

Bluewater and Climate Node: Summary of Reviewer's comments.

In response to the Federal Budget requirement for enhanced monitoring in the Southern Ocean and increase coverage in northern Australian waters, the Bluewater and Climate and Western Australian Node Science and Implementation Plans (NSIPs) have been subjected to international peer review. The IMOS office contacted ten reviewers and seven responded to say that they were willing to review the node proposals. This is testament to the level of interest in IMOS activities internationally, as a leader in Southern Hemisphere ocean observations. Reviewers were chosen on the basis of their expertise in;

- Organisation of major ocean observing activities.
- Understanding of Australasian ocean climate.
- Understanding of broad scale ocean variability
- Focus on the Southern Ocean
- Linking BROADSCALE to regional/boundary current variability.
- Focus on the Indonesian Throughflow/Indian Ocean.
- Focus on boundary current systems (Leeuwin is a unique Eastern Boundary current)
- Linking physics to biology.
- Ocean current/shelf interactions

Each node plan had five reviews, with three reviewers looking at both plans and two other reviewers looking at one plan and a further two reviewers looking at the other plan. This approach was designed to handle the breadth and depth of IMOS.

The reviewers were asked to determine whether or not:

1. Science questions posed by the Nodes are relevant and appropriate given the context for sustained ocean observing in Australia, and the state of the science globally.
2. The observations being provided to the Nodes by the Facilities are, in combination, likely to address the science questions being posed.

Generally, the reviewers' comments were brief, with little in the way of in depth specific comments. However, it must be borne in mind that the reviewers were given only a few weeks notice prior to receiving the documents, and then two weeks to review substantial documents. In the case of reviewers 1-3, this amounted to a total of over 160 pages for the two documents.

All the reviews of the Bluewater and climate NSIP were resoundingly positive, with reviewer 1 describing investment in this space as "*substantial, ambitious, and appropriate*". This is not surprising, as the international requirements for observations are well articulated, and members of the node have been engaged with the international process. Reviewers were generally in agreement with the priorities identified by the node.

Reviewer 1 noted that: "*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.*"

Two of the reviewers made a point of highlighting concerns for sustained funding and coordination of Deep Hydrography sections, which sit outside of the IMOS framework. Two reviewers also questioned whether the links with the modelling community were properly addressed.

Regarding the specific responses to the questions set;

1) Whether the Science questions posed by the Nodes are relevant and appropriate given the context for sustained ocean observing in Australia, and the state of the science globally.

There seems to be unanimous agreement that the science questions proposed are relevant and appropriate:

Reviewer 1: "*The IMOS plan is substantial, ambitious, and appropriate, including contributions that effectively utilize partners' efforts as well as increasing the overall value of the system. It poses the important questions for understanding the climate system, and it includes a broad spectrum of measurements that will bring a wealth of new information to bear on these issues.*"

Reviewer 2 felt that the issues were right, but was more concerned about ordering them in terms of priority. The comments regarding ecosystem readiness, echo what was said at OceanObs09; "*The connections to the ecosystem are just as important, [as the other themes], but not as "ready" yet. From a relevance perspective, this has the potential to come first*".

Reviewer 3: "*The science questions posed are fully relevant and appropriate. The proposal is very well integrated within the international global ocean system and related priorities.*"

Reviewer 4: "*The proposal articulates topical, urgent and important science questions which can often only be addressed in a global context, and recognises that the proposed measurements fit within the global effort. Therefore, the strength of the observation program is that gaps in the international effort, relevant to Australia are proposed for enhancement.*"

Reviewer 5: "*The posed science objectives are of importance from a global perspective, as perhaps one of the largest gaps in our knowledge is the role of the Southern Hemisphere air-sea heat, freshwater and gas exchanges in mitigating or regulating the impact of climate change.*"

2) The extent to which the observations being proposed will, in combination address the science questions being posed.

While reviewers felt that the correlation between the science questions and the observations required was strong, reviewer 3 questioned the clarity and reasoning behind the prioritisation. While it is likely to have been discussed, the reasoning has not been articulated on paper. Specifics related to the prioritisation will be discussed under section 5.

Reviewer 1: "*[The plan] includes a broad spectrum of measurements which will bring a wealth of new information to bear on these issues.*"

Reviewer 2: "*I think there is a high correlation with the science questions chosen and the observational strategy. The structure of the document made the link very clear. In that sense, one could not have done a better job, considering the available technology and prospects for implementation.*"

Reviewer 3: "*It is not clear to me how the priorities are defined with respect to science questions but also taking into account costs, feasibility and maturity issues.*"

Reviewer 4: "*Clearly we know that the IMOS network of observations will not be an optimal System - it can't be because the ocean is so grossly under-sampled and the scientific questions so large in space and time. There was no particular observation or enhanced observation that seemed without its merit, and it seems growing observations in the way suggested by the node will help tackle the articulated questions.*"

Reviewer 5: " *The proposal does a great job of clearly identifying the outstanding the outstanding science issues and has clearly elucidated science objectives and approaches for addressing these issues.*"

Sections 2, 3 and 4 (Socio-economic context, Scientific Background and Pre-existing observations) received no specific critique bar a few general positive comments. So the remainder of this document focuses on section 5:

5. What observations does the Node require during 2009-2013, and how will they address the research questions?

Reviewer 1: identified high priority items with demonstrated value as long time series measurements (Argo, satellite observations, SOOP XBT, (some) Moorings), and high priority items with developmental elements whose role in a sustained observing system needs to be demonstrated (Gliders, Seals as Samplers, additional Argo sensors, SOOP BGC).

Reviewer 2: "*I was really impressed by section 5. This is the difficult one to write and the group has made excellent judgment call as to what is ready to implement, and where the most significant payoffs might be. I found in particular their ranking scheme very helpful. Agreed with 95% of what was listed; exceptions identified below....*"

Reviewer 3: " *There are obvious priorities (e.g. complete and sustain the Argo core mission, repeat XBT, Clivar/Carbon repeat hydrographic program, etc). There is also a push towards ecosystem observations (CPR, seals, bioacoustics) that must be encouraged. Overall, however, it is not clear to me how the priorities are defined with respect to science questions but also taking into account costs, feasibility and maturity issues. Requirements from modeling and data assimilation systems should also be better addressed. I did not follow why the tsunami, coastal networks are listed in this node although developing coastal hydrological stations (for anthropogenic and climate change studies) should certainly be a high priority. I assume this is developed in other nodes or elsewhere.*"

Reviewer 4: " *This proposal is a broad package of multidisciplinary observations contributing to a number of topics and I found this breadth combined with a lack of detail made it difficult to review in a quantifiable way. There is just not room for specifics in the proposal - which would be required - to give more helpful criticism.*" The reviewer went on to identify the essential elements of the observing system (all physics).

Comments on specific elements:

Argo (Essential):

Reviewer 1: "*Argo should receive the highest priority for support, including its extension to high southern latitudes, and ongoing technical improvements such as bi-directional communications, high vertical resolution and enhanced surface layer sampling... Additional Argo float sensors for biogeochemical and ecosystem impacts. Dissolved oxygen is the most advanced of the added sensors, but its long-term sensor stability in relation to science objectives should be demonstrated, as well as a routine delayed-mode quality control process.*"

Reviewer 4: "*Argo: Critical measurements for most of the science questions. The Australian effort is commendable and the deployment strategy is clearly articulated: to maintain the array to prescribed operating float densities around Australia. The commitment to growing the number of floats operating in the marginal ice zones is important: the sign of the net air-sea heat flux is still uncertain in the Southern Ocean and monitoring ocean properties is one key part of closing the budget by understanding water mass transformations. In this regard I consider the southern seals as oceanographic samplers programme also important.*"

Reviewer 5: " ... I fully support the extension of the Argo float array, particularly in the data-void Southern Ocean. The operation and dissemination of data from this program continues to set a "gold standard" for how an international observational program should be conducted. Through the IMOS initiative, Australia is clearly a significant partner in the Argo program contributing floats in the climatically important Indian and Southern Oceans. I am also happy to see the expansion of the program to include the deployment of ice-capable and oxygen-sensor floats. I think the technology has now developed beyond a proof of concept level, and the ice-capable deployments will provide crucial information on the changes in stratification at the ocean-cryosphere boundary."

Deep Hydrography (Essential)

Reviewer 1: " Deep ocean repeat hydrographic transects, which have critical standalone objectives (sampling decadal change in the deep oceans) as well as important synergies with the Argo array. "

Reviewer 4: " My biggest concern is for deep ocean hydrography and biogeochemistry. This is still, I contend, the single most important programme for global oceanography - despite the enormous impact made by Argo (upper-ocean, mainly excluding boundary currents). " And

"A number of key scientific objectives in this proposal can only be addressed by deep ocean hydrographic and biogeochemical measurements. The proposal points out that there is a gap in national ability to measure CFCs and other key tracers. Also, the ship-time and operational costs for these deep ocean cruises are subject to individual application to the Marine National Facility and annual research funding. Three sections are proposed for repeat occupation on a 5-10 yr cycle. This seems rather modest. I would have thought that to develop national facilities for tracer analysis more than one transoceanic standard section should be occupied each year. It would now be timely to reach a national agreement for the occupation of repeat sections as a part of the sustained observing system - reducing the uncertainty of annual funding. Hydrographic sections are much more of a technical, rather than scientific challenge with modern instrumentation and ought to be a central component of any strategy of sustained observations. It is becoming very difficult to argue for novel scientific advancement coming through relatively infrequent repeat hydrographic sections, but they are the only method for surveying the deep ocean. These sections are desperately important for long-term climate studies (being an integrator of change), for testing models (both ocean and climate) and for defining the initial state of the ocean (which is likely where any decadal climate predictability lies). There is no prospect in the near future for alternative methods of obtaining the precise physical and chemical measurements of the deep ocean."

Satellite Remote Sensing

Essential: Assemble case 1 calibration data for Ocean colour

High Priority: Reprocess historical Satellite SST datasets

Reviewer 1: " Support for satellite observations (sea surface height, sea surface temperature, ocean color) should receive the highest priority. This includes in situ observations needed for calibration/validation such as SST measurements by surface drifters and sea level gauges and calibration site in support of altimetry. Increasing the value of these satellite observations through modest investments is a highly cost-effective activity."

Reviewer 4: " 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 analysis in general. The node made clear that a present the focus on ocean color for coastal regions need to be expanded to cover the open ocean."

SOOP

Essential: XBT, SST, CO2 on Research vessels, Sustain fluxes, CPR, Bioacoustics

High Priority: Enhance fluxes, Nutrients,

Reviewer 1: "SOOP XBT (upper ocean circulation and transport on seasonal-to-decadal timescales) and CPR networks should receive the highest priority. SOOP biogeochemical sampling potentially have high value, equal to those elements listed above, but also contain developmental elements."

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."

Reviewer 4: "Ships of opportunity: proposed extension of SST, carbon and CPR work is obvious and should be supported."

Reviewer 5: "I also fully support the addition of additional measurement systems (meteorological, PCO₂, radiometers, biogeochemical water samples etc) on Australia's research vessels. This makes perfect sense, especially given that the Aurora Australis probably transits similar routes to Antarctica so that some information on interannual variability might be garnered from the repeat measurements. The benefit here is also that R/Vs typically have a dedicated technician who can help to troubleshoot any problems in the instrumentation, and there is also more leeway compared to a commercial vessel as to the most advantageous location of the sensors to avoid interference with the ship superstructure.

The addition of CPRs, nutrient and SST/radiometer measurements from SOOP vessels is also highly recommended. Again, given that these vessels frequently repeat the same transits, will eventually provide the capability of separating space from time variability and provide the much needed cal/val data for satellite products. The SOOP XBT program provides some of the longest time series on the mean and fluctuating ocean heat and circulation within the Australasian region and has substantially contributed to our understanding of how the upper ocean responds to largescale climate variations. 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."

Deep Moorings (ABOS)

Essential: Indonesian Throughflow Line, Polynia Moorings, RAMA Flux Mooring, Southern Ocean Timeseries

High priority: Kerguelen deep array, EAC Array

Low priority: Leeuwin Current Array, Perth Basin deep array, Hiri Current, Tasman Outflow, pH at SOTS.

Reviewer 1: "Moored time-series observations should receive the highest priority. 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 throughflow program all rate especially highly for cost effectiveness and for leveraging of international partner efforts and of other related program elements. Other arrays described in the plan also address important scientific objectives, including abyssal transport monitoring, air-sea flux reference measurements, and biogeochemical time-series, but may not necessarily be appropriate or practical for a sustained observing system. These capabilities and practicalities should be tested while proceeding very cautiously toward commitments for sustained observations."

Reviewer 2: "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 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)."

Reviewer 4: " Deep ocean moorings: I strongly endorse the Deep Water Array enhancements, particularly aimed at constraining parts of the lower limb and upper limbs of the global overturning circulation. An array in the Atlantic has shown that the overturning is variable, and that to determine climate-relevant lower frequency variability will require long-term continuous sampling to eliminate aliasing. Such measurements should have a profound influence on our confidence in models of decadal climate variability, as well as providing scientific understanding of basic oceanographic processes and circulation. One note: PIES are a very poor substitute for measuring the vertical density structure (with moorings, gliders or whatever). Without prior dense sampling of the full water column resolving the seasonal cycle, PIES travel times recover very little of the variability of the vertical temperature gradients - they are entirely dependent on the quality of the available climatology. They are a poor mans attempt to get something for nothing....."

..... Tropical moored buoy arrays: Science case clearly recognizes the global benefits in seasonal forecasting derived from this system. The gap in the network can and should be filled, and the Australian commitment is appropriate given the benefits already derived from this network."

Reviewer 5: " The proposal makes a very good point that Australia has never contributed to the tropical mooring array in the Indian and Pacific Oceans. Yet this array has provided absolutely critical information to Australian scientists and policy makers, both directly and through model assimilation/calibration, on the impact of large-scale modes of climate variability such as ENSO and the IOD on the Australasian region. These climate modes play a substantial role in the variations of the Australian economy. It therefore seems timely to support the deployment of moorings to this array, particularly the proposed air-sea flux buoy off northwest Australia as part of the RAMA array and also in Ombai and Timor Passages as part of the Indonesian Throughflow (ITF) monitoring scheme. Both mooring deployments will have realized cost benefits from being integral parts of existing internationally funded monitoring efforts. The RAMA moorings provide information on the Indian Ocean Dipole mode while the ITF array will monitor changes in the transfer of heat and transport anomalies associated with El Nino. The heat content and SST in the region have a significant impact on Australian weather and rainfall. The total arrays will provide vital data to help detect shifts in the large-scale climate modes and help Australia to develop mitigation and adaptation policies in response. .

... Air-sea flux products in the Southern Ocean have large sources of uncertainty and differences between the flux products themselves can be substantial - over 50 W/m². Again, this is largely because there are relatively few direct air-sea flux measurements in the region, and in fact, I don't think that there are any flux buoys deployed in the Southern Ocean at present. As the successive PULSE mooring attempts have shown, the wave and wind conditions in the region make the deployment of a surface mooring problematic, to say the least! Nonetheless, the time series air-sea flux measurements from the proposed ASFS mooring will provide vital information for ground-truthing of the NWS and satellite derived flux products. The recent success of the SOTS deployment shows it can be done, and it is heartening that CSIRO is enlisting the WHOI group to help with this deployment as they have extensive experience in the design and deployment of buoys in harsh subtropical regimes and in the Arctic. The additional payload of TS, nutrients and many other biogeochemical measurements from both the PULSE and ASFS moorings also provides valuable parameters for understanding climate variability."

Drifters (FLOCC) (Lower priority)

Reviewer 1: "[Support for a] Surface drifter network (circulation) [should receive the highest priority]"

National Reference Stations

Essential; Sustain

High Priority: Enhance with CO2

Reviewer 1: "[Support for] Coastal long time-series hydrographic stations (that are representative of the open ocean) [should receive the highest priority]"

Reviewer 5: "While not a direct focus geographical region of this IMOS funding round, I also support the continued instrumentation of the National Reference Stations. These coastal time series provide an important link between the shelf and deep water regions. Oceanographic time series such as this are carefully considered prior to their implementation because their usefulness is in their longevity. Interrupting or disbanding them seriously degrades the data already collected. The program involves a small financial outlay for a huge scientific benefit providing valuable data to directly address the science objective of tracking multi-decadal ocean changes."

Gliders (ANFOG):

Essential: Develop Multiglider approach for 1-3 systems (Tasman Outflow/SOTS, EAC, Leeuwin Current)

Lower Priority: Bluewater glider arrays for other major systems (Leeuwin Extension, Hiri Current, EAC Extension.

Reviewer 1: "Glider transects for boundary current transport monitoring observations potentially have high value, equal to those elements listed above, but also contain developmental elements. The optimal combination of gliders together with floats and/or moorings is an important design task. For Australia, a priority is selection of a specific glider technology that can be maintained within the region. On a global basis, implementation of glider observations in boundary currents and marginal seas is among the highest priorities for enhancement of the ocean observing system."

Reviewer 2: "I think the glider approach under 4.3 should be seen as a pilot effort, not much is proven about glider approaches to monitor flow regimes and hence should be merged with the second point, i.e. a joint/complementary/integrated approach to glider observations to link open ocean with more near coast observations (i.e. both high priority)."

Reviewer 3: "It will be crucial for IMOS to make sure that the facilities (e.g. gliders) have enough skilled personnel to deploy and monitor the instruments at sea and calibrate/process the data."

Reviewer 4: "A rapidly developing tool in ocean observing. The costs, benefits and potential of gliders to address climate, process, physical and biogeochemical questions is not known. However, there have been several programs using gliders with great success: as regional samplers, as alternatives to moorings and for process studies. Building capacity, in a measured way, linked to clearly defined scientific proposals is a sensible measure. Likely to be a key for monitoring of the EAC and providing the broad physical characteristics around long timeseries sites."

Southern Seals as Oceanographic Samplers (Essential)

Reviewer 1: "Southern Seals as Oceanographic Samplers. Marine mammals present a unique opportunity for oceanographic sampling in the ice-covered regions that remain problematic for floats and gliders. The capabilities of marine mammals for systematic sampling need to be established; the miniature sensor packages require further technical development and validation; the routine delivery of climate-quality data streams needs to be demonstrated."

Reviewer 5: "Similarly, the T-S profiles obtained from tagged seals as part of the SSOS program has also vastly increased the number of stratification profiles in the Southern Ocean and the MAPSO fully deserves support. These profiles have contributed to our understanding of frontal variability in the Southern Ocean, and an additional bonus of MAPSO is that foraging behaviour helps with identification of ecologically significant areas."

Monitoring of Apex Predators (Essential)

No reviewer comment.

QA/QC

Reviewer 3: *" There are synergies between facilities as far as sensor performance, data processing and validation is concerned (e.g. gliders, Argo and CTD seals) and I do not know how those are addressed."*

6. Implementation Plan - July 2009 to June 2013

Reviewer 2: *"The implementation plan in section 5 was very helpful for me to understand for example of how the higher trophic level observations would be done. But all the rest was done well also."*

7. Describe how data provided by IMOS will be taken up and used by the Node

Reviewer 2: *" There is no doubt in my mind that the data collected are used already and its use will increase dramatically over the coming decade. One should not forget, that any environmental forecasting, which all marine agencies want you to do, will have to be based on successful hind casting. And without any long term observations that can not be done... so while much of the information is already useful its value will multiply many fold in the years to come. For that (and other) reasons a data management concept is essential, which I believe is take care of well within the IMOS framework."*

8. Describe what impact the IMOS observations will have regionally, nationally and globally:

Reviewer 5: *" There is every reason to believe that significant contributions to the international climate community will continue if they secure funding from IMOS to maintain and enhance the monitoring of these relatively data-poor regions. It is probably also worth explicitly pointing out that without the input from the IMOS supported operations to this Node within the Australasian region, a "global" analysis would not be possible. Still, the uncertainty estimates in the air-sea fluxes and the global heat balance are largest in the Southern Hemisphere, and the sustained monitoring system suggested in the proposal would go some way to improving the estimates."*

9. Governance, structure and funding.

Reviewer 2: "

- a) *How and who will ensure the integration between open ocean and more coastal information. They do address different issues, but quite often the coastal systems are less cognizant of the open ocean changes outside their own information reach. As evidenced by some compatibility issues between the nodes.*
- b) *How can the ocean assessment and modeling community make the needs heard in the context of the node development?*

Both are governance issues, that are maybe more relevant to IMOS as a whole."

Reviewer 3: *" Requirements from ocean models and coupled ocean/atmosphere models are not, however, specifically addressed (although this is implicit for some components such as Argo)."*