IMOS Integrated Marine Observing System

IMOS EIF Node and Facility Proposals

Consolidation, Review and Analysis by the IMOS Office

November 2009

Australian Government
Department of Innovation Industry, Science and Research

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

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Introduction

This document has been prepared by the IMOS Office as a bridge between the submission of Node and Facility Proposals on 30th October, and the National Meeting to consider these proposals on 26th November. Per the IMOS EIF Timetable, the National Meeting will aim "to reach consensus on items best responding to the IMOS Five Year Strategy and best addressing IMOS EIF funding requirements". The conclusions of the National Meeting will provide crucial input to the Advisory Board's consideration of a Draft IMOS EIF Project Plan on 18th December, and the Board's eventual approval of a Final Plan for submission to DIISR by 28th February 2010.

It is the responsibility of the IMOS Office to consolidate, analyse and review the package of proposals submitted in order to:

a. frame the agenda for the National Meeting,
b. facilitate the meeting, and
c. prepare to deliver a high-quality report within two weeks of the meeting date, so that it can be duly considered by the Advisory Board as a synopsis of the Draft IMOS EIF Project Plan.

As noted in IMOS EIF Update #5 (available at http://imos.org.au/eif_updates.html), the 2009 National Meeting will "build on the strengths" of IMOS i.e.

- a critical mass of equipment in the water,
- data streams growing daily and available through the Ocean Portal,
- an established Office and Advisory Board
- respected people from across Australian marine and climate science who have been in Node and Facility leadership positions for some time, and
- our approved Five Year Strategy.

The National Meeting will therefore be guided by well-articulated priorities, and will be structured around the following elements:

1. Overview and synthesis of the Node Proposals as a package, including international peer review
2. Consolidation and analysis of Facility Budgets against known parameters
3. Overview and synthesis of the Facility Proposals as a package.

This document provides a record of the consolidation, analysis and review of Node and Facility Proposals and Budgets undertaken by the IMOS Office. It identifies approximately 50 issues for consideration.

Our goal as a national marine and climate science community is to reach consensus on what IMOS should be observing, and why, and through discussion and debate of the issues, provide the Advisory Board with the best possible advice to assist them in dealing with the more difficult decisions about how, where, when, and by whom.

Prepared by Tim Moltmann, Katy Hill, Marian McGowan, Jo Neilson, Simon Allen & Virginia Bowen
20 November 2009

1. Overview and synthesis of the Node Proposals as a package, including international peer review

Six Node Proposals have been submitted:

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

Significant developments in the scope of the Nodes

Significant developments in the scope of Nodes during the Proposal writing stage of the IMOS EIF planning process 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 have limited interest in the offshore focus of IMOS, and are looking for opportunities to leverage the national strength of the Program to address shelf-to-coastal impacts in the NSW region.
5. Ongoing interest from Southern Australian IMOS (SAIMOS) to expand east, but 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. Also a strong push for a more “biologically-coloured” IMOS.
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.

Node proposals need to be considered with these developments in mind.

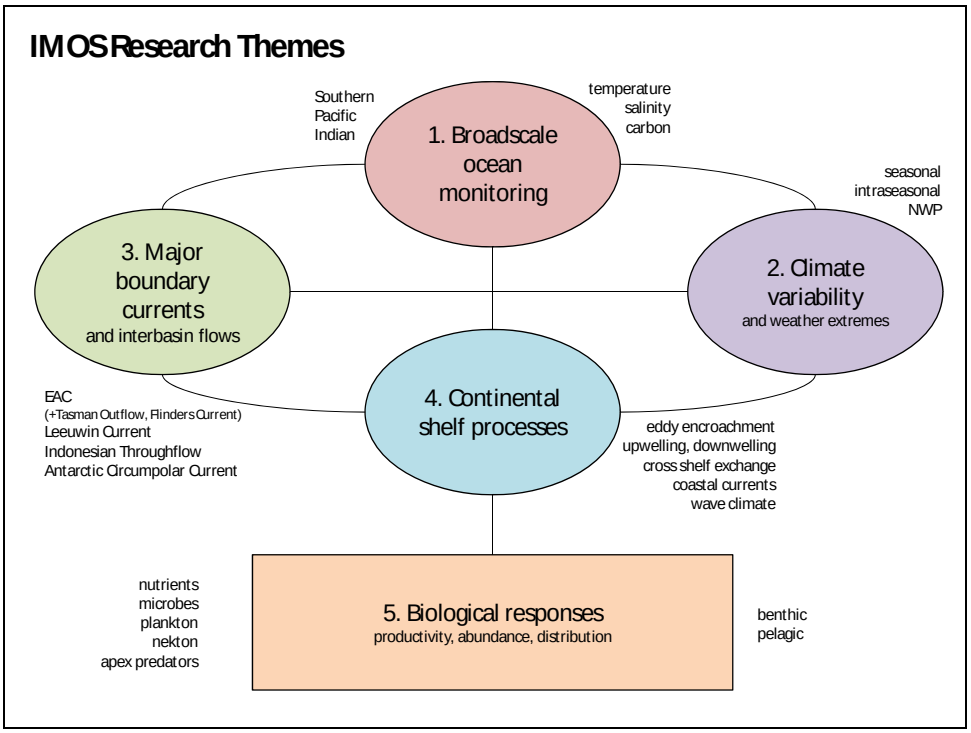
Synthesis of Node Proposals

As a package, the Node Proposals address the goals of IMOS and respond constructively to the Five Year Strategy.

Each Node Proposal has up to four major research themes and, on average, a dozen or so more detailed research questions. A summary of the major research themes by Node is shown as Attachment 1.

At the whole-of-IMOS level, these can be synthesised into five research themes as follows:

1. Broadscale ocean monitoring
2. Climate variability
3. Major boundary currents, and interbasin flows
4. Continental shelf processes, and
5. Biological responses (productivity, abundance and distribution).



By looking at these five research themes across the package of Node Proposals, and considering the observing strategies articulated, a number of issues emerge.

1. Broadscale ocean monitoring – temperature, salinity, carbon

This is solely the remit of the Bluewater and Climate Node, and the observing strategies must be 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 gaps of relevance to Australia's focus on the Southern Ocean.

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 - - -	- Polynya Array (Adelie Coast) Kerguelen Array Perth Basin Array
BW&C – global ocean carbon cycles	SOTS (SAZ, PULSE, profilers) pCO2 on MNF + Astrolabe - -	Sea gliders to SOTS* 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

Issues include:

1. Development of a national game plan for Argo, with the roles of all investors (including IMOS, CSIRO/BOM, ACE CRC, DCC and others) understood and agreed. N.B. This issue may well apply to other Facilities, and relates to the "Patrons of IMOS" suggestion made in the BW&C Plan.
2. Sustainability of investment in Seals as samplers (advised that $600K EIF investment in 2009-10 is required on an annual basis to sustain i.e. a further $1.8M required to 2013).
3. Level of community support for enhanced altimetry cal val to reduce sea state bias and water vapour corrections.
4. Research need for more accurate (<0.1^{o} C) skin SST from Radiometers.
5. A strategy for monitoring Antarctic Bottom Water. Three deep mooring arrays are proposed to provide an integrated view, with descending priorities from essential to high to low. Is it meaningful for IMOS to "pick"? Also, for the essential Polynya Array, EIF investment is required for "maintenance, operating costs and delivery of climate quality data [to] IMOS eMII".
6. Level of community support for monitoring seasonal fast ice.

7. A new “Southern Ocean” SOOP Sub-Facility is proposed by AAD. This is really an “Integrated Southern Ocean Ecosystem and Biogeochemical Observation Program”. The observations proposed do not appear to be reflected in the Bluewater and Climate Node Proposal.

2. Climate variability, and weather extremes

This is primarily the remit of 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).

Node focus	**NCRIS observations**	**EIF enhancements**
BW&C – coupled modes ENSO, IOD, SAM (upper ocean thermal dist^{n})	core Argo SOOP XBT Altimeter cal val x 1 -	- - Altimeter cal val + 3 ITF shelf/deep moorings
BW&C – intraseasonal variability and severe weather	SOOP surface fluxes (MNF, AA) -	+ Astrolabe, Nth Aust/Tasman RAMA tropical moored buoy
WAIMOS	- -	Shelf moorings ** • Arafura/Wessels • ITF • Kimberley • Pilbara
QIMOS	-	Stradbroke NRS* SEQ shelf mooring array
NSW-IMOS	NSW shelf mooring array	-

* Approved under the EIF first $8M

** $1.7M of $xM total cost approved under the EIF first $8M

Issues include:

8. Level of community support for enhanced altimetry cal val to reduce sea state bias and water vapour corrections (as above).
9. Relative priority of enhancements to improve seasonal vs intraseasonal prediction if we are unable to support both.
10. Realistic assessment of loss rates in RAMA area of operation (20%?).
11. Clarity around BOM responsibility for ocean observations to support seasonal prediction.
12. Capacity of shelf arrays and moorings in Regional Nodes to contribute to research questions around seasonal/intraseasonal variability and extreme weather.

3. Major boundary currents, and interbasin flows

The term “boundary current” is widely used across the Node Proposals:

- Undeniably, Australia’s EAC is a classically-defined, western boundary current of the South Pacific gyre.
- The Leeuwin Current is described as an eastern boundary current, though 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 Throughflow 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 bifurcation of the South Equatorial Current and has claims as a low latitude western boundary current, though it is not currently a major focus for QIMOS.

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

- EAC, including Tasman Outflow and Flinders Current
- Leeuwin Current
- Indonesian Throughflow, and
- 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 both the Bluewater and Climate Node and all the Regional Nodes (WAIMOS, QIMOS, NSW-IMOS, SAIMOS and TasIMOS).

The 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.”

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.

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 Throughflow (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 section).

The primary focus of Regional Nodes is on the impact of major boundary currents on continental shelf environments, ecosystems and biodiversity (see next section), though a few further points need to be made in this section:

- IMOS is investing in sea gliders, which are capable of working in deep water (up to 1000m, for up to 6 months), and making them available to the Regional Nodes. To date, their use has been more in support of process studies and further thought needs to be given as to how best to mature this into a sustained observing approach.
- 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 require further debate.

- 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 proposal, either in the research questions or the observations required. However it is included in the Mooring Facility Budget. The merit of this approach requires further debate, particularly in combination with the ITF deep mooring which is designed to capture the inter-annual signal.
- Related to the above, the NT community has provided a late submission outlining their needs which are perhaps not fully reflected in the sum of WAIMOS and QIMOS Nodes Proposals.

Node focus	**NCRIS observations**	**EIF enhancements**
BW&C – Monitoring major boundary currents	SOOP XBT 1 x sea glider	Deep moorings: • ITF** • EAC (off Brisbane) • Perth Basin • Tas Outflow • Hiri Curent Glider array (sustained pattern of repeat tracks with multiple gliders - at Tas Outflow/SOTS [4 x sea glides approved*], EAC off Brisbane and or Leeuwin Current off Perth) SVP Drifters
NSW-IMOS - EAC separation zone	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	2 x sea gliders	Arafura Wessels mooring pair
QIMOS	-	2 x sea gliders*
SAIMOS	1 x sea glider	-

* Approved under the EIF first $8M

** $1.7M of $xM total cost approved under the EIF first $8M

Issues include:

13. Should IMOS invest in monitoring the full-depth transport of mass, heat and fresh water of major boundary currents and interbasin flows?
14. If so, are the priorities in the Bluewater and Climate Node Proposal widely agreed in the Regional Nodes i.e. ITF “essential”, EAC off Brisbane “high”, Leeuwin Current off Perth “low”, followed by Tasman Outflow and Hiri Current?

15. What is the relative priority of NSW-IMOS focus on the separation zone in the context of a national approach to monitoring the EAC?
16. What is the relative priority of WAIMOS interest in an Arafura Wessels mooring pair in the context of a national approach to monitoring the Leeuwin Current? Are the interests of the NT community adequately reflected?
17. Should the sea glider fleet continue to be spread around the Regional Nodes, or should it be bulked up into a series of arrays in strategic positions?
18. Should deep mooring and glider approaches be combined (i.e. both required to answer the questions), or separated (i.e. suitable for different questions in different conditions), or both (depending on the circumstances)? Approved sea glider enhancements (to SOTS and Coral Sea) are not well-aligned with deep mooring priorities (ITF and EAC off Brisbane). This may or may not be a good thing.
19. How does the SVP Drifter proposal fit? It is rated a low priority in the Bluewater and Climate Proposal, and is supported by NSW-IMOS and WAIMOS, but without priority given. In WAIMOS, it is unclear whether the support is for both the SPOT Drifters and the Leeuwin Current SVP pilot.
20. The Bluewater and Climate Node Proposal discusses the use of satellite altimetry under research questions (section 2.3), but makes no reference to it under observations required (section 4.3).

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, wave climate etc. (N.B. Given that many of these research questions are linked to biological responses, this section is closely related to the following section.)

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 (WERA)

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

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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.

Issues include:

21. Is it really feasible to go from 11 to 20 focal points on the shelf? Would it be better to focus on perhaps half this number and continue to develop truly integrated and sustained observing systems in line with the IMOS mandate? N.B. Theoretically, this could involve forgoing some existing focal points.
22. Should the selection of focal points on the shelf be more strongly guided by priorities and co-investment offered by State Governments and other partners, given that the benefits of these observations are most likely to directly address the socio-economic and ecological impacts of interest to them?
23. The Esperance NRS continues to sit outside all areas of interest. Is it worth continuing with this investment, noting that WAIMOS is actually proposing an enhancement to take it from quarterly to monthly sampling? Also, the Darwin NRS is not mentioned in any Node Proposal, and Ningaloo is not really squarely in focus in either the SW or NW sections of the WAIMOS Proposal.
24. Are the Slocum gliders really going to be used for sustained observing, as opposed to process studies?
25. Should we invest in Ferry Boxes on supply vessels, noting that the cost is not currently included in any Facility budget?
26. Is the REMUS AUV a better alternative to gliders on the shelf, or not? If seen as complementary, can we afford both?
27. Are SPOT drifters suitable for sustained observing?
28. Is support for Torres Strait Regional Authority (TSRA) tide gauges really an appropriate investment for IMOS?
29. Should the Bluewater and Climate Proposal to add pressure sensors on AATAMS cross shelf arrays be considered by the Regional Nodes?
30. Satellite Remote Sensing (SST and OST) gets little or no mention in the observational requirements of the Regional Nodes. Could we make more of this capability?

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.

It must be remembered that the IMOS strategic priority in this area is about “whole-of-system approaches”, rather than “more biology”, and this needs to inform our thinking.

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 internationally as a challenge for the next decade, and IMOS is being and will be applauded for rising to it.

Issues include:

31. A clear trend in the Node/Facility Proposals to do more of what we are already doing, especially AUV surveys, SOOP lines, and AATAMS curtains. This is not necessarily wrong, though it is almost certainly unaffordable. The proposals for these Facilities need to be much more clearly prioritised, particularly in light of comments in the previous section about focal areas for observing continental shelf processes.
32. In undertaking this prioritisation, it will be helpful to apply the test of data streams being delivered via the Ocean Portal, and used by a broad section of the Australian marine and climate science community (either directly, or indirectly via models, SRS products etc).
33. There are many references to ecosystem modelling in the Node Proposals. Is there a national community that can begin to be engaged about their requirements from a national ocean observing system? This process has begun with the physical modelling community.
34. The role of National Reference Stations at the chemical/microbial/planktonic levels emerges as very significant, and will be discussed in more detail in Section 4.
35. Is it plausible for IMOS to invest in broadscale nutrient mapping using SOOP platforms? Is there a well-funded research community ready to take up and use these data streams?
36. Should IMOS begin to invest in Molecular Microbial Observing, or is it premature?
37. The SAIMOS Node Proposal is titled “Towards a more biologically-coloured SAIMOS”, but the proposals around stable isotope analysis, DNA sequencing, and experiments on primary productivity and carbon cycling (which are buried in the Mooring budget) appear to well and truly cross the line from sustained observing to funding field/lab/process studies. As an indicator, there is a request for an additional 3 FTE in the mooring sub-Facility.
38. Satellite Remote Sensing of Ocean Colour is potentially a major contributor to observing “biological responses”. However ocean colour in “case 2” coastal waters is very difficult, and in IMOS we do not yet have national consensus on how best to approach this issue.
39. Under NCRIS, we invested in the Lucinda Jetty Coastal Observatory (LJCO) for ocean colour satellite cal val. There is a proposal to extend and substantially enhance this Facility under EIF, but the Node-pull is currently uncertain. There is also a proposal to add “bio-optics” to the NRS, establish a bio-optical database for Australian waters, and parameterise and validate national ocean colour products. How should we respond to these proposals in the absence of a national consensus as noted above?
40. There is a proposal to add sediment trap moorings to NRS/shelf mooring sites in WAIMOS (SW), NSW-IMOS, and SAIMOS, to provide a National Coastal Times Series (NCOTS). It is quite possible that this infrastructure will be prioritised-out of over-crowded Nodes. Is there any compelling reason to give this a higher priority from a whole-of-IMOS perspective?
41. The mid-trophic levels are not currently observed by IMOS, and are widely-acknowledged by ecosystem modellers as a/the key gap in their system understanding.

A SOOP Bio-acoustics sub-facility proposal has been developed in response to this challenge. Should IMOS begin to invest in this area? Is the potential user community broad enough to justify this?

42. Under NCRIS, IMOS invested in passive acoustic observatories. These are gradually being rolled out (Perth Canyon, Bonney Upwelling, NSW Coast) and data should begin to flow some time soon. There is a proposal for enhancements 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. Can passive acoustics be better integrated and more widely used?

International peer review

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

The Bluewater and Climate and WAIMOS Node Proposals were sent to reviewers on Wednesday 4th November, with comments due by Wednesday 18th November.

At the time of writing this document only half of the reviewer comments had been received. We expect the balance of the comments to be available early next week, but it is premature to summarise the comments at this stage. However Node Leaders will be provided with review comments in two stages (now and next week) in the interests of giving them as much time as possible to consider any significant issue arising.

2. Consolidation and analysis of Facility Budgets against known parameters

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 are concentrated in four Facilities - three in SOTS/ABOS, eight in SOOP, eight in ANMN and four in SRS.

This means there are in fact 34 “budget units” to consolidate i.e. 23 Sub-Facilities and 11 standalone Facilities.

Significant Facility developments during the Proposal writing stage of the IMOS EIF planning process 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 Remus 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 extension of OTN on 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 addition of 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, called Facility for Lagrangian Ocean Currents (FLOC).
15. Proposed establishment of a new Fast Ice Facility, called Australian Fast Ice Monitoring (AFIM).

In summary, Facility Budgets submitted with Proposals on 30th October requested ~60% more NCRIS/EIF funding than available in 2009-13. We have $82M of NCRIS/EIF Funding available and $133M has been requested – a gap of $50M.

Considering that IMOS was ~200% over-subscribed in its establishment phase, this can be seen as a relatively reasonable starting point for EIF.

However when IMOS was being established, the Australian marine and climate science community effectively had nothing to lose. With significant infrastructure now in the water and delivering data, the stakes, in this respect, are much higher.

The worrying figures underlying this superficially "reasonable" starting point are that:

1. Costs of sustaining NCRIS-funded infrastructure in 2011-12 and 2012-13 are budgeted to be ~$16M pa, and
2. Costs of sustaining EIF (first $8M)-funded infrastructure in 2011-12 and 2012-13 are budgeted to be ~$3M pa.

With $18M of EIF funding available in these years, this says we have NO capacity for any further enhancement.

This is clearly an unacceptable situation.

The IMOS Five Year Strategy recognises that the cost of sustaining what we've started will consume a significant proportion of the new funding. However our thinking has been that this would be in the order of 67%, not 100%+. The Strategy also has a priority on driving down the cost per observation.

What's driving this?

Our view is that, fundamentally, Facilities have over-promised on what they can deliver, and Nodes have formed unrealistic expectations of what they can expect for the amount of NCRIS funds available. This is now coming home to roost.

So we will need to go through the difficult exercise of cutting our cloth to fit the current funding, to ensure that "scope creep" does not fully consume our capacity to invest in strategically determined priorities for the future.

Issues include:

43. Cost to sustain – General Issues

- Facilities have, at least in some cases, submitted "gold taps" budgets. We'll need to come back to "serviceable, chrome plated" in line with the above comments.
- IMOS was established with substantial ($4.2M) co-investment from the Queensland State Government. Ongoing co-investment is being negotiated, but $0M is included in the budgets submitted. Therefore the cost of sustaining GBROOS is currently showing up as 100% IMOS-funded. This is not really any different to other Regional Nodes, but it is a significant change.
- BOM has costed staff input at full cost recovery, with no co-investment of overheads in line with other institutional partners. This is being discussed.
- There may be other general issues we are yet to uncover.

44. Cost to sustain – Facility-specific Issues

- The bulk of unexpectedly high costs to sustain are concentrated in five Facilities – 50% in ANMN, 45% in the combination of Argo, SOTS and FAIMMS, and 5% in SRS.
- ANMN – This budget has become very complex, but the core issues appear to be:
    - No Queensland Government funding (see above)
    - Vessel charter costs for GBR (see next section)
    - Increased costs in WA (CSIRO)
    - Cost of hot-swapping ADCP's (general)
    - Staffing for the NRS (CSIRO)
    - Cost of moving to the NRS to real time (general)
    - Contingency funds (general)
- Argo – IMOS has been funding ~25 floats pa. There is a plausible argument from CSIRO for this to rise to ~34 floats pa, but it is yet to be discussed and agreed. At present, the difference is shown as extension whereas it needs to be separated out and considered as an enhancement, along with all other proposed enhancements.
- SOTS – Cost estimates continue to come back in excess of previous expectations. A second SOFS mooring (BOM) has been moved to enhancement, but replacement of PULSE and SAZ instruments and the cost of moving to real time (UTAS/ACE) are included in extension.
- FAIMMS – This appears to be driven by the issue of no Queensland Government funding (see above).
- SRS – This is partly driven by the issue of BOM full cost recovery (see above), and partly by increasing costs of the Lucinda Jetty Coastal Observatory (CSIRO).

45. EIF first $8M

- Key criteria for the Advisory Board in making very rapid decisions about the EIF first $8M included capacity to leverage existing NCRIS investment and avoidance of legacy commitments that would reduce future flexibility.
- Forward budgets provided by the Facilities entrusted with this investment are not necessarily reflecting these criteria. Extension costs are budgeted to be ~50% higher than what we considered to be a conservative estimate. However the issues are quite heterogeneous across the five Facilities and Sub-Facilities that have already received EIF funding.
- Extension estimates for Argo and ANFOG are well within expectations.
- Extensions estimates for the NRS, AATAMS, and ANMN Northern Australian Observing System are well outside expectations:
    - For the NRS (Stradbroke, ADCP's, some pCO2), the $1.8M EIF investment is budgeted to cost a further $2.4M in 2010-13.
    - For the AATAMS (SO creatures, GAB seals and GBR OTN arrays), the $1.2M EIF investment is budgeted to cost a further $2.7M in 2010-13.
    - For the ANMN Northern Australian Observing System (assumed to be Kimberley and Pilbara lines for now), the $1.7M EIF investment is budgeted to cost a further $3M in 2010-13.
- In total, these extension costs would consume ~50% of the flexibility we thought would be provided by EIF enhancement funding. This is clearly well outside the expectations of the Advisory Board, and these extensions budgets will need to be pruned to a significant extent.

46. Types of expenditure

- As a community, we were obviously able to reach agreement on what types of expenditure IMOS would/ wouldn't cover in securing the NCRIS funding. Since that date, the IMOS Office/ Advisory Board have had to rule on a range of specific funding issues that have arisen as we've moved to implementation.
- This gives us a body of "common law", but it is fair to say that the rules of what IMOS will/won't fund are not particularly well-codified, other than in the collective memory of those involved to date. The IMOS Office accepts responsibility for codifying these rules within a reasonable timeframe.
- That said, some definitive statements can be made now about some types of expenditure included in Facility Budgets submitted:
    - Need to remain focused on the EIF definition of "creating and developing research infrastructure"
    - Under EIF, IMOS is unlikely to provide operating support for infrastructure programs under-funded in other jurisdictions (e.g. Polynya Deepwater Array, TSRA Tide Gauges)
    - Requirement for co-investment of overheads (BOM, see above)
    - Related to the above, laboratory fit-out costs should be excluded (e.g. ANMN/CSIRO)
    - Computing cluster costs should be funded from other sources (MMO)

- There may be other types of expenditure issues we are yet to uncover.

47. Cash co-investment

Negotiations are continuing with several State Governments and other partners. Success of these negotiations, or otherwise, will obviously have a significant influence of what IMOS can/cannot do over the next four to five years.

Our understanding of the status of these negotiations is as follows:

- WA, Cab Sub, $0M to $6M over 3 years
- Queensland, Cab Sub, $0M to $5M over 3 years
- NSW , looking for $1M, plus SIMS co-investment
- Tasmania, UTAS $0.25M confirmed, negotiating with State for $0.25M+ (N.B. $0.5M co-investment is included as an offset in the IMOS Office budget)
- South Australia, nothing proposed
- Commonwealth included (e.g. DCC ACCSP co-funding).

N.B. There is ongoing debate about how to define cash vs in-kind co-investment, particularly in NSW. At this stage, our focus is on additional funding that might be available to help close the $50M gap.

3. Overview and synthesis of the Facility Plans as a package

A number of issues relating to the Facility Proposals have been teased out in the section on Node Proposals. Furthermore, some of the more difficult issues associated with the Facility Budgets as outlined above will need to be resolved before we worry too much about certain aspects of technical and operational feasibility. However there are a small number of significant, cross-cutting issues that need to be surfaced now:

48. Vessel access

Virtually all IMOS Facilities rely on access to vessels. Proposals have been reviewed to ascertain assumptions about vessel access, and about cost and co-investment. Issues include:

- In SOOP, there are eight Sub-Facilities clamouring for space, often on the same vessels. This could perhaps be better coordinated by platform, rather than by discipline.
- IMOS funding issues
    - Air-Sea Flux Stations: IMOS requested to fund $130-140K per trip (piggy-backed on DART buoy turnarounds).
    - NRS: Maria Island, Ningaloo, Esperance and Stradbroke Island stations have vessel time costed into operating.
    - ANMN: The GBR budget includes $1.3M for vessel charter, with Solander not available as co-investment on the east coast (see below).
    - ANMN: In WA, vessel time is costed into operating.
    - ANMN: In NSW, servicing is outsourced and the fee to the operator includes vessel time.
    - ANMN: In SA, 28 days pa are costed and 20 days pa co-invested. The days required for mooring turnarounds are much less than the total (48), reflecting the time required to support the high intensity hydrographic sampling being undertaken by SAIMOS. Also, vessel costs to IMOS rise from $84K to $140K to $168K over three years.
    - ANMN: The proposed TasIMOS shelf moorings have vessel time costed into operating.
- Co-investment issues
    - AIMS are prepared to offer up to 100 days of Solander time as co-investment in the North, though this will be dependent on what mooring arrays end up being supported. This also has the consequence of requiring substantial vessel charter cost to IMOS in maintaining the GBR arrays on the east coast (see above).
    - AATAMS is assuming substantial co-investment from AIMS to maintain the Ningaloo array (NRETA), but it is unclear whether AIMS is committed to this beyond June 2011.
- Assumptions about access
    - Deepwater Arrays: Assumes bi-annual access to Solander for ITF, to MNF for EAC, Kerguelen and Perth Basin, and annual access to Aurora for Polynya.

- AUV: For Sirius, up to 105 days of coastal/day boat time required (with 1 tonne A-frame or HiAb). For REMUS, up to 80 days of smaller (8m) boat time.
- NCOTS: Assumes access to Ngerin, Linneaus and the MNF.

49. National Reference Stations

There is a lot of interest in adding to the network of National Reference Stations. We're already planning to add ADCP's, at least some pCO2, and move to real time. We're now proposing to add more pCO2, bio-optics, sediment traps, and microbial sampling, and in some cases extend across the shelf. As a national community we'll need to think carefully about this strategy given the scale of investment being proposed. Are we willing and able to use such a network to do national scale science, as opposed to having a series of NRS's that are valued by Regional Nodes but are not really enabling national synergy? And can the impressively multi-disciplinary nature of the NRS's can be scaled-up from nine points on the Australian coastline to support multi-disciplinary studies at regional and national scales? Engagement with the modelling and satellite remote sensing communities is likely to be important in this respect.

50. Sustained observations

IMOS is focused on sustained ocean observing, with the data streams produced being the research infrastructure we are creating. From this perspective, some of the current Facilities are more mature than others, and it is reasonable for IMOS to maintain something of a "portfolio" approach in the interests of ensuring that we are investing in tomorrow's sustained observations today. However if we are to be successful in managing this portfolio over time, it will be important to actually make the transitions from less mature to more mature. The ANFOG and AUV Facilities have both been given the challenge of moving from an experimental stage in IMOS NCRIS to more mature, sustained observing stage in IMOS EIF. We will need to ensure that ongoing support for these Facilities is enabling this transition to actually happen.

51. Delivery under NCRIS and timing of possible enhancements

In looking at further investment in Facilities under EIF, it is reasonable for us to reflect on what will be delivered under NCRIS. Over 80% of the NCRIS funds are being invested in one large Facility (ANMN) and six moderately-sized Facilities. In total, "the moderates" represent 55% of our total investment i.e. Argo, SOOP, SOTS, ANFOG, ACORN and eMII. We are about two-thirds of the way through the initial NCRIS timeframe, and the reality is that availability of observations from these Facilities is currently very heterogeneous. The SOTS and ACORN Facilities are on track to begin delivering to their potential, but the lead times have been long, and expensive, and this is likely to be the case with any further enhancements. Serious consideration will need to be given to keeping these Facilities focused on delivery in "extended-NCRIS" mode.

52. Structure of Facilities and Sub-Facilities

We have seen something of a proliferation of Sub-Facilities in the Proposal phase, and this will need to be rationalised as we move towards approval and sub-contracting. In short, the most compelling reason for Sub-Facilities is to accommodate multiple institutions within a

Facility in line with our strategic priority to build national capacity. Prima facie, there is no need for multiple Sub-Facilities managed by the same organisation.

ATTACHMENT 1 – Analysis of major research themes by Node

	Broadscale Ocean Monitoring	Climate Variability	Major Boundary Currents	Continental Shelf Processes	Biological Responses
Bluewater & Climate	1. Tracking multi-decadal ocean change, understanding its role in setting the global response rates to increasing anthropogenic forcing and projecting regional, coastal and marine impacts	2. Understanding and predicting the major modes and drivers of climate variability in the Australian region	3. Improving the understanding and prediction of ocean currents and the links between large-scale offshore variability and the response of the Australian shelf/slope boundary current systems		4. Discovering and understanding the links between ocean and climate variability, marine chemical cycling and ecosystem structure and function (e.g. biodiversity) from multi-decadal through to monthly timescales
WAIMOS		1. Ocean and climate forecasting, including continental shelf processes	1. Ocean and climate forecasting, including continental shelf processes	1. Ocean and climate forecasting, including continental shelf processes	2. Biodiversity conservation and ocean productivity
QIMOS		*1. Regional Oceanography:* To quantify the strength and variability of the EAC and the impact on cross-shelf exchange and coastal oceanographic processes;	*1. Regional Oceanography:* To quantify the strength and variability of the EAC and the impact on cross-shelf exchange and coastal oceanographic processes;	*1. Regional Oceanography:* To quantify the strength and variability of the EAC and the impact on cross-shelf exchange and coastal oceanographic processes;	*2. Productivity:* To determine the influence of large-scale oceanographic and regional shelf processes on ecosystem productivity; *3. Connectivity:* To understand the impact of oceanographic and shelf processes on biological connectivity and movement; and *4. Climate change:* To use our improved understanding of the influence of physical processes on biology to predict the effect of climate change on marine ecosystems.
NSW-IMOS		1. To investigate the EAC, its separation and resultant eddy field along the coast of SE Australia	1. To investigate the EAC, its separation and resultant eddy field along the coast of SE Australia	2. To quantify key continental shelf processes along the coast of SE Australia	3. Determine the biological response to oceanographic processes and climatic effects
SAIMOS			1. The temporal and spatial variability of both shelf currents and the slope, Flinders Current, their connectivity to the Southern Ocean, Leeuwin and East Australian Currents and modulation by far-field forcing	1. The temporal and spatial variability of both shelf currents and the slope, Flinders Current, their connectivity to the Southern Ocean, Leeuwin and East Australian Currents and modulation by far-field forcing	2. How key biological patterns and processes respond to the above-mentioned physical forcings.
TasIMOS				1. What is the spatial and temporal variability in regional oceanographic conditions and how do these affect Tasmanian ecosystems?	1. What is the spatial and temporal variability in regional oceanographic conditions and how do these affect Tasmanian ecosystems?