea glider transects. SOFS#1 is still yet to be deployed, now due March 2010. Within the IMOS EIF

timeframe, it's proposed to fund SOFS#2 to enable continuous occupation of the site. This will obviously be dependent on successful deployment and retrieval of SOFS#1. PULSE is now fully deployed, and ongoing investment will be subject to positive results following the March 2010 recovery.

- SOOP CO2/BGC measurements are proposed to continue from RV Southern Surveyor and L'Astrolabe, and to be enhanced on RSV Aurora Australis. Inclusion of CO2 measurements on two NRS (Yongala and Maria Island) was approved by the Advisory Board in May 2009, and potential enhancement on three more NRS (Kangaroo Island, Port Hacking, Rottnest Island) is proposed – see Theme #5 on Biological Responses.
- In terms of satellite remote sensing of Ocean Colour, the Node Proposal states that it is essential to "Ensure that IMOS class 1 (offshore) in situ optical data sets are assembled, quality controlled and made available to international projects aimed at improving the global products derived from ocean colour satellites. (The Node notes that most of the Ocean Colour facility proposal is around tailoring products for coastal seas and not improving global products. The Node only supports the work in support of improving global products)."
- A new Facility in seasonal fast ice monitoring has also been proposed, building on international collaboration established during the International Polar Year. IMOS investment in ice-based equipment deployments has not been considered of high priority by the Node at this point in time, but may need to be carefully considered in the future.

The Bluewater and Climate Node Proposal prioritised observations into essential, high priority and low priority, as follows:

	Essential	**High Priority**	**Low Priority**
Extend	• core Argo • Altimeter calvalx1 • SOOP SST • SOOP XBT • SOTS • pCO2 on MNF + Astrolabe	• SRS SST (GHRSST)	
Enhance first $8M	• Seals as samplers • Sea gliders to SOTS	• Argo in seasonal ice • CO2 on NRS, Yongala + Maria	
Enhance other	• ITF Array • Polynya Array (Adelie Coast) • pCO2 on AA • Improved global OC products (from it situ data)	• Altimeter calval+3 • 3 x Radiometers (Solander, SS, Spirit of Tas) • Kerguelen Array • CO2 on NRS, other	• Perth Basin Array • Monitoring seasonal build-up and decay of near-shore ice

Assessment – Theme #1, Multi-decadal ocean change

Having considered the Node Proposal and related Facility Proposals in the overall context of the Five Year Strategy and available funding, and in the specific context of the international peer review and Node prioritisation, the assessment of priorities by the Advisory Board and IMOS Office is as follows:

	Essential	Highly Desirable	Next stage	Unsuitable
Extend	• core Argo • Altimeter calvalx1 • SOOP SST • SRS SST (GHRSST) • SOOP XBT • SOTS • pCO2 on MNF + Astrolabe			
Enhance first $8M	• Argo in seasonal ice • Seals as samplers • Sea gliders to SOTS • CO2 on NRS, Yongala + Maria			
Enhance other	• Altimeter calval+3 • ITF Array • Polynya Array (Adelie Coast) • SOFS#2 • pCO2 on AA • Improved global OC products (from it situ data)	• 3 x Radiometers (Solander, SS, Spirit of Tas) • CO2 on NRS, other • Monitoring seasonal build-up and decay of near-shore ice	• Kerguelen Array • Perth Basin Array •	

A summary of the financial implications of this assessment is as follows:

#1 Multi-decadal ocean change	NCRIS	Extension	EIF 1st $8M	Enhancement	2010-13			
	2006-11	2011-13	2009-13	Essential	Desirable	Next stage	Unsuitable	Total
1 Argo	5,602,206	3,667,233	1,800,000					
8 AATAMS - Southern Ocean Seals as Samplers			2,040,747					
11e Satellite Altimetry				1,093,000				1,093,000
2b SOOP - Tropical Research Vessels	250,000							
2c SOOP - SST Sensors	389,352	298,359			937,871			937,871
11a SST L2P Products	595,197	394,296						
2a SOOP - Underway Network XBT	2,951,199	1,458,182						
3c Deepwater Arrays - ITF	see Monitoring boundary currents, and interbasin flows							
3c Deepwater Arrays - Polynya				304,487				304,487
3c Deepwater Arrays - Kerguelen						1,282,457		1,282,457
3c Deepwater Arrays - Perth Basin						904,149		904,149
3a SOFS	1,536,300	515,784		1,148,162				1,148,162
3b PULSE +	2,567,700	1,442,577						
4 ANFOG - Seagliders for SOTS			1,507,004					
2a SOOP - Underway Network BGC				205,120				205,120
6j ANMN - CO2	see Biological responses							
11d Satellite Ocean Colour	see Biological responses							
15 Antarctic Fast Ice Monitoring (AFIM)					555,000			555,000
Theme sub-total	**13,891,954**	**7,776,431**	**5,347,751**	**2,750,769**	**1,492,871**	**2,186,606**		**6,430,246**
% of Grand Total	**27%**	**30%**	**45%**	**18%**	**13%**	**15%**		**12%**
	All as % of Grand Total			**29%**				

The following key points should be noted:

- Ongoing IMOS investment in tracking multi-decadal ocean change builds on a number of key strengths, responds strongly to the Federal Government imperative for enhanced monitoring capability in the Southern Ocean, and is consistent with feedback provided via international peer review.
- Extension costs appear reasonable relative to NCRIS investment.
- The Advisory Board has already responded to priorities in this area, with enhancements for Argo, Southern Ocean Seals as Samplers, and Sea gliders to SOTS funded under the IMOS EIF First $8M.
- Further enhancements will now include:
    - meaningful investment in Satellite Altimetry cal val
    - first-stage investment in the Deepwater Array (Polynya)
    - commitment to SOFS#2, subject to achievement of milestones for SOFS#1, and
    - bringing Aurora Australis into the BGC underway network.
- The ITF Deepwater Array considered under Theme #3 on monitoring boundary currents and interbasin flows is also highly relevant to the priority of monitoring the global ocean circulation.
- A second SOFS mooring (SOFS#2) has been planned from the outset, but was unaffordable under NCRIS. Given that SOFS#1 is still yet to be deployed, the further investment in SOFS#2 will be contingent on successful deployment and recovery of SOFS#1. (See comments in next sub-section on the RAMA tropical moored buoy array.)
- Through encouraging cooperation between the Bluewater and Climate and TasIMOS Nodes, the Storm Bay mooring for Satellite Altimetry cal val will serve a dual purpose. With so many IMOS moorings in the water, we need to continue to look for opportunities to leverage our existing investments so as to make a stronger international contribution in SRS cal val.
- Acquisition and deployment of multiple radiometers on research vessels/ships of opportunity would improve the accuracy of skin SST, but is perhaps not the highest priority given balance of current/proposed investment in SST vs other satellite data streams.
- Establishment of a new Facility in seasonal Fast Ice monitoring is not able to be supported at this stage. There is some divergence of views here. It was rated a low priority in the Node Proposal, but the AAD/ACE CRC community rate it more highly than that. The IMOS Advisory Board noted that the decision to not invest will have consequent effect on AAD/ACE CRC capacity to co-invest elsewhere.

2. Climate variability, and weather extremes

This theme is primarily within the Bluewater and Climate Node, where the focus is on:

- the three, major, well-described, coupled modes of seasonal variability - ENSO, IOD, SAM, and
- intraseasonal variability and severe weather, with particular emphasis on the MJO and tropical fluxes.

Variability and weather extremes are also included in research questions in:

- WAIMOS (propagation of ENSO signals, tropical cyclones and severe weather events),
- QIMOS (tropical cyclones and East Coast Lows), and
- NSW-IMOS (East Coast Lows and severe winter storms).

The Bluewater and Climate Node proposal identifies priorities for observations to train and validate prediction systems, better resolve and simulate ocean-atmosphere fluxes and upper ocean responses, improve accuracy of SST for diagnostic and modelling studies, and monitor transmission of ENSO signals from the Pacific into the Indian Ocean. A summary of proposed observations is as follows (with observations considered under other themes shaded out):

Node focus	**NCRIS observations**	**EIF enhancements**
BW&C – train and validate prediction systems	core Argo SOOP XBT Altimeter cal val x 1	- - Altimeter cal val + 3
BW&C – resolve and simulate ocean-atmosphere fluxes	SOOP surface fluxes (MNF, AA) -	+ Astrolabe, Nth Aust/Tasman RAMA tropical moored buoy
BW&C - improve accuracy of SST	SOOP SST SRS SST (GHRSST)	3 x Radiometers (Solander, Surveyor, Spirit of Tas) -
BW&C - monitor transmission of ENSO climate variations	-	ITF shelf/deep moorings

Discussion of proposals to extend and enhance observations is as follows:

- Most of the observations proposed are considered under Theme #1 (i.e. Argo, SOOP XBT + SST, and SRS Altimetry + SST) and Theme #3 (ITF Array). The only observations specifically considered under this theme are surface fluxes and proposed investment in the RAMA tropical moored buoy array.
- The SOOP surface flux network is another well-established element of the global ocean observing system, linked in to the international Shipboard Automated Meteorological and Oceanographic System (SAMOS). In addition to extending current activities for a further two years, it is proposed to add two additional vessels into the network – L'Astrolabe and one other to be determined.
- A second flux mooring, in addition to SOFS, has been proposed. Its purpose is to improve modelling of the Madden-Julian Oscillation (MJO) for seasonal prediction through the Bureau's Predictive Ocean Atmosphere Model for Australia (POAMA). The Global Tropical Moored Buoy Array is being expanded into the Indian Ocean through international collaboration (called the RAMA array), and this proposal would fill a gap north of Australia. It would be a pilot

deployment in collaboration with NOAA/PMEL (whereas SOFS is being deployed in collaboration with WHOI). Vandalism is also an issue in this region, with the US allowing for 20% loss rates.

The Bluewater and Climate Node Proposal prioritised observations into essential, high priority and low priority, as follows (Theme #2-specific Proposals in **bold**):

	Essential	**High Priority**	**Low Priority**
Extend	• core Argo • SOOP XBT • Altimeter calvalx1 • **SOOP surface fluxes (MNF, AA)** • SOOP SST	• SRS SST (GHRSST)	
Enhance other	• **RAMA tropical moored buoy** • ITF Array	• Altimeter calval+3 • **SOOP surface fluxes (Astrolabe, Nth Aust/Tasman)** • 3 x Radiometers (Solander, SS, Spirit of Tas)	

Assessment – Theme #2, Climate variability, and weather extremes

Having considered the relevant Node Proposals and related Facility Proposals in the overall context of the Five Year Strategy and available funding, and in the specific context of the international peer review and Node prioritisation, the assessment of priorities by the Advisory Board and IMOS Office is as follows:

	Essential	Highly Desirable	Next stage	Unsuitable
Extend	• SOOP surface fluxes (MNF, AA)			
Enhance other		• SOOP surface fluxes (Astrolabe, Nth Aust/Tasman)	• RAMA tropical moored buoy	

A summary of the financial implications of this assessment is as follows:

#2 Climate Variability	NCRIS 2006-11	Extension 2011-13	EIF 1st $8M 2009-13	Enhancement 2010-13 Essential	Desirable	Next stage	Unsuitable	Total
1 Argo	see Multi-decadal ocean change							
2a SOOP - Underway Network XBT	see Multi-decadal ocean change							
11e Satellite Altimetry	see Multi-decadal ocean change							
2d SOOP - Real-time Air-sea Fluxes	299,000	207,403			382,696			382,696
3a RAMA						1,342,519		1,342,519
2c SOOP - SST Sensors	see Multi-decadal ocean change							
11a SST L2P Products	see Multi-decadal ocean change							
3c Deepwater Arrays - ITF	see Multi-decadal ocean change							
Theme sub-total	**299,000**	**207,403**			**382,696**	**1,342,519**		**1,725,215**
% of Grand Total	**1%**	**1%**			**3%**	**9%**		**3%**
	All as % of Grand Total			**0%**				

The following key points should be noted:

- The majority of observational requirements in this area will be met by ongoing IMOS investment in tracking multi-decadal ocean change (see Theme #1) and monitoring boundary currents (see Theme #3).
- Extension costs for the SOOP surface flux work appear reasonable relative to NCRIS investment, and should be supported.
- The highly desirable SOOP surface flux enhancement is unable to be supported at this stage. Available funding is insufficient to support all essential Bluewater and Climate Node priorities, let alone high priorities such as this.
- Contribution to the RAMA tropical moored buoy array was rated as essential by the Bluewater and Climate Node. One external reviewer explicitly questioned this rating, suggesting a downgrade to high. Taking all factors into account, this proposal has been assessed as suitable for "next stage" investment. Given that the SOFS#1 deepwater mooring is yet to be deployed, establishment of a second deepwater flux mooring in the tropics, as a pilot, with a different group of US collaborators, is considered to be at high risk of not delivering useful data within the IMOS EIF timeframe. The advice of the Facility Leader and Operator is that if IMOS is unable to support both RAMA and SOFS#2, the priority should remain on completing SOFS as planned. However if SOFS#1 milestones are not met and SOFS#2 investment doesn't progress (see previous sub-section), the Advisory Board will carefully consider RAMA as a priority for alternative investment.

3. Major boundary currents, and interbasin flows

The term "boundary current" is widely used across the Node Proposals. By way of clarification:

- The EAC is a classically-defined, western boundary current of the South Pacific gyre.
- The Leeuwin Current is described as an eastern boundary current, noting that it is uniquely poleward-flowing.
- The waters around Australia form a complex intersection of the Pacific, Indian and Southern Oceans, and interbasin flows are significant at Australia's northern and southern boundaries i.e.
    - The Indonesian Through Flow in the north,
    - The Tasman Outflow in the south, which feeds the westward flowing Flinders Current as a remnant of the EAC (and claimed by SAIMOS as a "little sister" of the EAC), and
    - The Antarctic Circumpolar Current.
- The Hiri Current, which is the northward (vs southward/EAC) bifurcation of the South Equatorial Current, has claims as a low latitude western boundary current.

In terms of looking at continental slope and deep ocean processes (as opposed to continental shelf processes - see next sub-section), the major boundary currents and interbasin flows considered here are:

- The EAC system, including Tasman Outflow, Flinders Current, and Hiri current
- The Leeuwin Current system
- The Indonesian Through Flow, and
- The Antarctic Circumpolar Current.

Monitoring of the major boundary currents and interbasin flows, in terms of strength (heat and freshwater transport) and variability (seasonal, interannual, decadal), is addressed in the Bluewater and Climate Node and all the Regional Nodes (WAIMOS, QIMOS, NSW-IMOS, SAIMOS and TasIMOS).

A recent OceanObs'09 conference white paper entitled "A global boundary current circulation observing network" is a useful reference – see https://abstracts.congrex.com/scripts/jmevent/abstracts/FCXNL-09A02a-1779443-1-OO09_bc_revised.pdf

In terms of monitoring boundary currents for transport of mass, heat and fresh water, possible approaches include:

- transport mooring arrays,
- SOOP (XBT etc),
- gliders,
- end-point moorings and pressure inverted echosounders (PIES),
- electromagnetics, and
- satellite altimetry,
- or hybrid approaches involving various combinations.

The community white paper notes that "Ideally, a global network of boundary current monitoring arrays will be optimised within the greater ocean observing system, such as near the end points of

high density repeat XBT lines, under repeat satellite altimetry tracks or cross-over points, and overlap with long-range coastal radar installations."

It is important to note that IMOS is not currently monitoring the full-depth transport of mass, heat and fresh water of any of Australia's major boundary currents and interbasin flows.

High density XBT lines (to 700m) are undertaken on the east coast (Tasman Box) and west coast (Fremantle to Indonesia), and these can be combined with satellite altimetry to infer to greater depths. A single sea glider has also been allocated to the Bluewater and Climate Node for trialling in the EAC. None of the cross-shelf arrays in the Regional Nodes currently go deep enough to qualify as "transport mooring arrays".

The Bluewater and Climate Node Proposal notes that "A complete observation network which would capture all aspects of the current systems...is well beyond the resources available within IMOS with existing technology. A more realistic approach is to choose a limited number of strategic locations or 'chokepoints' where representative measurements of the currents may be obtained." It goes on to say that a "second approach is to utilize satellite data streams with full spatial and temporal resolution".

Potential chokepoints suitable for monitoring are suggested as:

- the Indonesian archipelago for the Indonesian Through Flow (ITF)
- the Leeuwin Current off Perth (32°S),
- the Tasman Outflow (south of Tasmania, across the South Tasman Saddle),
- the EAC off Brisbane (26°S) and
- the Hiri Current (14°S).

The Flinders Current is not specifically mentioned in the Bluewater and Climate Node Proposal, though it is dealt with in detail in SAIMOS and referenced in WAIMOS.

A new facility has also been proposed for routine observing of boundary currents – the Facility for Lagrangian Ocean Currents (FLOC). It proposes to deploy Surface Velocity Program (SVP) drifting buoys in the EAC and conduct a pilot in the Leeuwin Current. It is also proposing to use low cost SPOT buoys across Northern Australia's shelf seas (see next sub-section).

Although the primary focus of Regional Nodes is the impact of major boundary currents on continental shelf processes and biological responses (see following sub-sections), some further points do need to be made here:

- IMOS is investing in Sea gliders, which are capable of working in deep water (up to 1000m, for up to 6 months). They are being made available to Regional Nodes. To date, their use has been more in support of process studies. The approach needs to mature into sustained observing.
- NSW-IMOS is proposing substantial new investment in the EAC separation zone "To investigate the EAC, its separation and resultant eddy field along the coast of SE Australia". This could be seen as an alternative approach to the Bluewater and Climate Proposal for monitoring the EAC off Brisbane, and the relative merits of these approaches need to be considered together.

- The introduction section of the WAIMOS Node Proposal provides an overview of a national observing system for the Leeuwin Current. It includes an Arafura Wessels mooring pair designed to capture the seasonal cycle of the Leeuwin, which is hypothesised to originate in this region. Unfortunately, the mooring pair is not referenced in the body of the Node Proposal, either in the research questions or the observations required. However it is included in the Mooring Facility Budget. The merit of this mooring pair needs to be considered in combination with the ITF deep mooring which is designed to capture the inter-annual signal of the Leeuwin Current.
- Related to the above, the NT community provided a late submission outlining their needs, which are perhaps not fully reflected in the sum of WAIMOS and QIMOS Nodes Proposals.

A summary of observations proposed by the Nodes is as follows:

Node focus	**NCRIS observations**	**EIF enhancements**
BW&C – Monitoring major boundary currents	core Argo SOOP XBT 1 x sea glider	Deep moorings: • ITF** • EAC (off Brisbane) • Perth Basin Glider array (sustained pattern of repeat tracks with multiple gliders - at Tas Outflow/SOTS [4 x sea gliders approved*], EAC off Brisbane and/or Leeuwin Current off Perth) SVP Drifters
NSW-IMOS – To investigate the EAC , its separation and resultant eddy field along the coast of SE Australia	1 x sea glider	Stockton Bight mooring Coffs Harbour water sampling Four new coastal radars new REMUS AUV SVP drifters +1 sea glider deployment pa
WAIMOS – Factors influencing the Leeuwin current (from Arafura Sea to Tasmania), and influence of the ITF	2 x sea gliders	Arafura Wessels mooring pair**
QIMOS - variable mass transport in the Coral Sea and impact on GBR shelf circulation	-	2 x sea gliders*
SAIMOS – temporal and spatial variability of the Flinders and Leeuwin currents	1 x sea glider	-

* Approved under the EIF first $8M

** $1.7M approved under the EIF first $8M for a Northern Australian Observing System (details tba)

Discussion of proposals to extend and enhance observations is as follows:

- A new Deepwater (Mooring) sub-facility is proposed, to address identified gaps in monitoring both global ocean circulation (see Theme #1) and major boundary currents and interbasin flows. Deepwater Arrays are proposed to monitor "choke points" in the Indonesian archipelago for the Indonesian Through Flow (ITF), the EAC off Brisbane (26°S), and the Leeuwin Current off Perth (32°S). Lower priorities in the Tasman Outflow (south of Tasmania, across the South Tasman Saddle), and the Hiri Current (14°S) were not included in the ABOS Facility Proposal.
- The ITF Array will consist of three moorings, two in the Timor Passage and one in the Ombai Strait. US and Korean collaborators are proposing to monitor the other major passages (Makassar and Lombok Straits), thus providing full coverage of the ITF through international collaboration. The deployment will leverage experience gained through the INSTANT project, giving a high degree of confidence that it will be successful and can be sustained. The Array will integrate with a proposed shelf array in the Bonaparte Gulf, and will be sited along a satellite altimeter track.
- The EAC Array will take an "end-point" approach, with density moorings at the end points, Pressure-Inverted Echosounders (PIES) along the transect, and gliders running the line. This approach has been used to monitor deep western boundary currents elsewhere in the world e.g. for nine years at 16N in the west-Atlantic (CLIVAR/AMOC project "MOVE"). The Array will be sited along an existing XBT transect, and will integrate with a proposed shelf array off Brisbane, and a proposed coastal radar.
- The Perth Basin Array will consist of a "picket fence" of moorings, with six current meter and property moorings at the western and eastern boundaries, and three temperature and salinity moorings in the interior of the basin.
- The Arafura Wessels mooring pair is designed to capture the seasonal signal in the Leeuwin Current, which is hypothesised to originate from the Gulf of Carpentaria/Arafura Sea. Through discussion at the IMOS National Meeting and subsequent Steering Committee Meeting, questions were raised as to whether the mooring pair would in fact be adequate to capture the seasonal signal as proposed.
- Relative merits of the NSW-IMOS proposal for the EAC separation zone, and the Bluewater and Climate proposal to monitor the EAC "choke point" at 26^{o}S, were discussed at the Steering Committee meeting on 9th December. In summary, it was agreed that for monitoring the boundary currents (the focus in this sub-section), monitoring the "choke point" is the only plausible approach. It was further agreed that if this was done, some infrastructure proposed further south (e.g. around Coffs Harbour) could in fact be refocused or redeployed.
- ANFOG is currently operating five Sea gliders, with six more approved under the EIF First $8M bringing the total fleet to 11. Four will be deployed along the SOTS line, and two will be deployed in the Coral Sea (Hiri current). In undertaking these new deployments, emphasis will be placed on maturing the Facility into a sustained observing mode. Deployment of the other five Sea gliders will require further discussion, including requirements to support the proposed EAC "end-point" approach.
- The FLOC Drifter proposal says that it "will provide a national fleet of surface drifting buoys with the capacity to sustain a routine observing program for Australia's boundary currents". Through subsequent discussion, including at the IMOS National Meeting and Steering Committee Meeting, the focus was modified to "providing validation of Bluelink", noting that IMOS SVP Drifters would also augment the global drifter array and provide satellite cal val.

The Bluewater and Climate Node Proposal prioritised observations into essential, high priority and low priority, as follows:

	Essential	High Priority	Low Priority
Extend	• 5 x Sea gliders (but move for single to mutli-glider deployment) • SOOP XBT • core Argo		
Enhance first $8M	• ITF Deepwater Array • SOTS Sea gliders x 4	• GBR (Hiri) Sea gliders x 2	
Enhance other		• EAC Deepwater Array	• SVP Drifters

The Regional Node Proposals did not include explicit prioritisations. However the following points of convergence (or otherwise) have emerged through discussion at the IMOS National Meeting and subsequent Steering Committee Meeting:

- There is general agreement that IMOS should be monitoring the full-depth transport of Australia's major boundary currents and interbasin flows. Without this, efforts to answer Node research questions about strength (heat and freshwater transport) and variability (seasonal, interannual, decadal) will continue to lack fundamental context.
- There is general agreement that the ITF is an essential priority, given the contribution it will make to understanding the Leeuwin Current (and Holloway Current), as well as global ocean circulation and climate variability.
- There is strong support for the EAC Array, but it does have a different level of priority from different perspectives. It is the second order priority from a Bluewater and Climate perspective. However it is seen as the highest priority by the "east coast" Regional Nodes (Queensland, NSW and to a lesser extent Tasmania). There is even some willingness to forgo other infrastructure to assist with affordability.
- A suggestion was made by WAIMOS that it may be more cost effective to implement a Perth "end point" array given existing investment in the Two Rocks shelf array. However it was generally agreed that from a national perspective, it would not make sense to give a Perth array a higher priority than the EAC Array at this point.
- The NT community has also put the position that the ITF is the highest priority, followed by the Arafura Wessels pair.
- The recent decision to increase the Sea glider fleet from five to 11 is seen as positive, and there is general (though somewhat tentative) agreement that moving to sustained, multi-glider deployments is appropriate.
- There is general agreement that SVP Drifter data would be very interesting, but that at the deployment densities proposed, it will not make a direct contribution to monitoring the boundary currents and interbasin flows.

Assessment – Theme #3, Monitoring boundary currents and interbasin flows

Having considered the relevant Node Proposals and related Facility Proposals in the overall context of the Five Year Strategy and available funding, and in the specific context of the international peer review and Node prioritisation, the assessment of priorities by the Advisory Board and IMOS Office is as follows:

	Essential	Highly Desirable	Next stage	Unsuitable
Extend	• 5 x Sea gliders (but move for single to mutli-glider deployment)			
Enhance first $8M	• ITF Deepwater Array • SOTS Seagliderssx4 • GBR (Hiri) Sea gliders x 2		• Arafura Wessels mooring pair	
Enhance other	• EAC Deepwater Array		• SVP Drifters	

A summary of the financial implications of this assessment is as follows:

#3 Monitoring boundary currents	NCRIS	Extension	EIF 1st $8M	Enhancement 2010-13				
	2006-11	2011-13	2009-13	Essential	Desirable	Next stage	Unsuitable	Total
3c Deepwater Arrays - ITF			622,421	291,647				291,647
3c Deepwater Arrays - EAC				1,535,730				1,535,730
3c Deepwater Arrays - Perth Basin	see Multi-decadal ocean change							
6g ANMN - NAOS, Arafura Wessels						1,172,951		1,172,951
4 ANFOG - Seagliders for GBR			753,502					
1 Argo	see Multi-decadal ocean change							
2a SOOP - Underway Network XBT	see Multi-decadal ocean change							
14 FLOC - SVP Drifters						1,218,584		1,218,584
Theme sub-total			**1,375,923**	**1,827,377**		**2,391,535**		**4,218,912**
% of Grand Total			**12%**	**12%**		**16%**		**8%**
	All as % of Grand Total			**3%**				

The following key points should be noted:

- IMOS is not currently monitoring full-depth transport of any major boundary currents and interbasin flows, but targeting EIF investment into this area is considered to be strategically important.
- The ITF Array is the highest priority, and responds to the Federal Government imperative for extended coverage in northern Australian waters. The Advisory Board has already approved $1.7M to commence establishment of a Northern Australian Observing System.
- The EAC Array is the next highest priority. It will underpin "east coast" Regional Nodes, and enable some refocusing of proposed shelf-scale infrastructure. It is generally agreed that the deepwater array (considered here) should only be deployed if the shelf array (next sub-section) is also deployed. Therefore support for this priority is contingent on other decisions.

- It is recognised that the Arafura Sea/Gulf of Carpentaria will remain a gap for IMOS at this stage. The science case for the Arafura Wessels mooring pair is not currently strong enough to justify a $1.2M investment.
- The Advisory Board has already approved $0.75M for two Sea gliders to operate in the Coral Sea/Hiri Current, and along with the four Sea gliders for SOTS, this represents a tangible step towards sustained, multi-glider deployment.
- The SVP Drifter proposal does not currently have strong support from the Nodes. At $1.3M it appears relatively expensive for (primarily) Bluelink validation.

4. Continental shelf processes

All Regional Nodes have a strong focus on continental shelf processes, and many of their research questions are framed around eddy encroachment, upwelling and downwelling, cross shelf exchange, coastal currents, and wave climate. (N.B. Given that many of these research questions are linked to biological responses, this sub-section is closely related to the next one.)

Through the establishment of IMOS, with its emphasis on fixed infrastructure in the Regions (National Reference Stations, shelf mooring arrays, coastal radar and wireless sensor networks), a series of focal points have been established for observing continental shelf processes – areas that are impacted by boundary currents, and are impacting on coastal regions of socio-economic and ecological significance.

Node	**Focal points**	**NCRIS observations**
WAIMOS	Perth region (Jurien Bay to Fremantle)	Rottnest NRS Two Rocks shelf mooring array Perth Canyon shelf mooring array Turquoise Coast (CODAR) Perth Canyon (WERA) Slocum glider Two Rocks transect
	Ningaloo Reef	Ningaloo NRS (mainly biological – see next section)
GBROOS	Southern GBR (Capricorn Bunker)	Capricorn Channel/Heron Island moorings Southern GBR (WERA) Wireless sensor networks (H Is/OT Is)
	Townsville region	Yongala NRS Myrmidon shelf mooring array
	Northern GBR (Lizard Island)	Lizard Island shelf mooring array
NSW-IMOS	Sydney region	Port Hacking NRT Sydney shelf mooring array Slocum glider deployments
	Coffs Harbour	Coffs Harbour shelf mooring array Coffs Harbour (WERA)
	Jervis Bay	Jervis Bay shelf mooring array
	Eden	Eden shelf mooring array
SAIMOS	Adelaide region	Kangaroo Island NRS KI/Eyre Peninsula shelf mooring array Cape Spencer (WERA) Slocum glider deployments
	Bonney Coast	Bonney Coast (CODAR)

Regional Node Proposals include the following enhancements:

Node	Focal points	EIF Enhancements (approved in bold)
WAIMOS	Pilbara: Broome to North West Cape	Shelf mooring array** Slocum glider deployments Ferry boxes on supply vessels (no budget) SPOT drifters
	Kimberley: Broome to Cape Londonderry	Shelf mooring array** Slocum glider deployments Ferry boxes on supply vessels (no budget) SPOT drifters
	Bonaparte: Cape Londonderry to Darwin	**Darwin NRS** Shelf mooring array** SPOT drifters
	Carpentaria: Darwin to Torres Strait	Arafura Wessels mooring pair ** SPOT drifters (See QIMOS)
QIMOS	SEQ	**Stradbroke NRS*** Shelf mooring array Coastal radar
	Torres Strait/Gulf of Carpentaria	SPOT drifters Support for TSRA tide gauges (See WAIMOS)
NSW-IMOS	Stockton Bight	Additional mooring 4 x Coastal radar REMUS AUV SPOT drifters
SAIMOS	*Bonney Coast (intensification, not new)*	*Additional mooring*
TasIMOS	Maria Island	**Maria Island NRS** Shelf mooring array Slocum glider deployments
	Hobart region	Additional mooring Slocum glider deployments

* Approved under the EIF first $8M

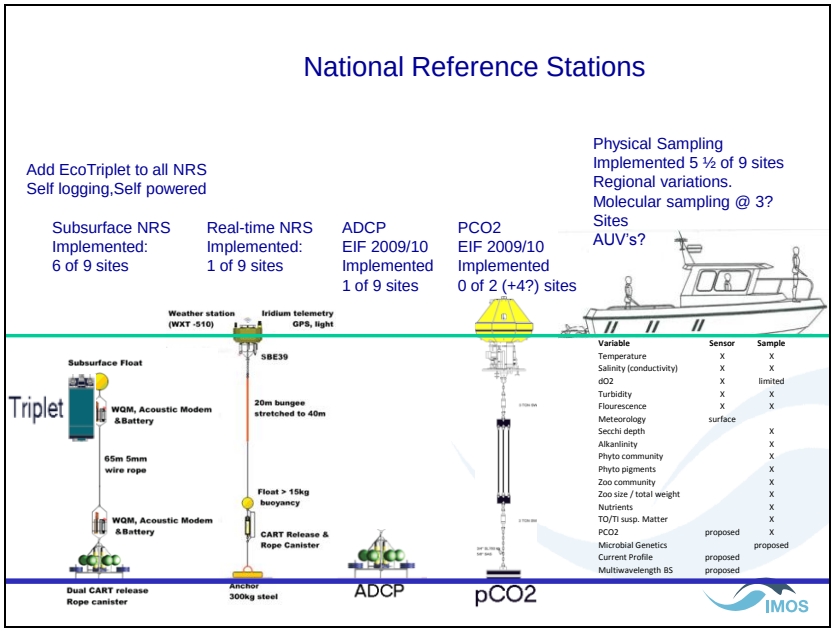
** $1.7M approved under the EIF first $8M for a Northern Australian Observing System (details tba)

The boundary current section of the Bluewater and Climate Node Proposal notes that a systematic effort to monitor the shelf region is essential, and proposes (in addition to a "fully-instrumented NRS") to add Pressure sensors on AATAMS cross shelf arrays. This has been included in the AATAMS Facility Budget, but is not noted in any of the Regional Node Proposals.

Discussion of the proposals to extend and enhance observations is as follows. Facility Proposals are discussed first, followed by the Node perspectives.

Facility Proposals

- Proposals to extend and enhance the National Reference Stations (NRS) were influenced by a number of drivers, which in total have led to an unrealistic plan and budget being submitted. The total picture is shown in the diagram below.



- This has forced us to go "back to basics" with the NRS. Through discussion at the IMOS National Meeting and subsequent Steering Committee Meeting, points of convergence appear to be as follows:
    - Primary focus of the NRS needs to be on long time series of core variables i.e. Temperature, Salinity (conductivity), dO2, Turbidity, Fluorescence, and Meteorology (where surface expression is logistically feasible).
    - This will be implemented via the standard NRS mooring (bottom left corner of diagram).
    - Ideally, we need to sustain the nine NRS sites already approved. Suggestions that we could do more at fewer points have been consistently rejected. However the need to balance cost and scope is now widely-accepted.
    - These moorings should be serviced no more frequently than required to maintain quality data sets for the above core variables.
    - Given the primary focus on long time series, the three (of nine) NRS sites that have a long history (i.e. Maria Island, Port Hacking, and Rottnest Island) will have priority for ongoing development.
    - Physical sampling (and processing of samples) to continue at all sites if achievable and affordable. Prima facie, mooring turnarounds provide an opportunity to undertake cost effective physical sampling (though not subsequent processing, which is expensive). However location and associated logistical considerations are a major factor, and physical sampling should only be undertaken where it can be afforded at a scientifically- appropriate frequency. For example, if logistics and cost

dictate that sampling can only be done quarterly, but a long time series of quarterly observations will be insufficient to resolve likely variability, then the sampling will not be undertaken.
    - No further investment in real time at this stage. Maria Island is now real time, and telemetry packages have been built for Rottnest and one more site. The rationale for real time could be use of data (e.g. to feed data assimilating models), or it could be to assist in maintaining quality data streams at remote sites. We need to be clear about the motivation in each case.
    - No further investment in ADCP's at this stage (i.e. beyond EIF First $8M). The rationale for ADCP's on the NRS is as context for other observations (especially biological), not as single point physical measurements. However ADCP's do make sense from a physical perspective when viewed as part of shelf arrays (e.g. in SA, WA and NSW).
    - Triplets to be added to a subset of the NRS sites to characterise regional water properties, as a step towards bringing bio-optical parameters into the suite of core variables. Advice on the priority locations will be sought from the recently-formed IMOS National Working Group on Bio-optical Instrumentation and Observing. This group will also be asked to advise whether full rollout across the NRS is feasible and justifiable within the IMOS EIF timeframe.
    - The NRS sites can also provide an effective and efficient platform for other measurements, and this will be enabled where appropriate. However it should not be seen as an increase in the scope of the NRS – see comments above about core variables. Recent enhancement for pCO2 is a good example. Any further expansion of the pCO2 network should be driven by the needs of the science, not necessarily by the location of NRS sites. For example, these measurements may be much more useful at sites with certain biochemical characteristics, such as reef systems and upwellings.
    - Funding for Operators to maintain NRS sites needs to be adequate for the agreed tasks. The major Operators of mooring infrastructure (especially CSIRO and AIMS) are saying that NCRIS-level budgets are not adequate by a substantial margin. Either NRS (and mooring) budgets will need to increase at the expense of other priorities, or scope will need to be reduced to match the resources available.
- Proposals to extend and enhance the Australian National Mooring Network were also influenced by a number of drivers, which again led to an unrealistic plan and budget being submitted. Issues around the shelf arrays are best discussed in the context of the Regional Nodes (see below), though two general comments can be made here:
    - Emphasis within the existing shelf arrays (GBR, southwest WA, NSW and SA) will be on consolidation and integration, rather than further enhancement.
    - Any new shelf arrays (proposed in northern Australia, SEQ and Tasmania) should be implemented with a focus on consolidation and integration from the outset.
- It is proposed to extend the GBR wireless sensor network Facility (FAIMMS) for another two years, to mid 2013. This will require ongoing co-investment by the Queensland State Government.
- In addition to the six paired coastal radar installations committed under NCRIS, a new WERA pair is proposed for SEQ as part of an integrated package (along with moorings, acoustic

receivers and AUV), and a significant enhancement is proposed in NSW, with three new CODAR installations (one co-invested by SIMS) and one new WERA installation. Enhancement at this scale is problematic given the ACORN Facility's current stage of development. Issues include the long lead times involved in becoming operational (approvals, installations, power), and the apparent complexities in delivering QC'd data for use by the community. Differences between WERA and CODAR data may also be significant. The Facility seems more comfortable with the WERA data, and it would seem prudent to gain some experience with use of CODAR data in Australia before committing to major enhancement on this front. Turquoise Coast (WA) and Bonney Coast (SA) installations will provide this opportunity during 2010. Willingness of State Governments and other partners to co-invest in coastal radar installations is another important issue to be considered.

- In addition to the Sea gliders discussed under the boundary current sub-section (see above), it is proposed to maintain the current fleet of three Slocums and acquire two more units to run on mooring lines in Northern Australia, and three new units for the proposed Tasmanian Node. There has been much healthy debate about the use of gliders for sustained observing vs supporting process studies, and this needs to continue. There is reasonable consensus on the need to move to multi-glider deployments, and enhancements will only be approved on this basis. Use of the Slocums in southwest WA, in concert with the Two Rocks transect, Perth Canyon moorings and Rottnest NRS, appears to set a good example for the use of these gliders in a sustained observing context.
- As noted in the sub-section on boundary currents (see above), a new Drifter Facility (FLOC) is proposed which includes a component for low cost SPOT buoys to be deployed across Northern Australia's shelf seas. At the National Meeting and subsequent Steering Committee Meeting, the difficulties of interpreting drifter data in a sustained observing context were raised. Adding temperature to these drifters would help, but raises some technical issues. There is also a question as to whether the SPOT satellite provider will actually support a shift from current casual access to 24/7 365 day pa use. It is possible that this proposal is a little premature for IMOS.
- The AUV Facility Proposal has two elements – extension and enhancement of the current Sirius AUV operation (see next sub-section) and acquisition of a new REMUS AUV. At least to some extent, the REMUS proposal is pitched as an alternative to Slocum gliders on the shelf. Slocum gliders clearly have limitations in observing the deep, energetic mesoscale eddy field in the Tasman Sea, but it will be more productive to investigate technology options in the context of forward planning for the Glider Facility than to set up a parallel activity in another Facility. It is also worth noting that this proposal is only supported by a single Regional Node (NSW).
- The Queensland Mooring Proposal includes a request for $0.5M to support operation of Torres Strait Regional Authority (TSRA) tide gauges. This is not an appropriate investment for IMOS.
- The Bluewater and Climate Proposal to add pressure sensors on AATAMS cross shelf arrays gained no traction with the Regional Nodes and will not be pursued at this stage.
- Ferry Boxes on supply vessels were included in the WAIMOS Node Plan, but unfortunately no SOOP Sub-Facility Proposal was developed.
- It is worth noting that Satellite Remote Sensing (SST and OST) gets little or no mention in the observational requirements of Regional Nodes.

Node perspectives (N.B. In general, Regional Node Proposals did not include explicit prioritisations.)

WAIMOS

- In response to the international peer reviews and feedback from the IMOS Board, the WAIMOS Node Proposal was rewritten during December.
- The Proposal has an emphasis on sustaining existing infrastructure in the Perth region, and enhancing in northern Australia in response to the Federal Budget imperative and WA State priorities.
- As noted above, the combination of shelf moorings, canyon moorings, NRS, gliders and coastal radar is already well-consolidated in the southwest, and the priority to sustain is clear and achievable.
- Plans for enhancement in the north are very ambitious given the cost and logistical challenges associated with working in this remote region, and include three shelf mooring arrays, two Slocum gliders and 324 (low cost) SPOT drifters, as well as a range of biological observations to be considered in the next sub-section.
- The enhancement spans Carpentaria, Bonaparte, Kimberley and Pilbara regions, and includes WA, NT, Queensland and Commonwealth interests. Prioritisation is therefore complex.
- From the WA State perspective, the interplay of socio-economic and ecological drivers that is occurring in the northwest means that the Kimberley, Pilbara, and Bonaparte regions are priorities (in that order). From the NT perspective it is Bonaparte and Carpentaria. From the Queensland perspective, it is Carpentaria. The priority for the Bluewater and Climate Node, which reflects Commonwealth climate interests, is the Indonesian Through Flow/Bonaparte Region.
- There is general agreement that the ITF deepwater array is an essential priority (see Theme #3), and there is also general agreement that to deploy the deep array and not the related Bonaparte shelf array would represent a significant missed opportunity.
- The WA State Government is contemplating cash co-investment, but there will be no decision until Q2 2010 so scenarios with and without co-investment will need to be considered.
- The NT Government has indicated that the ITF array (shelf and deep) is their highest priority, and are considering co-investment (as yet unspecified).
- In responding to the northern Australia imperative, it is clear that the drivers are strongest in the northwest, and so the northeast may remain a gap in the IMOS EIF timeframe (noting that there are other gaps that will also remain at the national level).
- Discussion about the NRS (see above) is particularly significant here, given that four of the nine sites are at Rottnest, Ningaloo, Esperance and Darwin, with logistical and cost challenges being particularly significant at Ningaloo and Esperance.

QIMOS

- The Node Proposal emphasises, in order of priority, sustaining existing infrastructure on the GBR, enhancing in SEQ, and enhancing in Torres Strait/Gulf of Carpentaria.
- GBROOS is well-established and the priority to sustain is clear, though integration of the coastal radar could be improved. GBROOS infrastructure has been established with Queensland State co-investment included, and combined with the fact that costs are increasing, it will be essential for co-investment to continue to mid-2013 if the shelf moorings and wireless sensor network are

to be maintained. In the unlikely event that continued co-investment cannot be negotiated, the view of the Node is that no further investment would be made in the wireless sensor network so as to maintain the higher-priority mooring data streams.

- Cost pressure in this region is in part driven by the general issue of matching resources to scope, but also a specific issue regarding vessel costs. WAIMOS enhancement in the northwest will be underpinned by AIMS contributing up to 100 days of RV Solander time. This will create a gap on the GBR to be backfilled by charter, thus increasing costs in this region. From a whole-of-IMOS perspective, the point is that there is a limit to the number of vessel days that can be provided as co-investment, and enhancements requiring increased vessel support will therefore come at a higher marginal cost.
- Plans for enhancement in SEQ are ambitious, though have the advantage of being located close to a major population centre. The plan includes our recently-approved Stradbroke Island NRS, a shelf mooring array, and a coastal radar pair (WERA), as well as a range of biological observations to be considered in the next sub-section. The shelf array is linked to a deepwater array proposed by the Bluewater and Climate Node, and strongly supported by the "east coast" Regional Nodes, including QIMOS.
- There is general agreement that the 26^{o}S deepwater array is a high priority for monitoring the EAC (see Theme #3), and there is also general agreement that to deploy the deep array and not the related shelf array would represent a significant missed opportunity.
- It is recognised that enhancement in Torres Strait/Gulf of Carpentaria will be modest to nil in the IMOS EIF timeframe.
- The Queensland State Government is contemplating further cash co-investment. As noted above, continued co-investment will be required to sustain the GBR shelf moorings and wireless sensor network. There will be no decision until Q2 2010, so scenarios with and without co-investment will need to be considered.

NSW-IMOS

- The Node Proposal includes plans to extend and enhance, and represents a reasonably significant intensification of current activity.
- In addition to sustaining the current infrastructure (which involves a yet to be installed coastal radar installation at Coffs Harbour), plans for enhancement include four more coastal radar installations (one WERA and three CODAR including one co-invested by SIMS), a new mooring in Stockton Bight, and a REMUS AUV, as well as a range of biological observations to be considered in the next sub-section.
- There appears to be room for some consolidation within this Node. The Sydney shelf mooring and Port Hacking NRS lie at the core, and are well-integrated with Sydney Water and Manly Hydraulics Laboratory interests and assets. During discussions about monitoring the EAC at the IMOS National Meeting and subsequent Steering Committee Meeting, it emerged that if the shelf array, deep array and coastal radar go in at 26^{o}S, the mooring and coastal radar at Coffs Harbour could be refocused or redeployed. Also, the utility of the single point Eden mooring designed to capture the southward flow of the EAC could be affected by establishment of a Tasmanian Node with an EAC focus. The value of the single point mooring at Jervis Bay has also been discussed. In summary, it could be argued that the Node has been attempting to take too much responsibility for monitoring the EAC with too few assets spread thinly, and the

opportunity to take a more national approach to the EAC under IMOS EIF creates the potential for greater focus and integration on continental shelf processes within the NSW Region.

- The NSW State Government is contemplating cash co-investment. The decision timeframe is not yet clear, so scenarios with and without co-investment will need to be considered.

SAIMOS

- The Node Proposal has an emphasis on sustaining existing infrastructure in the Adelaide and Bonney coast regions.
- The combination of shelf moorings, NRS, gliders (Slocum and Sea glider), and coastal radar is well-consolidated, and the priority to sustain is clear. Biophysical integration is a particular focus in this Node, and it also includes a range of biological observations to be considered in the next sub-section.
- There does appear to be some room for consolidation. An additional shelf mooring (SAM3MS) is proposed, and this looks to be a sensible decision based on system understanding gained in the first phase of IMOS. However one of the other shelf moorings (SAM4CY) near Cape du Couedic Canyon had not proven to be so important, and there is a case for redeployment. The required equipment is not a straight swap, but this should be manageable within the broader IMOS moorings portfolio.
- Also, in addition to proposing another new mooring on the Bonney Coast, SARDI is saying that the NCRIS-level budget is not adequate to sustain the current mooring infrastructure, which also has a significant hyrdographic sampling component. An alternative approach would be to maintain the budget and reduce the scope of what is being attempted to match the resources available.
- The SA State Government is not currently contemplating any further cash co-investment.

TasIMOS

- A new Node is proposed in Tasmania, supported by UTAS/IMAS, TAFI and CSIRO.
- A staged approach is outlined, starting with a modest first phase in the IMOS EIF timeframe.
- Building on the foundation provided by the Maria Island NRS, a combination of shelf moorings and Slocum gliders is proposed, as well as a range of biological observations to be considered in the next sub-section. Biophysical integration is intended to be a particular focus in this Node
- The Tasmanian State Government and University of Tasmania are providing cash co-investment in the NCRIS phase, in support of the IMOS Office being located at UTAS. Negotiations are underway to extend this for another two years. Establishment of a Tasmania Node is likely to be a requirement for ongoing investment, which is not unreasonable. Consistent with the approach taken in GBROOS, financial plans have been set on the assumption that continued co-investment will be forthcoming. Indications are positive.

Assessment – Theme #4, Continental shelf processes

Having considered the relevant Node Proposals and related Facility Proposals in the overall context of the Five Year Strategy and available funding, and in the specific context of the international peer review and Node prioritisation, the assessment of priorities by the Advisory Board and IMOS Office is as follows.

	Essential	Highly Desirable	Next stage	Unsuitable
Extend	• NRS x 8 • Shelf mooring arrays in all Nodes • Coastal radar x 6 • Slocum gliders x 3			
Enhance first $8M	• NRS at Stradbroke • pCO2 at 2 sites • ADCP's on NRS • Commence Kimberley shelf array			
Enhance other	• Bio-optics on NRS • Increased funding for mooring Operators • Commence SEQ shelf array (subject to Qld co-investment) • Bonaparte shelf array • TasIMOS gilders (partial)	• Complete SEQ shelf array • Complete Kimberley shelf array (subject to WA co-investment) • Pilbara shelf array (subject to...) • Glider for NW WA (subject to...)	• Tasmanian shelf array • Coastal radars in SEQ and NSW (but subject to State co-investment decisions) • TasIMOS gilders (partial) • SPOT Drifters	• Continued scope creep in NRS • TSRA Tide Gauge support • Continued intensification and expansion of regional shelf arrays

A summary of the financial implications of this assessment is as follows:

#4 Continental shelf processes	NCRIS	Extension	EIF 1st $8M	Enhancement	2010-13			
	2006-11	2011-13	2009-13	Essential	Desirable	Next stage	Unsuitable	Total
6f National Reference Stations	3,632,838	1,892,497	3,369,792	508,045			1,068,382	1,576,427
6a ANMN - Queensland	2,683,000	1,736,275					455,000	455,000
6b ANMN - New South Wales	2,528,999	1,570,950		147,629			1,758,125	1,905,754
6c ANMN - Southern Australia	2,883,599	1,021,014		352,204			2,430,811	2,783,015
6d ANMN - Western Australia	2,031,346	741,636		318,796	658,008		1,290,351	2,267,155
6h ANMN - SEQ				848,637	311,428			1,160,065
6i ANMN - Tasmania						1,054,354		1,054,354
6g ANMN - NAOS, Kimberley			1,077,579		1,658,412			1,658,412
6g ANMN - NAOS, Pilbara					2,071,535			2,071,535
6g ANMN - NAOS, ITF				2,023,008				2,023,008
7 ACORN	5,284,316	1,442,616			1,344,649	2,592,950		3,937,599
9 FAIMMS	1,915,000	589,430						
4 ANFOG	4,200,000	2,058,379		500,000	732,045	598,068		1,830,113
15 FLOC - SPOT Drifters						593,622		593,622
Theme sub-total	**25,159,098**	**11,052,797**	**4,447,371**	**4,698,319**	**6,776,077**	**4,838,994**	**7,002,669**	**23,316,059**
% of Grand Total	**49%**	**43%**	**37%**	**31%**	**58%**	**33%**	**56%**	**43%**
	All as % of Grand Total			**44%**				

The following key points should be noted:

- Scope and cost of the NRS needs to be capped, and actively managed onto a sustainable footing. Beyond the enhancements approved as part of the EIF First $8M, the only other enhancement will be for bio-optics. The detailed consequences will need to be worked through, but it is highly likely that physical sampling will not be undertaken at all sites.
- The existing shelf arrays in GBR, southwest WA, NSW and SA will be sustained, but not intensified and expanded. Some consolidation will be required in NSW and SA. A modest level of additional funding will be provided to all Operators to assist in the process of consolidation and integration. However it is accepted that in some cases, scope may need to be reduced to ensure sustainability within available resources.
- The scale of enhancement in SEQ will be dependent on the level of co-investment by the Queensland State Government. IMOS will make an initial investment of ~$0.850M to commence the shelf array, and invest $1.535M in the 26^{o}S deepwater array. If the maximum level of State co-investment is forthcoming, all of the Node requirements can be delivered. If the investment is mid-range, the shelf array and AATAMS curtains will be achievable, but not the coastal radar. If no co-investment is available for SEQ, IMOS will have ~$0.850M for reinvestment elsewhere and the $1.535M deepwater array will also need to be reconsidered given the desirability of a matching shelf array to maximise the benefits from the deep water array.
- GBROOS shelf moorings and sensor network will be sustained, subject to continued co-investment by Queensland Government, and greater integration of coastal radar encouraged.
- The scale of investment in northwest WA will be dependent on the level of co-investment by WA Government. IMOS will implement the Bonaparte shelf array, in concert with the ITF deepwater array, and will make an initial investment of $1.078M to commence the Kimberley shelf array. These decisions will be supported by the $1.7M approved in May 2009. If the maximum level of State co-investment is forthcoming, the Kimberley and Pilbara arrays, glider deployments, AATAMS enhancements and increased support for other WA moorings (including NRS sites) will be achievable. Various scenarios are possible at lower levels of co-investment. If no co-investment is available for northwest WA, IMOS will have $1.078M for reinvestment elsewhere.
- Subject to successful negotiation of continued co-investment by the Tasmanian State Government, TasIMOS will be established as a new Regional Node. Building on the foundation provided by the Maria Island NRS, glider deployments will be commenced (although at lower than requested levels), the Storm Bay mooring installed and AUV surveys supported. Close collaboration with the Bluewater and Climate Node will be strongly encouraged as there is excellent potential for synergy e.g. with Sea glider deployments.
- The NSW Node will be sustained, with some requirement for consolidation in the moorings area. The Node is expected to benefit greatly from enhanced focus on the EAC at the whole-of-IMOS level. If potential State Government co-investment is forthcoming, some desirable priorities will be supported.
- The SA Node will be sustained, with some requirement for consolidation in the moorings area. Availability of coastal radar data is expected to be of great benefit to the Node.
- Close attention will be paid to further development of the coastal radar Facility, to ensure that it maximises its potential. The significant investment made through NCRIS means that there is currently a lot of latent potential in this area.

5. Biological responses – productivity, abundance, distribution

As noted above, the strong focus of Regional Nodes on continental shelf processes is closely related to their focus on biological responses. However the relationship is by no means straightforward. Biological responses (in terms of productivity, abundance, and distribution) are being considered at chemical, microbial, and various trophic levels, in the benthic and pelagic domains. Furthermore, the Bluewater and Climate Node is also proposing stronger bio-physical integration.

The following table attempts to summarise the current NCRIS and proposed EIF observations from a "whole-of-system" perspective:

Focus	NCRIS observations	EIF enhancements (Nodes)
Chemical	NRS sampling	NRS pH* (BW&C)
		SOOP Nutrients (BW&C)
Microbial	-	Molecular Microbial Observing (QIMOS, NSW-IMOS, TasIMOS Stage 2) – extend NRS sampling
	-	SAIMOS proposal includes stable isotope analysis, DNA sequencing, and experiments on primary productivity and carbon cycling, buried in the Mooring budget
Benthos	AUV (4-6 missions pa) • GBROOS • NSW-IMOS (Jervis, Coffs) • SAIMOS (Joseph Banks Is, Whyalla) • WAIMOS (Ningaloo) • no node (Tas, Scott Reef)	AUV (22 sites) • Ningaloo and Scott Reef (WAIMOS/NW) • Naturaliste, Rottnest, Jurien, Abrolhos (WAIMOS/SW) • Townsville (QIMOS/GBR) • Stradbroke and Moreton Islands (QIMOS/SEQ) • Byron, Port Stephens, Batemans (NSW-IMOS) • 9 x survey sites visited every 2 years (4 pa), Cape Barren, Freycinet, Bruny, Maatsuyker (TasIMOS) • Cape Howe, Vic (no node)
Plankton (primary production)	NRS sampling	NRS bio-optics
	SOOP CPR • Brisbane/Melbourne (NSW-IMOS, no node) • Southern Ocean (BW&C)	SOOP CPR • Brisbane/Wellington (BW&C) • Cairns/Gladstone (QIMOS) • Melbourne/Adelaide (SAIMOS) • Wyndham/Broome, Carnarvon/Fremantle (WAIMOS) • Devonport/Nelson (annual) (TasIMOS) SOOP Southern Ocean
	SRS – Lucinda Jetty Coastal Observatory (LJCO)	LJCO enhancement NRS bio-optics Bio-optical dbase National ocean colour products
	-	NCOTS, sediment trap moorings at • Port Hacking (NSW-IMOS) • KI/Eyre Penn (SAIMOS) • Two Rocks (WAIMOS)
Nekton (mid-trophic)	-	SOOP Bio-acoustics (BW&C, Tas)
Apex Predators	AATAMS • OTN (WAIMOS, Bass Strait Gates-no node) • NRETA (WAIMOS) • Coffs, Sydney, SEACAMS (NSW-IMOS) • Glenelg (SAIMOS) • SW WA/CSIRO (no node)	AATAMS • OTN (QIMOS/GBR)* • Apex predators in SO* (BW&C) • Seals in GAB* (SAIMOS) • Rowley Shoals and Scott Reef (WAIMOS/NW) • 3 x curtains off Brisbane (QIMOS/SEQ) • 3 x curtains N/S of Glenelg line, 6 x receivers on shelf moorings, ~30 receivers off Portland (SAIMOS) • 2 x curtains at Maria Island (41) and St Helens (31)
	Passive Acoustics (WAIMOS, NSW-IMOS, SAIMOS)	Passive Acoustics (SO/BW&C, NW WA/WAIMOS, SEQ/QIMOS)

* Approved under the EIF first $8M

The overall picture is far from coherent. This is not surprising. From a global ocean observing system perspective, sustained biological observing remains immature, and IMOS is in waters that are not well-charted. This is recognised as global challenge for the next decade, and IMOS is well-placed to play a significant international role.

Discussion of the proposals to extend and enhance observations is as follows:

National Reference Stations (NRS)

- Proposals to extend and enhance the NRS have been discussed in the previous sub-section. The issues of particular relevance to the Biological Responses Theme are biogeochemical sampling, and bio-optical sensors.
- Commitment to biogeochemical sampling at NRS sites remains strong. However the proposed cost of extension and enhancement is unaffordable. The extension budget submitted by CSIRO is $600K higher than expected based on a projection of 2010-11 costs into 2011-12 and 2012-13. AIMS and SARDI mooring budgets are also in excess of expectations. The cost of extending the $1.8M enhancement approved under the EIF first $8M is another $2.1M (or $700K pa). Further biogeochemical enhancement of ~$1M has also been proposed by CSIRO. In line with key elements of the IMOS Five Year Strategy, it is time to cap the NRS biogeochemical sampling budget, and reduce the scope of what is being attempted to match the resources available.
- Enhancement of bio-optical sensors on the NRS is seen to be strategically important, but the initial proposal was overly ambitious and too costly at ~$1.1M. A phased rollout is now planned, and the cost has been reduced to ~$0.5M.

Acidification Moorings

- pCO2 Acidification moorings at the Yongala (tropical) and Maria Island (temperate) NRS sites were approved under the EIF First $8M. For the $600K investment approved to date, the total cost to mid-2013 is now estimated to be $1.375M. A proposal has been submitted to enhance the fledgling acidification network, by adding three new sites (Kangaroo Island, Port Hacking and Rottnest Island) at a cost of $2.061M. With the exception of GBROOS/QIMOS, the Regional Node Plans currently place no significant emphasis on acidification. Arguably, IMOS is still underinvested in this important area, and enhancement is worthy of serious consideration. Engagement with the international community to create a global network will be important. In summary, this area does appear suitable for further, strategic investment.

Sediment Traps (NCOTS)

- A proposal was submitted for a new Moorings Sub-Facility to establish a network of sediment traps near NRS sites – the National Coastal Time Series (NCOTS), at a cost of $1.092M. Although referenced in the WAIMOS (SW), NSW-IMOS, and SAIMOS Node Plans, the proposal was not given a high priority in WA or SA. Discussion at the National Meeting and subsequent Steering Committee Meeting did not provide any compelling reason to give this proposal a higher priority from a whole-of-IMOS perspective.

Molecular Microbial Observing

- A proposal was submitted for a new Facility in Molecular Microbial Observing (MMO), involving AIMS, SIMS and CSIRO. This community put in a lot of work to establish themselves and develop a credible proposal, based on physical sampling at NRS sites and subsequent extraction, sequencing, and bioinformatic analysis. However through discussion at the National Meeting and subsequent Steering Committee Meeting, a consensus emerged that the proposal is

premature for inclusion in our sustained observing system. Opportunities to use IMOS infrastructure to support this emerging national community should continue to be explored.

Biological enhancement included in SA Moorings

- The SAIMOS Node Proposal includes enhancements in stable isotope analysis, DNA sequencing, and experiments on primary productivity and carbon cycling. These are included in the Mooring budget. These activities would be more appropriately funded by other mechanisms, using existing IMOS infrastructure as leverage.

Ships of Opportunity

- A series of Proposals for Ship of Opportunity (SOOP) Sub-Facilities represent a potentially significant enhancement in biological observing. In addition to extending current IMOS investment in Continuous Plankton Recording (CPR) ($1.795M), enhancement of CPR and establishment of three new Sub-Facilities in Nutrients, Bio-acoustics and "Southern Ocean" has been proposed at a total cost of $2.9M.
- The SOOP CPR proposal ($0.854M for enhancement) looks to extend the current Brisbane-Melbourne "EAC" route on to Adelaide, but to reduce sampling from monthly to quarterly. The proposed Nutrients Sub-Facility would also start on this line. New routes are proposed from Cairns to Gladstone (quarterly) and Wyndham to Fremantle (quarterly). The engagement with Regional Node interests is commendable, and the proposal looks to have significant potential from an integration perspective. In terms of Bluewater and Climate Node interests, the proposal engages the 19-year SCAR Southern Ocean CPR Survey and establishes two trans-Tasman routes (one quarterly, one annually) which are integrated with the proposed Bio-acoustics Sub-Facility. Enhancement of CPR is also consistent with developments in the global ocean observing system, and the proposal is appropriately linked to the international community.
- The SOOP Nutrients proposal ($0.460M) is integrated with CPR, as noted above. There is reasonably strong support for an increased focus on nutrients from within the national community. However the first 12 months of the proposal will be spent building and testing the system, indicating that it may be premature for inclusion in the SOOP Facility. This is not a proposal to use off-the-shelf technology with demonstrated track record in the international arena.
- The SOOP Bio-acoustics proposal ($0.853M) is also integrated with CPR. It is designed to estimate mid-trophic organism distribution and abundance in shelf, slope and oceanic environments. The approach has been proven through research projects undertaken outside of IMOS, and an emerging collaboration between CSIRO and AAD in this area is encouraging, as is the potential for direct engagement with the fishing industry. There has been some discussion as to whether the potential user community is broad enough to justify investment. On the other hand, it has also been noted that the mid-trophic levels are not currently observed by IMOS, and are widely- acknowledged by the ecosystem modelling community as the key gap in their system understanding. The following comments from international peer reviewers of the Bluewater and Climate Node are relevant:
    - Bluewater Reviewer 2: *"I also would challenge under 4.4 the bio-acoustic data collection. This on its own will be difficult to interpret and although I really hope that this can be supported I would suggest to make it a high priority item."*
    - Bluewater Reviewer 5: *"It is also likely that the collection of bio-acoustic data will provide beneficial information on the mid-trophic level organisms, although I was unable to*

determine from the proposal exactly how the backscatter measurements indicate species abundance or distribution. It seems sensible to first conduct this measurement on the R/Vs where perhaps some in situ measurements can help with calibration and species identification for ground-truthing this measurement."

- A SOOP "Southern Ocean" Sub-Facility has been proposed by AAD ($0.731M). This is really an "Integrated Southern Ocean Ecosystem and Biogeochemical Observation Program", and is not a Sub-Facility proposal per se. The planned observations are not reflected in the Bluewater and Climate Node Proposal. However there are elements of the proposal that could be appropriately incorporated into other SOOP Sub-Facilities, and this will be explored.

Ocean Colour Satellite Remote Sensing

- Three Proposals were received in the area of Ocean Colour Satellite Remote Sensing (SRS), in addition to a proposal to extend and enhance the Australian Ocean Distributed Active Archive Centre (AO-DAAC), which is dealt with in the next sub-section.
- In general, proposals in the SRS area were not well-coordinated and integrated with the Node Proposals, and establishing an appropriate strategic focus in this element of the "national backbone" remains a challenge in the IMOS Node and Facility structure. An SRS national workshop was held during the proposal development phase, but only limited progress made in the time available. The situation has not been helped by the fact that the Facility Leader retired, and a replacement is yet to be officially identified.
- The three proposals are (1) To extend ($0.520M) and enhance ($1.209M) the Lucinda Jetty Coastal Observatory, (2) Establish a bio-optical database for Australian Waters ($0.388M) and (3) Provide Regionally-validated national ocean colour products ($0.840M).
- The Lucinda Jetty Coastal Observatory (LJCO) was established for ocean colour satellite cal val. Funding of $0.675M was provided under NCRIS, and our expectation was that extension costs for 2011-13 would be $0.200M ($100K pa). However the extension budget submitted by CSIRO is for $0.367M (an 84% increase), and an enhancement proposal for $1.209M has also been submitted. As with the NRS, scope creep has emerged as a serious issue. It is time to cap the LJCO budget, but in this case, it is less clear how to match the scope to available resources, and a serious discussion with the Operator about the future of this Sub-Facility is now required.
- There are elements of the Bio-optical database and National ocean colour products proposals (total $1.228M) that are well-aligned with the IMOS strategy, but as currently developed they are too narrowly-focused. For example, we need to ensure that the views of the Bluewater and Climate are adequately reflected i.e. "Ensure that IMOS class 1 (offshore) in situ optical data sets are assembled, quality controlled and made available to international projects aimed at improving the global products derived from ocean colour satellites." The recently-formed IMOS National Working Group on Bio-optical Instrumentation and Observing also needs to have greater input, and overlaps and synergies between these proposals and the AO-DAAC enhancement proposal (see next sub-section) must also be explored. In summary, there is prima facie justification for investment in the order of $1.2M, but the IMOS Office needs to work with the community to redevelop a more broadly-based proposal.

AUV

- The "Sirius" component of the AUV proposal includes extension of current activity to mid-2013 ($0.797M) and enhancement (of $0.452M) in line with a national plan developed by a cross-Node benthic ecology community (including NSW-IMOS, QIMOS, WAIMOS and TasIMOS). There has been healthy debate about how these data streams fit into a sustained observing system. On balance, through modest ongoing investment, IMOS will benefit from substantial engagement by a significant national community that represents a key element of ecosystem function.

AATAMS

- The AATAMS Facility proposal includes extension of NCRIS-funded activity, substantial enhancement via the EIF First $8M (a doubling), and significant further enhancement in multiple locations (more than doubling again). In summary, the Facility Plan as a whole appears overly-ambitious and not sufficiently aligned with Node plans and priorities in some areas.
- The proposal is quite complex, but chunks into four components, excluding Southern Ocean Seals as Samplers (see Theme #1). These components are (1) Extension of existing AATAMS lines, and addition of new lines, (2) Monitoring Apex Predators in the Southern Ocean (MAPSO) (3) Biologging in the GAB, and the addition of Predator Responses, and (4) Addition of Turtles as Samplers in NW WA.
- Extension of existing AATAMS lines at ~$1M looks fairly straightforward. So too the $300K for GBR/OTN approved under the EIF First $8M. In terms of additional lines, the overall picture is a bit hard to tease out from a combination of the Facility Proposal and relevant Node Proposals. It looks something like this:
    - $325K for 40+90 = 130 more receivers in NSW (capital only),
    - $300K for 3x8+6+30 = 60 more receivers in SA ($96K capital + $204K operating i.e. fairly high operating cost due to acoustic releases),
    - $440K for ? more receivers in WA at Rowley Shoals & Scott Reef ($60K capital + $380K operating i.e. high operating cost due to remote location),
    - $353K for 110 receivers in SEQ ($275K capital + $78K operating i.e. more reasonable),
    - $586K for 36+44 = 80 receivers in Tas (all capital, but very expensive due to acoustic releases and depth of deployments)
    - $200K for a Technical Officer
    - $300K for temperature pressure loggers
    - TOTAL cost of #1 ~$3.8M
- In summary, the Technical Officer is required based on approved levels of activity. The WA and SEQ deployments rate highly as part of integrated packages, subject to State co-investment decisions. The NSW deployments rate well for leverage provided. The SA and Tas deployments are relatively expensive and of less obvious priority. The pressure sensor proposal is unsuitable.
- An enhancement of $1.493M is requested for Monitoring Apex Predators, which is stated as an essential priority in the Bluewater and Climate Node Plan. The proposal addresses the Southern Ocean budget imperative, and includes $6M of co-investment from the AAD.
- Sea lions/Fur seals /Mako sharks-as-samplers in the GAB (bio-logging) was approved at $400K in 2009-10 under the EIF First $8M. A revised extension budget now requires a further $200K pa for three years (2010-13) plus ~$100K for deployment personnel i.e. $1.1M. The initial extension budget included a further $900K for these activities, which has now been moved to

enhancement i.e. $2M in total. The justification for this work is in the SAIMOS Node Plan, not the Bluewater and Climate Node Plan. The enhancement drops Mako sharks and includes Cape terns. Two comments. Firstly, the biophysical integration does not look to be anywhere near as strong as in the Bluewater and Climate Node. Secondly, the co-investment is comparatively very low (<$500K). In summary, this has rapidly become a very expensive proposal, with a request for a further $1.6M on top of the $400K committed. Prima facie, the justification does not look strong.

- Turtles as Samplers are proposed as a further bio-logging addition under the WAIMOS Plan. The cost is $440K, with ~$800K co-investment. The relative priority within the WAIMOS Node Proposal is not clear. Also, notwithstanding the relatively attractive co-investment in this case, bio-logging is expensive and IMOS will need to be cautious about how many fronts it opens up given that our goal is to sustain observational streams over decades. Long-term institutional commitment will be an important consideration.

Passive Acoustics

- The Passive Acoustics Sub-Facility proposal includes extension of NCRIS-funded activity ($0.741M), and reasonably significant enhancement in multiple locations ($1.193M). NCRIS-funded passive acoustic observatories are gradually being rolled out in Perth Canyon, Bonney Upwelling, and NSW Coast, and data should begin to flow some time soon. The enhancements are proposed in the Southern Ocean, NW WA (Pilbara and Kimberley) and SEQ (Stradbroke Island). The primary justification in the Node Proposals is around monitoring whale movements, though the data streams potentially have broader utility. At the IMOS National Meeting and subsequent Steering Committee Meeting there was some discussion about the limited size of the user community for this data. The proposal for enhancement looks premature, and the focus should be on completing the approved installations, delivering the data, and working to make it of broader utility to the science community.

Assessment – Theme #5, Biological responses

Having considered the relevant Node Proposals and related Facility Proposals in the overall context of the Five Year Strategy and available funding, and in the specific context of the international peer review and Node prioritisation, the assessment of priorities by the Advisory Board and IMOS Office is as follows:

	Essential	Highly Desirable	Next stage	Unsuitable
Extend	• NRS sampling • AUV Sirius • SOOP CPR • SRS – LCJO • AATAMS various • Passive Acoustics x3			
Enhance first $8M	• AATAMS (Seals in GAB and GBR/OTN) • Acidification x 2			
Enhance other	• Acidification x 1/3 • AUV Sirius national program • NRS bio-optics (in previous section) • SOOP CPR enhancement • SRS Bio-optical dbase & National products • SOOP Bio-acoustics • ATAMS - MAPSO	• Acidification x 2/3 • AATAMS in SEQ, NW WA and NSW (subject to State co-investment decisions)	• SOOP Nutrients • MMO • Passive acoustics x 3 • AUV REMUS • AATAMS in SA and Tas	• SOOP SO • LJCO enhancement • NCOTS sediment traps • Biologging in the GAB

A summary of the financial implications of this assessment is as follows:

#5 Biological responses	NCRIS	Extension	EIF 1st $8M	Enhancement	2010-13			
	2006-11	2011-13	2009-13	Essential	Desirable	Next stage	Unsuitable	Total
6f National Reference Stations	see Continental shelf processes							
2a SOOP - Underway Network CPR				853,601				853,601
2e SOOP - Bio-acoustics				852,654				852,654
2f SOOP - Macro-nutrients						460,000		460,000
2g SOOP - Southern Ocean							731,000	731,000
5 AUV	700,000	430,500		452,000		758,300		1,210,300
6e ANMN - Acoustic Observatories	843,000	357,706				1,193,494		1,193,494
6j ANMN - CO2				687,027	1,374,053			2,061,080
6k ANMN - National Coastal Time Series							1,091,638	1,091,638
8 AATAMS	1,510,786	518,502	721,728	1,689,661	1,558,293	886,476	1,234,000	5,368,430
11d Satellite Ocean Colour	675,001	201,000		1,228,000			1,208,500	2,436,500
13 Molecular Microbial Observatory (MMO)						694,818	300,000	994,818
Theme sub-total	**3,728,787**	**1,507,708**	**721,728**	**5,762,943**	**2,932,346**	**3,993,088**	**4,565,138**	**17,253,515**
% of Grand Total	**7%**	**6%**	**6%**	**38%**	**25%**	**27%**	**36%**	**32%**
	All as % of Grand Total			**11%**				

The following key points should be noted:

- As highlighted in the previous sub-section, scope and cost of the NRS needs to be capped, and actively managed onto a sustainable footing. Beyond the enhancements approved as part of the EIF First $8M, the only other enhancement will be for bio-optics. The detailed consequences will need to be worked through, but it is highly likely that physical sampling will not be undertaken at all sites.
- Enhancements to SOOP CPR and Bio-acoustics are well-integrated, and present an exciting opportunity to enhance biophysical observing within IMOS, and in line with international developments. Developments in the area of Nutrients will be closely monitored. Integration of data streams across SOOP platforms will be actively pursued, including consideration of relevant elements of the SOOP "Southern Ocean" proposal from AAD.
- In addition to pCO2 enhancements approved under the EIF First $8M, an additional acidification mooring will be deployed, preferably in the upwelling zone off Kangaroo Island. Opportunities should be explored to engage in development of a global network.
- Reasonably substantial investment will be made in the area of Ocean Colour SRS, subject to development of an acceptable proposal that draws on the strengths of proposals submitted, but broadens engagement to ensure a truly national approach. Future development of the Lucinda Jetty Coastal Observatory will be discussed with the Operator (CSIRO).
- The Sirius AUV Facility will be enhanced in line with a national program developed by the benthic ecology community.
- The AATAMS Facility has grown significantly through EIF First $8M investment. Further enhancement will occur through Monitoring Apex Predators in the Southern Ocean (MAPSO). Investment in bio-logging in the GAB will be capped at the initial $400K, as significant enhancement proposed does not appear to be well-aligned with Node priorities or integrated with the physics. Further enhancement of AATAMS curtains in SEQ, northwest WA and NSW is desirable, subject to State Government co-investment decisions.

6. Other Proposals not covered under the Themes

- Proposals for the IMOS Office, eMII, and the SRS AO-DAAC make up the balance of available funding.
- All proposals have been submitted on an extension only basis.
- The option of merging AO-DAAC into eMII will be considered. Enhancement is not warranted, but the enhancement proposal should be considered as part of the review of priorities in ocean colour (see previous sub-section).

Other	NCRIS	Extension	EIF 1st $8M	Enhancement 2010-13				
	2006-11	2011-13	2009-13	Essential	Desirable	Next stage	Unsuitable	Total
10 eMII	4,870,000	3,280,001						
11b AODAAC	822,595	180,000					970,000	970,000
11c Ground Stations	577,999							
12 Office	2,136,043	1,591,000						
Theme sub-total	**8,406,637**	**5,051,001**					**970,000**	**970,000**
% of Grand Total	**16%**	**20%**					**8%**	**2%**
	All as % of Grand Total			**13%**				

The Advisory Board has assessed these Proposals and considers them to be appropriate.

3. Portfolio Balance

A summary of all Facility and Sub-Facility Proposals is as follows. Taking into account the cost of extending NCRIS investment to mid-2013 ($25.6M), and the full cost of EIF First $8M investment ($11.9M), approximately $15M of the EIF $52M remains for investment. At this level, only essential enhancements will be able to be funded without further co-investment.

	NCRIS	Extension	EIF 1st $8M	Enhancement	2010-13			
	2006-11	2011-13	2009-13	Essential	Desirable	Next stage	Unsuitable	Total
1 Argo	5,602,206	3,667,233	1,800,000					
2a SOOP - Underway Network XBT	2,951,199	1,458,182						
2a SOOP - Underway Network BGC				205,120				205,120
2a SOOP - Underway Network CPR				853,601				853,601
2b SOOP - Tropical Research Vessels	250,000							
2c SOOP - SST Sensors	389,352	298,359			937,871			937,871
2d SOOP - Real-time Air-sea Fluxes	299,000	207,403			382,696			382,696
2e SOOP - Bio-acoustics				852,654				852,654
2f SOOP - Macro-nutrients						460,000		460,000
2g SOOP - Southern Ocean							731,000	731,000
3a SOFS	1,536,300	515,784		1,148,162				1,148,162
3a RAMA						1,342,519		1,342,519
3b PULSE +	2,567,700	1,442,577						
3c Deepwater Arrays - ITF			622,421	291,647				291,647
3c Deepwater Arrays - Polynya				304,487				304,487
3c Deepwater Arrays - EAC				1,535,730				1,535,730
3c Deepwater Arrays - Kerguelen						1,282,457		1,282,457
3c Deepwater Arrays - Perth Basin						904,149		904,149
4 ANFOG	4,200,000	2,058,379		500,000	732,045	598,068		1,830,113
4 ANFOG - Seagliders for SOTS			1,507,004					
4 ANFOG - Seagliders for GBR			753,502					
5 AUV	700,000	430,500		452,000		758,300		1,210,300
6a ANMN - Queensland	2,683,000	1,736,275					455,000	455,000
6b ANMN - New South Wales	2,528,999	1,570,950		147,629			1,758,125	1,905,754
6c ANMN - Southern Australia	2,883,599	1,021,014		352,204			2,430,811	2,783,015
6d ANMN - Western Australia	2,031,346	741,636		318,796	658,008		1,290,351	2,267,155
6e ANMN - Acoustic Observatories	843,000	357,706				1,193,494		1,193,494
6f National Reference Stations	3,632,838	1,892,497	3,369,792	508,045			1,068,382	1,576,427
6g ANMN - NAOS, Kimberley			1,077,579		1,658,412			1,658,412
6g ANMN - NAOS, Pilbara					2,071,535			2,071,535
6g ANMN - NAOS, Arafura Wessels						1,172,951		1,172,951
6g ANMN - NAOS, ITF				2,023,008				2,023,008
6h ANMN - SEQ				848,637	311,428			1,160,065
6i ANMN - Tasmania						1,054,354		1,054,354
6j ANMN - CO2				687,027	1,374,053			2,061,080
6k ANMN - National Coastal Time Series							1,091,638	1,091,638
7 ACORN	5,284,316	1,442,616			1,344,649	2,592,950		3,937,599
8 AATAMS	1,510,786	518,502	721,728	1,689,661	1,558,293	886,476	1,234,000	5,368,430
8 AATAMS - Southern Ocean Seals as Samplers			2,040,747					
9 FAIMMS	1,915,000	589,430						
10 eMII	4,870,000	3,280,001						
11a SST L2P Products	595,197	394,296						
11b AODAAC	822,595	180,000					970,000	970,000
11c Ground Stations	577,999							
11d Satellite Ocean Colour	675,001	201,000		1,228,000			1,208,500	2,436,500
11e Satellite Altimetry				1,093,000				1,093,000
12 Office	2,136,043	1,591,000						
13 Molecular Microbial Observatory (MMO)						694,818	300,000	994,818
14 FLOC - SVP Drifters						1,218,584		1,218,584
14 FLOC - SPOT Drifters						593,622		593,622
15 Antarctic Fast Ice Monitoring (AFIM)					555,000			555,000
Grand Total	**51,485,476**	**25,595,340**	**11,892,773**	**15,039,408**	**11,583,990**	**14,752,743**	**12,537,808**	**53,913,948**
				52,527,520				

Key aspects of Portfolio Balance considered are:

7. Response to the Federal Budget and Five Year Strategy,
8. Shifts in investment by research theme,
9. Trends in investment by Facility, and
10. Trends in maturity of observations.

In terms of response to the Federal Budget and Five Year Strategy, key points are as follows:

- Enhanced monitoring capability in the Southern Ocean is well-addressed. EIF first $8M decisions re ice-capable Argo, gliders to SOTS, and Southern Ocean Seals as samplers set the stage. Further enhancements in SOOP (pCO2 on Aurora, CPR, Bio-acoustics), SOFS#2, Deepwater moorings (Polynya), Monitoring Apex Predators, and Satellite altimetry and ocean colour come together into a well-rounded package. The focus on biophysical integration is particularly strong, in line with the Five Year Strategy.
- Extended coverage in northern Australian waters is addressed. The EIF first $8M decision on a Northern Australian Observing System, to be implemented through an ITF deepwater array and commencement of the Kimberley shelf array, laid the platform. Further enhancements in SOOP CPR, the ITF/Bonaparte self array, and Satellite altimetry and ocean colour add more weight. The opportunity exists for WA State co-investment to complete the Kimberley shelf array and add the Pilbara shelf array, gliders, AATAMS and other moorings support.
- Development of Nodes is well addressed. Bluewater and Climate is strengthened in the Southern Ocean (bringing in new partners), and in biophysical integration. WAIMOS is extended into the northwest, GBROOS into SEQ to form QIMOS, and a new Tasmanian Node created. The opportunity exists for Queensland State Government co-investment to complete the Brisbane shelf array and add AATAMS curtains and coastal radar. Opportunities remain for co-investment by other partners e.g. NSW State Government.
- Monitoring full depth transport of the ITF/Leeuwin Current and EAC systems is addressed.

The percentage of investment by research theme from NCRIS through to EIF enhancement is shown in the table below:

	NCRIS	Extension	EIF 1st $8M	Enhancement 2010-13				
	2006-11	2011-13	2009-13	Essential	Desirable	Next stage	Unsuitable	Total
#1 Multi-decadal ocean change	27%	30%	45%	18%	13%	15%		12%
#2 Climate Variability	1%	1%			3%	9%		3%
#3 Monitoring boundary currents			12%	12%		16%		8%
#4 Continental shelf processes	49%	43%	37%	31%	58%	33%	56%	43%
#5 Biological responses	7%	6%	6%	38%	25%	27%	36%	32%
Other	16%	20%					8%	2%
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Key points are as follows:

- Multi-decadal Ocean Change/Climate Variability was fairly heavily invested in the EIF First $8M, but less so under EIF enhancement.
- Investment in Monitoring the Boundary Currents is now explicitly identified.
- Investment in Continental Shelf Processes remains significant, but is being rebalanced by increased investment in Biological Responses in line with the Five Year Strategy.

In terms of investment by Facility, the following table shows investment under NCRIS and EIF:

Facility	NCRIS	NCRIS	EIF	EIF
Argo	5,602,206	11%	5,467,233	10%
SOOP	3,889,551	8%	3,875,319	7%
SOTS/ABOS	4,104,000	8%	5,860,808	11%
ANFOG	4,200,000	8%	4,818,885	9%
AUV	700,000	1%	882,500	2%
ANMN - NRS	3,632,838	7%	5,770,334	11%
ANMN - Other	10,969,944	21%	10,882,461	21%
ACORN	5,284,316	10%	1,442,616	3%
AATAMS	1,510,786	3%	4,970,638	9%
FAIMMS	1,915,000	4%	589,430	1%
eMII	4,870,000	9%	3,280,001	6%
SRS	2,670,792	5%	3,096,296	6%
Office	2,136,043	4%	1,591,000	3%
	51,485,476	**100%**	**52,527,520**	**100%**

Key points as follows:

- Overall, there are no dramatic shifts in investment by Facility.
- Major increases are in:
    - SOTS/ABOS, reflecting SOFS#2 and deepwater/boundary current monitoring priorities
    - NRS, reflecting cost to extend and EIF First $8M decisions
    - AATAMS, reflecting biological enhancement.
- Major relative decrease is in ACORN, where the focus needs to remain on capturing latent potential of NCRIS investment.
- FAIMMS and eMII did not seek enhancement, and EIF funds are for two-year extension only.
- IMOS has a continued and increasing reliance on moorings. SOTS/ABOS, NRS and ANMN represent 42% of EIF investment (36% under NCRIS). It will be important to review the capacity of Operators to deliver within the IMOS EIF timeframe.

In terms of maturity of observing technologies, key points to note are as follows:

- Core Argo, SOOP (XBT, BGC, SST and Fluxes) and AATAMS curtains are mature observing technologies, and transition to operational services needs to be considered beyond mid-2013.
- Ice and oxygen capable Argo, SOOP (CPR), deepwater moorings, shelf-moorings, NRS (core variables and physical sampling), coastal radar, satellite tagging, and satellite remote sensing (SST, OST, OC) are maturing technologies in the IMOS/Australian context, and will move toward more systematic delivery of data within the IMOS EIF timeframe.
- SOOP Bio-acoustics, SOFS, acoustic observatories, Acidification moorings, gliders, AUV, NRS bio-optical enhancement, monitoring apex predators and wireless sensor networks are emerging technologies in the sustained observing context, and will be further developed within the IMOS EIF timeframe.

In summary, the Portfolio Balance is consistent with the Federal Budget imperatives and the IMOS Five Year Strategy. Shifts in investment by theme, and trends in investment by Facility, taking maturity in account, are considered to be aligned with the strategic intent of decisions made.

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