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Request: Documents and related material coming out of the CMAR Capability [Development] Plan 2008-2010 process from 1 August 2008 to 31 July 2009

Documents: Part 1 – Docs 1-30

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Morgan, Janet (CMAR, Hobart)

From: Smith, David (CMAR, Hobart)
Sent: Friday, 1 August 2008 4:29 PM
To: Davies, Campbell (CMAR, Hobart); Dichmont, Cathy (CMAR, Cleveland); Smith, Tony (CMAR, Hobart); Fulton, Beth (CMAR, Hobart)
Cc: Prendergast, Meredith (CMAR, Hobart); Parslow, John (CMAR, Hobart)
Subject: FW: Input to CMAR Biogeochemistry Review
Attachments: Aquatic Biogeochemistry & CMAR.doc; BGC and Themes.doc

Dear All,

Attached is an excellent paper by John to inform a review of CMARs biogeochemistry capability.

During the capability development process we identified the importance of this area for informing our ecosystem models in particular but did not anticipate specific needs in terms of FTEs for SAFE. In fact we didn't identify any change plus or minus. Currently we only have a small percentage of Peter Nichols and have asked him to (with others) review the application of biochemical tools to fisheries. We also have JP mapped into several projects but this is more for his overall understanding of marine systems rather than any focus on biogeochemistry.

I would appreciate your views on whether this may change into the future.

Please note timelines.

Cheers

David

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From: Parslow, John (CMAR, Hobart)
Sent: Thursday, 31 July 2008 10:22 AM
To: Smith, David (CMAR, Hobart)
Subject: Input to CMAR Biogeochemistry Review

Dear David,

I have been asked by CMAR OTC to undertake a review of CMAR's broad biogeochemistry capability. As part of this review, I've been specifically asked to consult with Theme Leaders on their anticipated need for the capability. I am writing to seek your input as a minor user of this capability. I realise you've already been asked for input in late 2007, and kindly attended capability workshops at that time. I hope this represents a chance to update that input in the light of SIP3 decisions, and perhaps take a more strategic view of the capability and your needs for it. To that end, I've prepared two attached documents. One is a general overview of status and trends in international biogeochemical science and a summary of CMAR's capability. I hope that will help to give you a clear idea of the kind of capability I'm reviewing, and how it might be relevant to your theme. The second document is a questionnaire. Again, it's intended to act as a prompt for a dialogue about the contribution of the capability to your theme.

I'm afraid the first overview document is rather long, but it's written in a non-technical way, and I hope you might find it fairly easy to read, and of general interest. If you're pressed for time, Sections 1 and 6 are the most critical, followed by 5, 4 and then 2 & 3, although I hope it reads better in the order 1 to 6. (I should emphasize that this represents my own preliminary take on the science and capability at this point. Any comments you might have on this document are also most welcome.)

You may prefer to provide a brief written response, but if you'd prefer, I'm happy to go through the
questionnaire with you by phone instead. I'd expect that might take 15 to 30 minutes. I'm afraid I need your response (either verbal or written) by COB Wed 6 August. I apologise for the time frame, but I have a looming deadline on the report. Obviously, it would be preferable if you have time to scan the documents prior to our discussion.

I realise you're busy, and I do want to stress how much your input is appreciated. Getting the input capability and output needs aligned is obviously a key challenge in the matrix, and I hope this exercise will benefit your theme down the track.

Best Regards
John
Aquatic Biogeochemistry – Status and Trends in the Science and its Applications.

This summary overview is intended to inform discussions with Theme Leaders about their current and future needs for CMAR’s aquatic biogeochemistry capability. It includes a definition and brief description of the capability area, presents recent international trends and projected future advances in the underlying science, highlights some hot application areas where the capability might be expected to contribute, and summarises CMAR’s key strengths.

1. What is aquatic biogeochemistry?

For the purposes of this review, aquatic biogeochemistry is defined as “the study of the cycling, fate and impact of materials (major and minor elements, and pollutants or toxicants) in aquatic ecosystems (typically focused on lower trophic levels).” This field of study is necessarily multi-disciplinary, and in the marine domain, it effectively integrates across the classical disciplines of physical, chemical and biological oceanography. Within each of these disciplines, it embraces field observations, lab and field process studies, and modelling. We have used “aquatic” to include freshwater deliberately, although most of the experience and applications of CMAR’s capability have of course been in marine systems, extending from estuaries to ocean basins.

Unsurprisingly, the capability has a fuzzy boundary. Physical transport and other physical processes play a critical role in biogeochemical cycles, yet not all physical research is carried out with biogeochemical applications in mind. Traditionally, biogeochemical studies and models are distinguished from ecosystem studies and models rather arbitrarily, in that the former tend to stop at secondary production in both pelagic and benthic systems. But biogeochemical understanding of the bottom-up control of biological production underpins most trophodynamic and ecosystem models, and higher trophic levels may play an important role in top-down control of primary production and carbon and nutrient cycles. Biogeochemistry increasingly makes use of new disciplines such as genomics and remote sensing, but again not all effort in these areas is targeted at biogeochemistry.

For the purposes of this review, we have defined a core capability group of CMAR staff whose research is partly or wholly directed at aquatic biogeochemistry as defined above. There is a much larger group of CMAR staff in related capability areas whose research can contribute to or benefit from biogeochemical studies. Collaboration across these boundaries will be important both to the success of individual projects, and the long-term development of the capability.
2. Historical development and applications

The early development of marine biogeochemistry was arguably driven by scientific curiosity, and the desire to observe and understand the ocean. But its further development can be understood in the context of four broad application areas. Perhaps the oldest of these has been the connection between primary and secondary production and fisheries production. Links between rates of primary production, plankton composition, trophic structure and fisheries production were established relatively early. The subsequent relationship between oceanography and fisheries science has been uneasy, with some fisheries scientists feeling that oceanography had little to contribute to fisheries management. More recently, emerging evidence of interdecadal oscillations and regime shifts in ocean circulation and production, and their potential role in major fisheries collapses, has refocused attention on this connection. Attempts to understand the dynamic spatial distribution of pelagic stocks and relate fish movement to their environment have also helped revived this link, and this has been reflected in major international research programs such as GLOBEC and IMBER. The emergence of the paradigm of ecosystem-based fisheries management might be expected to refocus attention on top-down controls in marine cycles.

The second application area has grown with the recognition of chronic pollution and especially eutrophication in coastal marine systems. This field arguably has an earlier genesis in lake eutrophication. Awareness of the environmental impact of a broader range of toxicants and pathogens in coastal marine systems increased in the second half of the 20th century, leading to a desire for monitoring, understanding and prediction of the fate and impact of these contaminants. More recently, concern has extended to the impact of catchment land use and water management on the delivery into coastal marine systems of freshwater and sediments as well as nutrients and toxicants. This has led in turn to recognition of the need to measure, understand and predict catchment loads and their transport and transformation through rivers, wetlands and floodplains.

A characteristic of biogeochemical cycles in shallow coastal systems is the important role of benthic processes, and exchanges of materials between the water column and the bed. Of course this is true on very long time scales for ocean basins as well, but many smaller scale biogeochemical studies in the open ocean have focused entirely on pelagic processes and systems in the upper ocean. The focus on basin scale biogeochemical cycles increased drastically in the 1980s and 1990s with recognition of the potential climate impacts of anthropogenic CO2, and of the dominant role the ocean plays in the global carbon cycle. This has led to the development of major international research programs (WOCE, JGOFS, SOLAS), and major advances in our understanding of basin scale biogeochemical cycles. Coastal systems play an important role in these cycles, partly as a filter between catchment export and the oceans, and partly as a site of enhanced biological activity, but quantifying their role has proved more challenging, because of their diversity.

Finally, the rapid growth of mariculture in the last few decades has created another potential application area. It’s fair to say that environmental impacts of fish farm
aquaculture can be generally treated like those from other sources of contaminants. But the development of extensive shellfish aquaculture, and particularly prawn pond aquaculture, has created a new science concerned with enhancing food production by manipulating and fertilizing marine systems. Biogeochemical science has been applied to help manage these systems, but the application of biogeochemistry to “engineered marine systems” is still in its infancy. Most recently, the ante has been upped substantially, with emerging proposals for large scale ocean fertilization to increase fish production, or sequester carbon, or both.

3. Major Trends in the Underlying Science

Observations and process studies

One can make a strong argument that, throughout its history, marine biogeochemistry has been strongly constrained by the expense and difficulty of making (and interpreting) observations. There are many reasons for this.

- Historically, making observations has required a ship and trained technicians or scientists at the observation point. That’s obviously very expensive for open ocean measurements, but non-trivial for coastal measurements. The result has been that most variables have historically been badly under-sampled in space and time.
- Many materials of interest are present at vanishingly small concentrations, at least by terrestrial or even freshwater standards. Macronutrients may be present at around 10 nM, and micronutrients at orders of magnitude less. Until relatively recently, it was not possible to sample for key micronutrients such as iron without serious contamination. Very low biomass concentrations mean that measuring biological fluxes requires specialized highly sensitive techniques, which often perturb the natural state.
- Many variables or components have high inherent complexity. There may be tens to hundreds of species of phytoplankton and zooplankton present in a sample. Dissolved organic matter in seawater, and particulate organic matter in sediments, comprise very complex mixtures of labile and refractory compounds, which are largely uncharacterized. (There have been debates in recent decades about how to measure DOC in seawater.)
- Many of the key organisms and processes occur at very small scales. Some of the key primary producers in the picophytoplankton are less than 1 μm in diameter. It has been very difficult to characterise these organisms, and indeed some of the dominant primary producers in the oligotrophic oceans (and therefore on the planet) have only been characterised in the last two decades. The study of bacteria has also lagged badly for the same reasons. Interactions at these friction-dominated scales are hard to study, and can be counterintuitive. Recent studies of detrital particles suggest that the structure of the environment at scales of microns may look more like a forest than an “empty ocean” to an individual organism.
- This is a fluid environment. The water column we sample today is somewhere else tomorrow, and given vertical shear in currents, different parts of it are at different
places. This makes it very difficult to interpret sparse observations, or for example to close budgets. Even in the 1990s, large scale ocean experiments involving multiple ships attempted to close budgets with limited success.

- Because it is a fluid environment without boundaries, it is very difficult to conduct controlled experiments. Much of our process understanding has been based on controlled studies in very artificial environments in the laboratory. Conversely, many so-called “process studies” in the field are really just attempts to measure in-situ fluxes as well as concentrations. Mesocosms offer an opportunity to study more complex systems in a more controlled way, and have made some substantial contributions to understanding. The Fe-fertilization experiments of the last decade are interesting because they represent large scale perturbations of natural systems on scales which allow effects to persist over periods of weeks or longer. (By comparison, there is a long and rich tradition of whole-system manipulation experiments in lakes.)

Given these challenges, it’s hardly surprising that the history of biogeochemistry as a science has been heavily influenced, perhaps even dominated, by developments in observation technology. In biological oceanography, the introduction of $^{14}$C tracer techniques for primary production, of electronic and optical particle size analysers, of high-resolution pigment analysis, natural isotope techniques, in situ fluorometers, flow cytometers, and ocean colour remote sensing, have all led to advances not only in what we can measure, but in our process understanding and concepts of biogeochemical cycles. The same can be said for physical and chemical oceanography.

Over the entire history of the science, advances in observation technology have led to an ability to make more measurements, with finer spatial and temporal coverage, with more precision, and more discrimination. Needless to say, progress has been faster in some areas than others, and different technologies offer different trade-offs among spatial and temporal coverage and resolution, precision and discrimination.

Physics has generally led the way, arguably because the variables of interest are fewer and inherently simpler. We’ve had robust in situ sensors for most physical properties for at least two decades. The big advances of the last decade or so have been in the development of autonomous platforms (gliders, profiling floats and moorings, sensor networks) and remote sensing technologies (SST, altimeter, sea state, but also coastal radar). Interestingly, it might be argued that physical observing systems are most highly developed and effective at ocean basin scales. They are arguably less effective at shelf scales, and least effective at inshore coastal scales, because of the high spatial and temporal gradients in these systems.

By comparison, advances in chemical observation technologies are more uneven. We now appear to have a robust in situ oxygen sensor (optode) suitable for deployment on autonomous platforms such as ARGO for long periods. In situ sensors for CO$_2$ and nitrate exist but are not yet widely used. We lack robust in situ sensors for other nutrients, suitable for use at ocean concentrations. Most chemical measurements still require the collection of samples for laboratory analysis. Laboratory instruments have generally become more powerful, with better precision, more discrimination and higher throughput.
Perhaps the most powerful development over the last decade has been the integration of techniques for isolating specific organic biomarkers with mass spectrometry, so that it is now possible to measure isotope ratios in specific biomarkers. This has proven a particularly powerful diagnostic tool in understanding current biogeochemical sources and sinks, and also in reconstructing past changes from sediment cores.

The key advances in robust in-situ biological observation technologies have occurred in bio-optical sensors, which can measure pigments (fluorescence and/or absorption) and particle densities and sizes (through transmission and scattering). Ocean colour remote sensing of chlorophyll in open ocean waters is now relatively mature, and we are close to development of effective algorithms for coastal waters. Other in situ fluorescence instruments (FRRF and PAM) measure parameters in phytoplankton photosynthetic systems. More sophisticated systems for in situ automated analysis of plankton communities through pattern recognition have been developed as experimental systems (eg Videoplankton Recorder), but not routinely deployed. Otherwise, detailed microscope analysis of phytoplankton and zooplankton communities is still laborious and expensive. Biological rate measurements also generally still require time-consuming manipulation and analysis of in-situ samples. Analysis of bacterial communities and processes is still lagging behind.

Vertical fluxes of settling particles in the open ocean, and benthic-pelagic exchanges in the coastal ocean, play particularly important roles in biogeochemical cycles. There have been important advances in techniques for in situ measurement of settling rates and fluxes, but inconsistencies among methods persist.

The development of genomic technologies, in particular cheap metagenomic sequencing and gene array technologies, promises to revolutionise some aspects of our biological observations and process studies. These offer direct access to the feedback loops and mechanisms which control environmental response and adaptation at the organism level. They also offer a way to rapidly screen microbial communities, for both species identifiers and gene expression. Application of this technology to marine applications is just beginning, but we can expect the field to develop rapidly.

**Biogeochemical Models**

The development of models has generally paralleled and, as suggested above, often reflected advances in observations. Another key driver of modelling, at least over the last 40 years or so, has been the exponential growth in computer power (computation and storage).

Again, physical oceanography has led the way. At the basin scale, we have moved from idealised, linearised models in rectangular basins, amenable to analytic solutions, to highly resolved numerical models which are now some of the most computationally demanding environmental models in existence. A major advance over the last 20 years has occurred in our capacity to deal with the ocean mesoscale eddy circulation, and its
interaction with the mean field. Again, the development has followed observational advances. We’ve moved from an awareness that eddies existed, to extremely expensive multi-ship campaigns just to obtain a snapshot of a single eddy, to routine visualization of the surface expression of complete eddy fields through satellite SST. Our ocean basin models have moved from coarse resolution models, which parameterise the effects of eddies, to eddy permitting and then eddy resolving models.

Large scale ocean research over the last two decades has been mostly driven by the need to understand the role of the oceans in climate change and climate variability. This has required the development of global coupled atmosphere-ocean, and atmosphere-ocean-land-ice models. The development of operational ocean models for short-term ocean forecasting, akin to numerical weather forecasting models, is a relatively recent development. Such models need to resolve eddies to be useful for most applications. These operational ocean models, like numerical weather forecasting models, incorporate sophisticated data assimilating schemes.

The use of data assimilation has lifted the interaction between physical models and observations to a new level. Despite the very sophisticated nature of the physical ocean observing system, combining SST and satellite altimeter, ARGO floats, ships of opportunity, and mooring arrays, it is still true that observations of the ocean interior are incredibly sparse in space and time, certainly with respect to the eddy field. Data assimilating ocean models, like their meteorological cousins, allow us to combine the process understanding inherent in the models with observations to infer the full 3-D ocean structure, at eddy-resolving scales, with known levels of accuracy. This provides an extremely powerful window on the structure and dynamics of the ocean, which will be particularly important for understanding biogeochemical cycles.

We have the advantage in physical modelling of having a rigorous and concise mathematical formulation of the equations of motion underpinning the circulation. But of course in any numerical solution, there are limits to the spatial resolution, and we must approximate the (chaotic) processes occurring at finer scales. A rich theoretical and experimental science has led to the formulation of sophisticated turbulence closure schemes, now widely implemented in ocean models. This science is now fairly mature, but there may still be surprises to do with subtle aspects of vertical mixing in the deep ocean, which have important consequences on long time scales. (Vertical mixing is also critically important for biogeochemical cycles, because it controls the return of nutrients to the surface euphotic zone, and therefore the magnitude of primary production.) Another area where there still seems to be room for improvement in process formulation concerns the exchanges of heat, momentum and freshwater across the ocean surface.

In the coastal zone, we have also seen the rapid development of physical models. Again we can point to two phases of model development. In many shallow coastal systems the water column is well-mixed for much of the time, and it was argued that we could approximate circulation and transport by 2-D vertically averaged models. A range of sophisticated numerical models, employing both finite difference and finite element methods, were developed, and became standard tools in coastal environmental studies.
More recently, it has been recognised that, even in vertically “well-mixed” systems, failure to resolve the 3-D pattern in transport can have important consequences for tracer fate, and it is now generally accepted (at least in the research community), that 3-D hydrodynamic models should be used in coastal studies. These models can operate at very high spatial resolution, which in turn requires very high temporal resolution, so their computational cost is also high, even though the spatial extent is small.

Coastal systems can have very high spatial gradients in both the vertical and horizontal, especially near river inputs, requiring the use in models of sophisticated mixing schemes, and high order numerical schemes. It’s probably fair to say that the key constraints on the accuracy of these models now lie with the specification of input data (bathymetry, bottom roughness, and surface forcing). In these shallow systems, and especially along exposed shorelines, wave-current interactions play an important role. We noted above that measuring and predicting exchanges between the underlying sediment and the water column is critical for coastal biogeochemistry, and is still a key challenge. Sediment dynamic models attempt to represent the effects of resuspension and deposition of particulate material, and their interaction with the circulation, on suspended concentrations (turbidity) and bed thickness and composition (geomorphology). Models of these processes are still under active development.

The development of data assimilation into coastal physical models has lagged behind its development in larger scale models, and is still in its infancy. It has a vital role to play, not only as a tool to provide short-term forecasts, but more importantly for the rigour it brings to the analysis of model error, and to the design of observing systems. As coastal management decisions are more vigorously contested, coastal models developed to inform these decisions are placed under ever greater scrutiny. Traditional ad hoc or heuristic methods of assessing model error or reliability are proving inadequate under those circumstances.

Most biogeochemical models deal with biologically-mediated transformations of materials, but there are of course many key chemical and physico-chemical processes which must also be represented in these models. The exchanges between dissolved CO₂, bicarbonate and carbonate in seawater and their relationship to pH represent an obvious and very topical example. The chemistry of some elements and compounds in seawater is much more complicated, as for example the speciation of micronutrients such as Fe, or toxic heavy metals, which not only affects their biological availability, but also their solubility and retention time in surface waters. Complicating this further is the interaction of many simple inorganic compounds with complex organic molecules, as chelators, and with the surface chemistry of particles (organic and inorganic). Speciation and interactions are often affected by the oxidation state and pH of the (micro)-environment. There has been much laboratory research into these processes, and there are some very sophisticated models for chemical equilibria in seawater. The representation of these processes is often neglected or highly simplified in dynamical system models of biogeochemical cycles.
Once we move to biological processes, we are faced with the general problem of ecosystem modelling; namely, choosing the right level of abstraction and approximation in describing and predicting the structure and function of a complex system with many nested levels of complexity. There is of course no “right” choice in an absolute sense; the best choice at any time will depend both on the problem to be addressed, and the prior knowledge and new data available to support model implementation and calibration.

If we look back over the history of the field, we can see a parallel development of increased process knowledge for different system components, its representation in process submodels, and then the incorporation of these submodels into system models. This process knowledge is arguably most advanced for phytoplankton, where there is a very large literature based on lab and field studies of the processes of photosynthesis and nutrient uptake and their effects on phytoplankton growth. Quite sophisticated models of these processes were developed relatively early (several decades ago). More sophisticated (or at least more complicated) models are available now, but many system models continue to use earlier and simpler forms.

There is also a considerable history and literature on zooplankton ecology and physiology, including grazing rates on phytoplankton or other zooplankton, assimilation, respiration and growth. Again, quite sophisticated submodels were developed early, and current models are mostly variations on a theme.

In both phytoplankton and zooplankton studies, it’s apparent that parameters and even some processes vary across species. Different taxonomic groups may have different morphology, different physiology and different life history strategies. Interest in the dependence of parameters and processes on organism size emerged especially strongly in the 1970s, around the time that field data from particle size analysers became available. Interest in allometric relationships extends well beyond plankton of course, but it’s worth noting that the phytoplankton cell volumes span more than seven orders of magnitude, and zooplankton around eight or more. Size-dependent models have enjoyed something of a resurgence recently.

A major paradigm shift in our conceptual understanding of plankton ecology occurred in the 1970s and 80s, when improved observational techniques showed that the role of bacteria, and the role of small zooplankton (microzooplankton and nanozooflagellates) had been overlooked or badly underestimated. It had been assumed that the large, obvious mesozooplankton (copepods and euphausiids) are responsible for most of the grazing in the ocean. This may be true in some circumstances, but in most of the ocean most of the time, it appears that grazing is dominated by the microzooplankton. This paradigm shift is still represented very unevenly in biogeochemical models.

The difficulties involved in observing and studying marine bacteria are reflected in the way bacteria are treated, or more often neglected, in biogeochemical models. Bacteria play a critical role in recycling organic matter and regenerating nutrients, but this role is often represented in models by a simple decay constant for detritus. Compounding our ignorance of bacterial composition and function is the complexity of both particulate and
dissolved non-living organic matter. Some of the dissolved organic matter in the oceans may be thousands of years old, and highly resistant to bacterial attack. Some consists of recently released amino acids which may be taken up within seconds. Bacteria may be free-living, or attached to particles, including complex aggregates with their own particle dynamics.

In coastal systems, we must consider the benthic primary producers (benthic microalgae, macroalgae and seagrasses), benthic herbivores, and detritivores. We have process studies and submodels for these components, although less information than for plankton. In these systems, the sediments often contain a very large pool of organic matter and organic or inorganic nutrients. Key processes in the sediment such as remineralisation, nitrification and denitrification, mediated by bacteria, may effectively control the behaviour of the system on time scales from weeks to years. We have a broad conceptual understanding of these processes, and crude process models, but remain some way from precise knowledge or prediction.

System models of biogeochemical cycles are generally obtained by assembling these component submodels to describe local transformations of materials, and then embedding this local “reaction” model in a physical transport model. There are several choices which determine the complexity of the resulting model.

The model can choose to use one or more elements as a currency, by which to measure pools and fluxes. (It is a fundamental property of biogeochemical models that they conserve mass. This is an important constraint on model behaviour, obviously affected by the choice of the element whose mass is conserved.) Up until recently, models typically chose only one currency (e.g. nitrogen). It is increasingly common for models to include multiple currencies (carbon, nitrogen, phosphorus, silicate, Fe, ...). Nitrogen was often chosen as a single currency, because it was thought to limit primary production in most of the ocean. As we discover other limiting nutrients (e.g. iron) and/or try to represent multiple functional groups (e.g. silicate limits diatoms) and/or cover more diverse regions, pressure has grown to add currencies.

The model can choose to represent each trophic level by one or more functional groups. Again, there has been a move from simple NPZ models which lump all phytoplankton and all zooplankton, to models which resolve multiple functional groups in each trophic level, and multiple classes of non-living organic matter, or to models which resolve size classes within or across trophic levels. This has not been driven simply by a desire for more realism. One can argue that the prediction of biological contributions to the global carbon cycle under changed climate and circulation requires multiple functional groups, because they play very different roles in feedbacks.

Finally, the local reaction model may be embedded in a very simple physical transport model (even a single box), or in a full 3-D hydrodynamic model of the kind discussed above. Not surprisingly, we have seen a tendency to move towards more highly resolved physical models as these have become widely available, and computational capacity has increased.
The net consequence of these trends is that complex biogeochemical models, involving multiple currencies and multiple functional groups, embedded in high-resolution 3-D circulation models, are becoming increasingly common at both ocean basin and coastal scales. This has sparked something of a debate in modelling circles, with some raising concerns that these models are already well beyond our capacity for rigorous calibration or validation, while others argue we have still not represented process understanding adequately.

In fact, it might be argued that the development of techniques for rigorous model – data comparison and/or data assimilation represents the most important challenge now for biogeochemical models. There have been intermittent attempts over the years to estimate parameters in biogeochemical models by fitting them to data. These have necessarily involved very simple physical models: typically 1-box or 1-D. More recently, we are beginning to see attempts to extend the data assimilation techniques developed for physical models to biogeochemical models. However, this is not straightforward. It is implicitly assumed in data assimilation into physical models that our major sources of uncertainty lie in knowledge of the initial (or current state), and possibly in forcing. But as we’ve just seen, the major sources of uncertainty in biogeochemical models may involve biogeochemical parameters, or even process formulation. Dealing with these will require more sophisticated approaches.

This is particularly true because biogeochemical models are not typically used for short-term forecasts. In fact, for short-term forecasts over 24 to 48 hours, we might do best by ignoring the biology, and just using the physical model to advect our best estimate of current state, based e.g. on satellite observations. But we typically want to use biogeochemical models to run scenarios and make “what-if” predictions. For these purposes, we need to be able to use data to establish posterior distributions for model parameters, and then propagate these to put confidence limits around model predictions. In this sense, the uncertainty problem for biogeochemical models is more akin to that for climate models.

We should not leave this discussion of modelling without referring to some more empirical biogeochemical models. There is a long tradition, in both ocean basin and coastal systems, of using inverse models to extract information from observations. In the open ocean, physical oceanographers and geochemists have used broad-scale distributions of salinity, nutrients, oxygen and some other tracers to infer information about transport and mixing in the ocean interior, and some fundamental biogeochemical ratios or sources & sinks. In coastal systems, salinity distribution and river flow have been used for many years to derive inverse estimates of exchanges in estuarine box models. As recently as the 1990s, LOICZ advocated the use of simple inverse calculations to derive estimates of nutrient and carbon sources & sinks for estuaries and coastal seas. These techniques can be quite powerful and easy to implement. They are often applied under the assumption that observed distributions are at steady-state, which can be misleading in dynamic systems. They can be modified to allow for variation in time, but that generally requires dense sampling in space and time. In principle, analysis
via data assimilation into dynamical models should be more powerful than inverse modelling, provided of course the dynamical model adds value.

There is a long tradition of using empirical models in ecology, to describe spatial pattern, or correlation over time. Empirical correlations and regressions may be used for interpolation, or for extrapolation and prediction. It's probably fair to say that biogeochemical and ecological systems are complicated enough that most simple regressions fail over time. Nonetheless, there may be an argument for using simple empirical or semi-empirical models to support decision making within an adaptive management framework. This is an area which has received relatively little attention in coastal environmental management (at least compared e.g. with fisheries). Management strategy evaluation provides a framework within which “realistic” process models and simple assessment models can be integrated to mutual benefit.

4. Looking Forward - The Next Five years

Given this history, across disciplines and across observations and modelling, what major developments can we expect to see in the next five years? (Predictions of scientific progress have included some notable failures, so no doubt the following should also be taken with a pinch of salt.)

Current trends would suggest some fairly predictable advances in physical oceanography. We'd expect to see a maturing of the eddy-resolving data-assimilating models, and likely an extension of these to global models, and stronger integration into climate modelling. There are still some significant challenges in the data-assimilation techniques themselves, and we'd hope to see improvement there. At the same time, this community is looking to extend these models inshore, across the shelf, and even into bays and estuaries. We might expect to see high-resolution data-assimilating coastal models in routine use. Better methods for nesting models, or for variable resolution and adaptive model grids, are likely to emerge.

The extension of data-assimilating models inshore assumes that we can develop coastal observing systems to support them. Existing satellite data can help, and coastal radar systems could become routine rather than research tools. The challenge will be to develop cost-effective in-situ coastal observing systems. We might expect to see more widespread use of gliders and moored networks of sensors. Acoustic data transmission within coastal sensor networks potentially offers a way to avoid surface buoys and reduce losses. One might argue that it's cost rather than technical capacity which is limiting in these cases.

I'm not aware of any radical advances planned for physical observing systems at basin scale, and it seems like the challenge will be to maintain the current density of ARGO, and satellite altimeters. It does seem likely that deployment of smart tags on pelagic animals will increase. If these sensors can deliver sufficiently accurate data, they might substantially augment ARGO.
We can expect to see improved integration of wave models into coastal hydrodynamic models, and consequently improved sediment model predictions of turbidity and coastal geomorphology. This will be partly driven by concern about effects of increased sea level and storm frequency/intensity on coastal erosion. We might expect to see these coastal models linked to or integrated with coastal inundation models. We might also expect to see coastal models routinely integrated with local area nested atmospheric models, to improve surface forcing.

Given that we can’t expect to have high resolution coastal models (at the estuary or embayment scale) everywhere, it will be critical to have a relocatable capacity. That means not only a relocatable model, and the databases and tools to support it, but the capacity for rapid design and implementation of efficient observing systems, which permit models assimilating the resulting data streams to achieve a specified level of accuracy.

We can expect to see continued convergence and consolidation of models internationally, through community modelling initiatives. We might confidently predict that there will be fewer independent modelling "platforms", but more options and versatility within each platform. The choice of platform, and the partners inherited with the platform, will be a critical decision for any research group.

For chemistry and biology, there do seem to be prospects for significant advances in observations at the basin scale over the next five years. The GEOTRACERS program will add substantially to our knowledge of the distribution of micronutrients, and likely produce advances in our (limited) understanding of the natural Fe cycle. Addition of optode oxygen sensors, and possibly other chemical or bio-optical sensors (CO₂, transmissometers, ...), to ARGO floats, could bring about an advance in our knowledge of the interior chemistry of the ocean, comparable to that which they've produced for the physical state. Shallow profilers or long endurance ocean gliders, or pelagic animals, might be better platforms for studying processes in the upper ocean and mixed layer.

The long-term ocean time series such as HOTS and BATS have made a disproportionate contribution to our understanding of biogeochemical processes in the open ocean. Collection of long time series assumes even more importance in an era of climate change impacts. We can expect the existing time series, which require frequent (expensive) ship visits, to be augmented by increasingly sophisticated automated measurements from deep ocean moorings, or other platforms, including ships of opportunity.

We might hope for advances in chemical sensors, and particularly for robust affordable nutrient sensors. Given the time lag between concept and wide uptake in ocean instrumentation, it seems unlikely such sensors will be available in the next 5 years (ie beyond the existing nitrate UV sensor).

We can expect to see further ocean fertilization experiments, likely on larger scales than conducted previously, and potentially involving additions of nitrogen as well as Fe. These will be driven by commercial and government interest in the potential for carbon...
sequestration, as much as by scientific interest, but will likely yield further insights into whole-of-system responses.

In the coastal domain, we can expect further development and demonstration of the sensor network concept, linked to gliders, coastal radar, etc. But sensor cost remains a pragmatic constraint on the widespread use of biogeochemical sensor networks. To represent a quantum leap over the old-fashioned concept of “coastal moorings”, one might expect a sensor network to involve of order 100 elements. If we used current standard instrumentation to provide a basic set of biogeochemical parameters, such a network would involve about $4M in sensors!

We noted earlier the recent developments in integrated biomarker and isotope measurements. As these are developed further, and applied and tested in different environments, we can expect to see a biomarker-isotope library emerge, which can be used as a diagnostic tool to interpret current and past biogeochemical sources, sinks and transformations.

The genomic techniques mentioned earlier are of course attracting a lot of attention in international circles. They are increasingly used as standard tools in physiological process studies. We might expect these to substantially improve our understanding of feedback controls and adaptation in bacteria, phytoplankton and zooplankton. For example, we currently have a good biophysical understanding of photosynthetic and nutrient uptake structures and mechanisms. But we have a much weaker understanding of how phytoplankton adapt to the resulting changes in internal carbon and nutrient supply by modifying the allocation of these resources to different functional pools. It’s not so clear how quickly advances in understanding of this kind will translate into improved system models. It’s arguable that our current models do not make full use of our existing understanding. As noted above, the advances may be more dramatic and effective in the case of bacteria, where our current models are very crude. It’s also possible that this could lead to rapid improvements in our understanding and representation of the physiology and autecology of particular species, for example those forming harmful or toxic algal blooms.

The other promise of the genomic technology is through the development of gene array sensors. It seems likely that these will become a routine tool for rapidly assessing microbial community structure, at least in the lab, and possibly automated in-situ.

Ocean colour remote sensing has of course made a dramatic contribution to our understanding of spatial and temporal pattern and variation in ocean phytoplankton biomass and production over the last decade. It’s probably fair to say that the development of effective coastal algorithms has turned out to be more difficult than hoped, and the dream of a “universal” coastal algorithm has almost evaporated. However, robust methods for developing regional algorithms have been developed, and we might expect the next 5 years to see ocean colour make a serious contribution to our knowledge of the distribution and dynamics of chlorophyll, turbidity and CDOM in coastal systems.
The last five years has seen something of an explosion in the development of biogeochemical models embedded in 3-D circulation models, especially at ocean basin scales. This rapid proliferation has also resulted in considerable diversity in model structure and process representation. We might expect to see some standardization of model structure over the next 5 years, through model inter-comparison experiments and model-data comparison. However, pressures for consolidation may be offset by genuine uncertainty or disagreement about processes, injections of new knowledge from the new experimental techniques described above, and the fact that models are being designed for different purposes.

We’d expect to see improvements in model representation of bacterial dynamics and associated fluxes, both in the pelagic zone, and in coastal sediments. The latter remains a key source of uncertainty in understanding and predicting the response of coastal (inshore and shelf) systems to changes in nutrient loads from both marine and terrestrial sources.

As concern increases about the potential impacts of ocean acidification on carbonate-fixing organisms, we can expect to see increased process studies of this effect, and introduction of these effects into biogeochemical models. While public attention has focused on the effects on coral reefs, the potential effects on planktonic ecosystems throughout the oceans are large, given that diverse and important functional groups at multiple trophic levels form calcium carbonate structures.

We can expect to see further integration of biogeochemical models with ecosystem models. The traditional boundary between these models, drawn at the level of herbivores, is arbitrary, and creates closure problems for both sides. The IMBER research program is largely targeted at eliminating this boundary, and establishing end-to-end models. A few ecosystem models already have moderately sophisticated representations of biogeochemical processes. The key integration challenge here is not about process representation, but about spatial representation and links to physics. Biogeochemical models are increasingly embedded in high-resolution 3-D circulation models, at great computational expense. It’s probably impractical and arguably unproductive to represent full ecosystem models at this resolution. We need to develop new methods, or refine existing methods, for coupling processes across scales.

Arguably the most important advances in biogeochemical modelling over the next 5 to 10 years will not involve specific process improvements, but instead involve better methods of treating error and uncertainty. We are staring to see adoption of quantitative assessments of mismatch with data in model calibration and validation, although there is still debate over the appropriate metrics. But there are very few examples where models have been subjected to formal statistical parameter estimation. Those examples typically involve simple process models with very simple underlying physical transport models. Even for such simple models, the usual conclusion is that data are inadequate to constrain the parameters in a useful way.

Most models are heuristically fit to observations, modifying model parameters to improve fit based on intuition and experience, perhaps supported by limited sensitivity analysis.
The elephant in the room here is “over-tuning”. While it may be difficult to find a parameter set which provides a good fit to parameters (in a high-dimensional parameter space), that’s no guarantee that there isn’t a large but overlooked parameter subspace which provides an equally good fit. There is then a grave risk that model predictions and scenarios are presented with overly optimistic confidence.

We would expect the occurrence of over-tuning to increase substantially as models become more complex, with many more parameters. And highly-resolved 3-D models are very computationally expensive, so that even heuristic model fitting is constrained. There are techniques which might be developed and applied to put model calibration and error analysis on a rigorous basis. If successful, these would not only provide defensible confidence limits around model predictions and scenarios in applications, but also allow the science community to address debates about model complexity on objective grounds. They would also allow us to design observing systems or programs which, coupled with models, would meet specified needs for accuracy or confidence. That would represent an enormous step forward, especially in environmental monitoring, but it should also offer substantial improvements in the design of effective scientific experiments. The scientific community has talked for a long time about the need to better couple modelling and field experiments, and have these proceed in an iterative fashion. This principle is still only weakly translated into practice, and there is great potential to improve it.

This issue is obviously related to data assimilation, and we might expect some early progress to come by adopting data assimilation techniques from physical models. But we have to be careful that simple and naïve applications of data assimilation (i.e. nudging model predictions towards observations) do not become another variant of over-tuning, or disguising fundamental errors in model process and parameters.

If, as seems likely, development of more sophisticated techniques for handling model-data fusion and model uncertainty conclude that existing data sets are inadequate (not fit for purpose), that should add renewed pressure and impetus to the development and implementation of the more advanced observing technologies and systems discussed earlier.

5. Hot Application Topics

While I’ve tried to focus on the underlying biogeochemical science, rather than its application, in the discussion to this point, we can already see that this is an artificial distinction. Advances in the science are driven by the applications, and these in turn may suggest or enable other applications. Here are some obvious application areas we might expect to drive the development of the science over the next 5 years, internationally and (hopefully) in Australia.
Climate change feedbacks and impacts.

Open ocean biogeochemistry has been heavily driven by the climate change issue over the last two decades, and this is likely to continue. However, the emphasis for much of that time has been on feedbacks in the ocean carbon cycle, and the potential for these feedbacks to affect the role of the oceans as a sink for anthropogenic CO₂. While there may still be some surprises there, and we can expect ongoing research in this area, the focus is already shifting to the impacts of climate change on marine ecosystems. There are several reasons for this. Climate change is proceeding faster than anticipated. We have shifted in the space of a decade from thinking of it as something to avoid by 2050 or 2100, to something well underway. And it’s clear that we are committed to substantial further climate change, regardless of international agreements and mitigation actions. In the marine domain, awareness of ocean acidification, and its potential threat to marine biota, including iconic ecosystems such as coral reefs, has suddenly increased.

Climate change impacts on marine ecosystems can occur through a variety of pathways. Ocean temperatures will increase through warming, changing the distribution of many organisms and causing mass mortality in sessile organisms e.g. coral bleaching. Changes in ocean circulation may affect larval transport and disrupt spawning patterns. Changes in ocean circulation may also affect the supply of deep ocean nutrients to surface waters, and therefore change primary production rates and plankton community composition. This can occur in the open ocean, in the oligotrophic gyres and equatorial systems, and in boundary currents and continental shelves. Continental shelves are disproportionately productive and provide much of the global fish catch. Most of this production is supported by injections of ocean nutrients. Predicting responses at this scale represents a severe test of our whole-of-system understanding and modelling. Our best test of this understanding is arguably observations of biogeochemical system responses to interannual and interdecadal changes in ocean circulation. There are some useful historical marine data sets for the Northern Hemisphere, but alarmingly, there is a lack of such data sets in most of the Southern Hemisphere oceans, including the oceans near Australia. We face a decision as to whether we will, belatedly, take actions to address this gap.

In the coastal zone, climate change will also change patterns of coastal runoff, and associated loads of nutrients and sediments. We know this will interact strongly with changes in land use. In Australia, we associate climate change (rightly or wrongly) with increasing drought, but we may also see increases in frequency and/or amplitudes of floods. In the southern half of Australia, we expect the impacts to be local i.e confined to estuaries and embayments. But in northern Australia, we might expect effects at continental shelf scales. This is already the subject of intense scrutiny in the GBR, but could be equally important in the poorly studied shelf systems across the top end.

Ocean acidification will be an increasingly hot topic. We can expect much attention on iconic corals, and commercially important species, but can also expect international research targeted at effects on pelagic planktonic systems.
We can see that many of the pathways to climate impacts involve or run through biogeochemical systems, and predicting or even assessing these impacts will be a severe test for our biogeochemical understanding, observation systems and models. The strong coupling to physics means that representation and resolution of ocean circulation will be essential. But at the same time, ultimately we will want to couple these biogeochemical changes to ecosystem models (and ultimately socioeconomic models). So the challenge of coupling these models across scales will be important here.

**Ocean Fertilization**

The concept of using Fe fertilization to sequester carbon in the deep ocean has been around for over two decades, and a subject of (largely academic) debate as to its efficacy and acceptability. That debate is rapidly moving from the academic to the policy domain. The drivers are again recognition that climate change is proceeding faster, and mitigation more difficult, than anticipated. But the creation of carbon markets means that Fe fertilization is already potentially an attractive commercial proposition, if the hurdles of approval and measurement can be overcome. This environment will almost certainly drive further, large scale fertilization experiments in the next 5 years, and has the potential to create a new high stakes research area and industry over the next decade.

There have also been longstanding advocates of ocean fertilization to increase food production from the oceans. Total food production from the oceans, which cover 70% of the globe, is orders of magnitude less than food production from the terrestrial biosphere, at 30%. Marine fish farming currently results in a net decrease in food production from the oceans, and replacement of fish meal by high-quality terrestrial crops won’t add to global net food production. Given projected increases in global population, and potential decreases in terrestrial food production from a variety of factors, one might expect increasing pressure to look for ways to increase food production from the ocean. That would require some kind of broad scale cropping, or the equivalent of “improved pastures”. This is currently pretty far-fetched, and definitely a long-term prospect. But it could be accelerated by attempts to combine fertilization for food production with fertilization for carbon sequestration.

**Ecosystem-based fisheries management**

There is now broad policy commitment to ecosystem-based fisheries management, although arguably still considerable debate as to what that means in practice. It’s fair to say that we are seeing a move from single stock assessment, to consideration of stock interactions, bycatch and habitat removal, to the consideration of fish stocks as components in end-to-end ecosystem models, with management strategies playing out in a whole-of-system context. It’s not clear just how important biogeochemical feedbacks may be in this new approach to fisheries management. It seems likely that these effects are best addressed as part of the end-to-end models discussed above. It’s not clear if this will require improved representation of physics and biogeochemistry in these models.
Given that fisheries management will increasingly need to take climate impacts into account, we might expect this issue to align strongly with the broader issue of marine climate impacts.

**Marine biodiversity and conservation.**

Traditionally, the science behind marine biodiversity and conservation has taken a different conceptual approach to understanding and modelling marine ecosystems. It has focused on spatial representation of the distribution of species, communities, key habitats, and on population dynamics of key threatened species. Interactions with biogeochemical processes and broader trophodynamic processes have been dealt with more in terms of defining suitable habitat, and/or spatial distributions of threatening processes. This is understandable, as biogeochemical models (and trophodynamic models) lump functional groups and haven’t dealt very successfully with species diversity.

Nonetheless, we might expect to see some convergence of these conceptual approaches. If they’re to succeed, conservation strategies will increasingly have to move from static approaches (declaring reserve boundaries) to dynamic approaches, given climate change and other pressures. It’s generally conceded that broader conservation goals can only be achieved by integrating conservation management strategies through reserves with resource and environmental management outside reserves. That will require an integration of EBFM and conservation management. Outputs of biogeochemical models will need to be integrated into conservation planning in a more sophisticated way. Circulation models are already used in reserve design to establish patterns of connectivity for larval recruitment, and this might be extended to look at larval survival. Climate change scenarios for productivity and acidification will need to be taken into account. To date, there has been very little integration of near-shore marine park planning with management of diffuse and point source loads from land, although the need is recognised.

We may see some integration driven from the other direction. There have been a number of studies looking at the effects of species diversity on the magnitude and dynamics of primary production. And some new modelling approaches might allow us to represent these effects explicitly in biogeochemical models.

**Integrated coastal zone management**

Marine biogeochemical observations and models have played an important role in coastal zone management for several decades. Yet there is an ongoing debate about their value and effectiveness in management. Part of this debate stems from the dysfunctional nature of institutions and governance for coastal management in most jurisdictions. This means that even “perfect” biophysical information might be expected to lead to poor outcomes. It’s also argued that the social and economic aspects of coastal systems and decision-making have been neglected (“we’re not managing coasts, we’re managing people affecting coasts”). There is merit in both of these arguments. But does that mean we
should stop investing in research to improve biogeochemical observations, understanding and prediction in coastal systems? I argue not, for the following reasons.

Whatever their defects, the current institutional arrangements are driving large investments in biogeochemical models and observations to support coastal decisions. And as society imposes greater requirements for better environmental protection with lower risk, the demands on those models are increasing, and they are ever more vigorously contested. The net result is very large expenditures on observations and modelling, yet in many cases this investment is arguably inefficient and poorly directed, and leads to relatively poor outcomes in terms of biophysical assessment and prediction. There is both a need and opportunity to improve the available tools and platforms to make these studies better and more cost-effective.

Lack of marine biophysical understanding and prediction continues to be recognised as a major knowledge gap affecting coastal management decisions. In Australia’s highest profile system, the Great Barrier Reef, lack of quantitative knowledge about the connection between end of catchment loads, lagoon water quality, and reef health, is recognised to be a major constraint on management decisions. An important point here is that the need for knowledge increases as the tradeoffs involved become more difficult. We know that a reduction in catchment loads will be good for the reef. But the difference between a 20 and 80% reduction in catchment loads is the difference between win-win changes in farm practices, and potentially the disappearance of entire industries and communities.

It’s argued that we can replace biophysical understanding and prediction by adaptive management. It’s certainly true that adaptive management reduces our reliance on accurate long-term prediction, and that’s very desirable. But there is often a blind faith in adaptive management among coastal managers. It’s assumed that putting in some kind of monitoring system, implementing a plan, and then changing it if things go wrong, is bound to work. In fact, it’s most likely to fail. Monitoring systems are often poorly designed and inadequate. Observations are noisy and may be misleading. There are long lags in both socioeconomic and biophysical systems. And signals are confounded by other factors, especially climate variability. As fisheries management has illustrated, designing a robust adaptive management strategy, even in a much simpler situation using more sophisticated tools, is not easy. We need both adaptive management and improved biophysical science, not one or the other.

I’d argue that the major advance in this area in the next decade will come from a better treatment of model-data comparison and uncertainty. We need that to address all of these issues. We need objective criteria to evaluate model performance, and to put confidence limits around model predictions. That’s necessary to inform risk assessments and triple-bottom line trade-offs. We need an ability to design monitoring systems to deliver assessment and support prediction with adequate levels of confidence, if we’re to create effective adaptive management strategies. And model-data fusion, linked to observing system design, will allow us to operationalise coastal studies to support management, and make them much more cost-effective.
Of course, it’s also clear from the preceding that we need to better integrate biogeochemical models and observations with ecosystem and socio-economic models and observations.

Biofuel and aquaculture production

I mention these here, although they sit on the margin of aquatic biogeochemistry, as I’ve defined it. There are two ways in which they potentially interact.

In the past, investigation of microalgae both as aquaculture feed stocks, and as potential sources of biofuel, has driven studies of phytoplankton physiology and composition which have in turn improved our understanding of natural biogeochemical cycles. We might expect that to continue in the next decade.

As I noted earlier, once we move into mass production facilities, we inevitably have to deal with many of the biogeochemical processes and feedbacks occurring in natural systems. That will be true even for single-species cultures, but the analogy is much closer for systems such as prawn ponds, which effectively represent hypertrophic ecosystems. It arguably makes sense to think of the latter as an extreme example of coastal ocean fertilization. With the correct approach, and appropriate combination of observations and models, it should be possible to design and engineer better management systems for intensive production, and learn valuable lessons about the behaviour of enriched natural systems. These are synergies which we have only weakly captured to date.

6. CMAR Capability

The following overview is intended to place CMAR’s specific capability in this broader context, and help readers to identify areas where CMAR’s capability can contribute to output themes and applications.

Physics

I start with the physics, which is particularly strong. Only a small proportion of CMAR’s capability in physical oceanography is mapped formally into the BGC capability, but it’s worth looking briefly at the broader physical capability, because it plays such an important underpinning role for biogeochemical science. At ocean basin scales, CMAR has world-leading and/or world-class strength in physical oceanographic observations. We are world leaders in Southern Ocean studies, and play a regional lead role in studies of the Indian Ocean and Indonesian throughflow, and the Tasman and Coral Seas. We play a well-recognised role in the international ARGO program, and in the science of altimetry. We have played a long-term leading role in maintaining regional ocean observations through ships of opportunity.
We have a long history of oceanographic field at continental shelf scales, including the major boundary currents around Australia. Most recently, we have played a lead role in forming a national partnership to successfully bid for NCRIS funding for an Australian Integrated Marine Observing System. A substantial fraction of that investment is going towards enhancing our observations of Australia’s continental shelves and boundary currents, and their interactions with basin scale circulation.

Our physical modelling capability at ocean basin scales is also particularly strong. The CSIRO-BoM partnership CAWCR maintains an international reputation as one of a small number of credible producers of global coupled ocean – atmosphere climate models for IPCC scenarios and for studies of climate variability. We are valued partners in the development of the MOM community ocean model. Over the last 5 years, the BlueLink program has given us world-class ranking in the development of eddy-resolving, data-assimilating ocean forecasting models. The BlueLink modelling system is in itself a critically important platform for biogeochemical studies around Australia.

Our coastal physical oceanographic capability has been through something of a dip (at least in terms of numbers) over the last decade. Nonetheless, we have through this period developed a very strong and sophisticated coastal modelling suite, which has been adopted by other partners in Australia. Our coastal physical modelling capability has been recently enhanced through improved integration between offshore and inshore, primarily as a result of BlueLink extending its operational forecasting capability inshore. This has seen the development of the relocated, local atmosphere-ocean modelling system ROAM, and plans for a national high-resolution continental shelf model (Ribbon model). It has also seen our modellers assisting in the implementation of coastal processes into the MOM community model. The BlueLink data-assimilation scheme (BODAS) has just been implemented in our coastal circulation models.

We have maintained a small but effective effort in sediment modelling, primarily to address the role of turbidity in biogeochemical systems. BlueLink is driving an expansion in our capability in wave observations and modelling, and wave-current interactions, especially in near-shore areas, and this is likely to be extended to coastal geomorphology.

We have few dedicated observational scientists in coastal physical oceanography. Our coastal modellers have experience in making and interpreting field measurements. Moreover, the support group in CMAR provides extremely strong expertise and experience in maintenance and deployment of instruments and sensors, in mooring design, and in advanced platforms such as ARGO, across blue water and coastal scales. CMAR has a large and growing pool of oceanographic instruments, and access to others through national collaboration (IMOS) and international collaboration.

The bottom line here is that CMAR has the capability to implement state-of-the-art circulation models, supported by state-of-the-art observations, at scales ranging from ocean basin to estuaries. CMAR (with BoM) is seen in international circles as being at the forefront of attempts to develop a seamless nested ocean forecasting capability across these scales.
Chemistry and Biology

CMAR has a strong observational capability in chemical oceanography at both ocean basin and coastal scales. We have an internationally recognised ability to make high precision measurements of inorganic carbon parameters, and have made an important contribution to knowledge of these fields in the oceans around Australia, especially in the Southern Ocean. This capability should play an important role in monitoring and understanding regional variation in ocean acidification and carbonate saturation. We have internationally recognised expertise in measurements of vertical fluxes of sedimenting material, and have maintained an important time series of sediment traps for the Southern Ocean. We have a long history of ultra-clean sample collection and analysis at sea, and with the recent acquisition of ICP-MS facilities, capacity to make an important contribution to knowledge of regional micronutrient distributions. We support routine hydrochemistry through the national facility, and have the ability to measure very low (nM) levels of macronutrients in oligotrophic mixed layers.

CMAR has a strong capability in organic chemistry, and specifically in the identification and measurement of biomarkers, including pigments and lipids. There is the potential to link this to our capability in natural isotope measurement, to provide a powerful tool for source discrimination and historical reconstruction, as discussed above. These techniques are used in paleo-oceanography, but have recently been applied mostly in studies of the sources, cycling and fate of organic matter and nutrients in coastal marine systems, and in rivers and floodplains. CMAR has some capability and experience in measuring exchanges of dissolved material across the water-sediment interface, both in situ and in cores in the laboratory. Our trace metal capability has been used to understand cycling of metals as both micronutrients and pollutants in coastal waters and sediments.

CMAR has particular expertise in phytoplankton ecology and physiology, with strong links into the international community, especially around the study of Harmful Algal Blooms. This expertise is supported by an internationally recognised algal collection, and culturing facilities. We’ve made an important contribution to measurements of primary production, especially in the open ocean, including the use of new techniques such as fast-repetition rate fluorometry. We have the leading national laboratory for measurements of phytoplankton pigments and bio-optical properties. We have expertise in phytoplankton taxonomy, and access to flow cytometers to efficiently count and sort field and laboratory samples. As noted earlier, our expertise in phytoplankton physiology and composition has been heavily directed towards aquaculture production over the last 10 years, and is now being directed towards biofuel production. Laboratory phytoplankton experiments have also been directed towards the autecology and physiology of species of environmental significance, especially toxic or harmful bloom species.

By comparison, our capability in zooplankton, bacteria and benthic primary producers is limited, being restricted to one or two scientists in each case. This is augmented by one or two additional scientists studying zooplankton along with micro-nekton as part of fisheries ecology and trophodynamics. CMAR is building core capability (field studies
and modelling) of the role of benthic biota and processes in coastal and shelf biogeochemical cycles through the WAMSI NODE 1 project in SW WA.

Most of our capability in biological oceanography is currently deployed in the coastal domain. At both coastal and ocean scales, modern biological oceanographic field studies require a large team with a diverse mix of specialist skills and experience. We have relied heavily on collaboration with other agencies (Australian and international) in conducting major multi-disciplinary field programs and experiments, both in the open ocean (such as the Fe fertilization experiment SOIREE in the Southern Ocean), and in coastal studies. CMAR has a good record of collaboration with CLW biogeochemistry capability (field and modelling) in estuaries and in rivers.

CMAR has a world-class biogeochemical modelling capability. Our “blue-water” modellers have implemented ocean carbon cycles within global coupled climate models, and used these to investigate global climate feedbacks and impacts. These models are represented in international intercomparison experiments and in IPCC reports, and will be further developed through ACCESS.

The coastal modelling community is not so international in character, but our modellers are well recognized internationally, and our models compare well with the international state-of-the-art. Our coastal biogeochemical models have been at the forefront in benthic-pelagic coupling, in incorporating multiple functional groups, and in coupling to 3-D hydrodynamic models. Our coastal modelling has also had a strong applied flavour, so the group has a lot of experience in the formulation of management scenarios, and the analysis and visualisation of model output to support decision-making. The group has had strong software support, and pioneered web-based applications for model visualisation and delivery.

Biogeochemical models tend to integrate physical, chemical and biological processes, so we don't usually distinguish “chemical” from “biological” modellers. We do lack experience in models which deal with specialized chemical processes (e.g. with speciation and equilibria for complex mixtures of trace metals).

CMAR is just beginning to develop its capability in data assimilation and model-data fusion for biogeochemistry. In doing this, we are drawing on the strong experience in data assimilation in physical models gained through BlueLink, but also on increased collaboration with CMIS.

As discussed above, CMAR's biogeochemical modellers enjoy the benefits of a very strong underpinning physical modelling capability, but they also have the opportunity to support and interact with a world-leading ecosystem modelling capability, in the form of the Atlantis and In Vitro modelling suites. We would expect the biogeochemical and ecosystem models to become more closely integrated over time.
Using CMAR’s Biogeochemistry Capability - Questions for Theme Leaders

This is a request for your input on your theme’s projected needs for CMAR’s aquatic biogeochemistry capability over the next 5 years or so, to inform CMAR’s strategic capability planning. The capability and the underpinning science are described in an accompanying background document. The questions and options below are meant to serve as prompts in formulating your response, and are not intended to be prescriptive. I’d generally prefer some explanation / elaboration rather than yes/no answers, and would welcome any other comments you might have.

1. Does CMAR’s biogeochemistry capability (as described in the companion paper) have a role in your theme over the next 5 years?

2. What are the key application areas for the capability in your theme?

3. What are the key skill areas you expect to use?

4. Do you see your needs for the capability in these areas increasing or decreasing over that period? (Estimates of the size of the increase or decrease (e.g. in FTEs) would be extremely useful.)

5. Are there constraints or obstacles which prevent your theme from using as much biogeochemistry capability as you would like? If so, what are the key constraints? E.g.
   - BGC could contribute more to theme goals, but is not a sufficient priority given theme size.
   - Fits my strategic goal, but clients are not prepared to co-invest in these application areas.
   - CMAR has insufficient capacity in key areas. I would use more people if they were available in the following skill areas ....
   - CMAR is completely lacking the key skill I need, which is ....
   - CMAR has the right people, but lacks the key CAPEX needed which is ...

6. Are there areas of the capability where you see a need for your theme to invest in strategic development of the capability and the underlying science?
   - If so, which areas?
   - Does CMAR have the right skill mix to carry out that strategic research?

7. Would you like to see increased collaboration between CMAR’s biogeochemistry capability and other research groups (inside or outside CSIRO) in your theme? If so, which groups?

8. Other comments or suggestions?
Hi John,

attached is my response to your questions. I suspect like most people I haven't been able to give this the time it deserves but hopefully you get the general idea. If you need any clarification let me know.

cheers, Andy
Deletion
Morgan, Janet (CMAR, Hobart)

From: Zhong, Liejun (CMAR, Floreat)
Sent: Friday, 1 August 2008 2:30 PM
To: Parslow, John (CMAR, Hobart)
Subject: RE: Opportunity to have input into Biogeochemistry Capability Review
Attachments: BGC questions_zhong.doc

John,

Hope that my response would be of a little help.

Liejun

CSIRO Marine and Atmospheric Research
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From: Parslow, John (CMAR, Hobart)
Sent: Thursday, 24 July 2008 6:23 AM
To: Abell, Guy (CMAR, Hobart); Akl, John (CMAR, Hobart); Andrewartha, John (CMAR, Hobart); Armand, Stephane (CMAR, Hobart); Berry, Kate (CMAR, Hobart); Blackburn, Sue (CMAR, Hobart); Bonham, Pru (CMAR, Hobart); Butler, Edward (CMAR, Hobart); Clementson, Lesley (CMAR, Hobart); Esmay, Rebecca (CMAR, Hobart); Greenwood, Jim (CMAR, Floreat); Griffiths, Brian (CMAR, Hobart); Gunson, Jim (CMAR, Floreat); Hassler, Christel (CMAR, Hobart); Herzfeld, Mike (CMAR, Hobart); Holdsworth, Danny (CMAR, Hobart); Hughes, Peter (CMAR, Floreat); Latham, Val (CMAR, Hobart); Leeming, Rhys (CMAR, Hobart); Lourey, Martin (CMAR, Floreat); Margvelashvili, Nurgiz (CMAR, Hobart); Matear, Richard (CMAR, Hobart); McLaughlin, James (CMAR, Floreat); Moore, Thomas (CMAR, Hobart); Navidad, Alicia (CMAR, Hobart); O'Sullivan, Jeanette (CMAR, Hobart); Paterson, Kristina (CMAR, Hobart); Rayner, Mark (CMAR, Hobart); Revill, Andy (CMAR, Hobart); Rizwi, Farhan (CMAR, Hobart); Robert, Stan (CMAR, Hobart); Skerratt, Jenny (CMAR, Hobart); Symonds, Graham (CMAR, Floreat); Terholl, David (CMAR, Hobart); Thompson, Peter (CMAR, Hobart); Tilbrook, Bronte (CMAR, Hobart); Trull, Tom (Tas Uni); Volkan, John (CMAR, Hobart); Watson, Ros (CMAR, Hobart); Wild-Allen, Karen (CMAR, Hobart); Zhong, Liejun (CMAR, Floreat)
Subject: RE: Opportunity to have input into Biogeochemistry Capability Review

Dear Colleagues,

I'm resending my email of last week, asking for your input into the Biogeochemistry Capability Review. I realise that yesterday's deadline was very tight. I'd like to thank those of you who have already responded. Yesterday's deadline was to allow me to develop an interim report, to form a basis for further consultation, especially with theme leaders. However, there will be an opportunity to incorporate additional responses received up until COB 1 August into my final report.

This is an important report, and I really value your input. So if you would like to respond, but haven't had the opportunity yet, please consider submitting a response by COB 1 August. Again, brief responses are welcome, as are responses which only address a subset of questions which interest you.

Best Regards
John

From: Parslow, John (CMAR, Hobart)
Sent: Friday, 18 July 2008 9:28 AM
To: Abell, Guy (CMAR, Hobart); Akl, John (CMAR, Hobart); Andrewartha, John (CMAR, Hobart); Armand, Stephane (CMAR, Hobart); Berry, Kate (CMAR, Hobart); Blackburn, Sue (CMAR, Hobart); Bonham, Pru (CMAR, Hobart); Butler, Edward (CMAR, Hobart); Clementson, Lesley (CMAR, Hobart); Esmay, Rebecca
IAR, Hobart; Greenwood, Jim (CMAR, Floreat); Griffiths, Brian (CMAR, Hobart); Gunson, Jim (CMAR, Hobart); Hassler, Christel (CMAR, Hobart); Herzelf, Mike (CMAR, Hobart); Holdsworth, Danny (CMAR, Hobart); Hughes, Peter (CMAR, Floreat); Latham, Val (CMAR, Hobart); Leeming, Rhys (CMAR, Hobart); Rey, Martin (CMAR, Floreat); Margyvelashvili, Nuzig (CMAR, Hobart); Matear, Richard (CMAR, Hobart);oughlin, James (CMAR, Floreat); Moore, Thomas (CMAR, Hobart); Navidad, Alicia (CMAR, Hobart); Sullivan, Jeanette (CMAR, Hobart); Paterson, Kristina (CMAR, Hobart); Rayner, Mark (CMAR, Hobart); Rill, Andy (CMAR, Hobart); Rizwi, Farhan (CMAR, Hobart); Robert, Stan (CMAR, Hobart); Skerratt, Jenny (CMAR, Hobart); Symonds, Graham (CMAR, Floreat); Terhelle, David (CMAR, Hobart); Thompson, Peter IAR, Hobart); Tilbrook, Bronte (CMAR, Hobart); Trull, Tom (Tas Uni); Volkman, John (CMAR, Hobart); tson, Ros (CMAR, Hobart); Wild-Allen, Karen (CMAR, Hobart); Zhong, Liejun (CMAR, Floreat)

**Objective:** Opportunity to have input into Biogeochemistry Capability Review

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- Assess the current and future needs for this capability by output Themes.
- Make recommendations about the future development of the capability.

A significant part of this has been covered in previous workshops and reports, and I'll draw heavily on those. But I want to hear from people identified as forming part of the biogeochemistry capability an opportunity for direct input. The attached questionnaire represents that opportunity.

Note that, like any such classification, "aquatic biogeochemistry" has a fuzzy boundary. The Team have defined this term for the purposes of the review, we'll define "aquatic biogeochemistry" as referring to the study of cycling, fate and impact of materials (major and minor elements, and pollutants or toxicants) in aquatic ecosystems, but typically focused on lower trophic levels. It is multi-disciplinary, including physics, chemistry and biology. It embraces field observations, lab and field process studies, and modelling. CMAR has a current formal set of major and sub-capabilities, but there are other areas of research which map to this definition. However we define the core capability, there will be related capabilities and disciplines physical oceanography, genomics, ecology) which sit outside, but are essential to the success of the core. And there will be individuals who map partly in the core and partly outside. I propose to deal with this in my review by considering a core biogeochemistry capability interacting with a number of related capabilities.

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John
Deletion
Morgan, Janet (CMAR, Hobart)

From: Greenwood, Jim (CMAR, Floreat)
Sent: Friday, 1 August 2006 4:56 PM
To: Parslow, John (CMAR, Hobart)
Subject: RE: Opportunity to have input into Biogeochemistry Capability Review
Attachments: BGC questions (JG).doc

John,

I skipped a few of the questions (mostly the output ones!) because I didn’t leave enough time to give them my full attention. Sorry about that. Anyway, I hope that the other comments/ answers will be of some interest and use in your review. Thanks for the opportunity to contribute.

Jim

From: Parslow, John (CMAR, Hobart)
Sent: Thursday, 24 July 2008 6:23 AM
To: Abell, Guy (CMAR, Hobart); Akl, John (CMAR, Hobart); Andrewartha, John (CMAR, Hobart); Armand, Stephane (CMAR, Hobart); Berry, Kate (CMAR, Hobart); Blackburn, Sue (CMAR, Hobart); Bonham, Pru (CMAR, Hobart); Butler, Edward (CMAR, Hobart); Clementson, Lesley (CMAR, Hobart); Esmay, Rebecca (CMAR, Hobart); Greenwood, Jim (CMAR, Floreat); Griffiths, Brian (CMAR, Hobart); Gunson, Jim (CMAR, Floreat); Hassler, Christel (CMAR, Hobart); Herzfeld, Mike (CMAR, Hobart); Holdsworth, Danny (CMAR, Hobart); Hughes, Peter (CMAR, Floreat); Latham, Val (CMAR, Hobart); Leeming, Rhys (CMAR, Hobart); Lourey, Martin (CMAR, Floreat); Margvelashvili, Nuzgar (CMAR, Hobart); Mattez, Richard (CMAR, Hobart); McLaughlin, James (CMAR, Floreat); Moore, Thomas (CMAR, Hobart); Navidad, Alicia (CMAR, Hobart); O’Sullivan, Jeanette (CMAR, Hobart); Peterson, Kristina (CMAR, Hobart); Rayner, Mark (CMAR, Hobart); Revill, Andy (CMAR, Hobart); Rizwi, Farhan (CMAR, Hobart); Robert, Stan (CMAR, Hobart); Skerratt, Jenny (CMAR, Hobart); Symonds, Graham (CMAR, Floreat); Terhell, David (CMAR, Hobart); Thompson, Peter (CMAR, Hobart); Tilbrook, Bronte (CMAR, Hobart); Trull, Tom (Tas Uni); Volkman, John (CMAR, Hobart); Watson, Ros (CMAR, Hobart); Wild-Allen, Karen (CMAR, Hobart); Zhong, Liejun (CMAR, Floreat)
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2/03/2011
Detention
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Cheers Sue

Dr Susan Blackburn
Principal Research Scientist - Microalgae Research
Head, CSIRO Collection of Living Microalgae
CSIRO Marine and Atmospheric Research
GPO Box 1538
Hobart, Tasmania,
Australia, 7001
Phone: +61 (0)3 62325307
Fax: +61 (0)3 62325000
susan.blackburn@csiro.au
http://www.cmar.csiro.au/microalgae/

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John
Deletion
Hi John
Hard questionnaire! Glad you weren't setting the exam questions when I was at school!
JohnK.

From: Parslow, John (CMAR, Hobart)
Sent: Thursday, 31 July 2008 10:21 AM
To: Richardson, Anthony (CMAR, Cleveland); Keesing, John (CMAR, Floreat); Strzelecki, Joanna (CMAR, Floreat); Phillips, Julia (CMAR, Floreat)
Subject: Aquatic Biogeochemistry Capability Review

Dear Anthony, John, Joanna, Julia,

I sent the email below to people identified as belonging to the broad biogeochemistry capability in CMAR. You were not included, due to some hiccups in the system. I'm sending it to you now with a revised, and unfortunately short, deadline of Monday 4 August. I apologise for the oversight and the tight deadline, and hope you can find time to respond.

Best Regards
John

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Deletion
Morgan, Janet (CMAR, Hobart)

From: Blackburn, Sue (CMAR, Hobart)  
Sent: Monday, 4 August 2008 11:04 AM  
To: Parslow, John (CMAR, Hobart)  
Subject: FW: Opportunity to have input into Biogeochemistry Capability Review  
Attachments: SB_V2_BGC questions.doc

Hi John I thought of a couple of things that I wanted to add to the biogeochemistry capability review. They are inserted in red in this version. Cheers Sue

From: Blackburn, Sue (CMAR, Hobart)  
Sent: Friday, 1 August 2008 6:24 PM  
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Principal Research Scientist - Microalgae Research  
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CSIRO Marine and Atmospheric Research  
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Hobart, Tasmania,  
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From: Parslow, John (CMAR, Hobart)
Sent: Thursday, 31 July 2008 10:21 AM
To: Richardson, Anthony (CMAR, Cleveland); Keesing, John (CMAR, Floreat); Strzelecki, Joanna (CMAR, Floreat); Phillips, Julia (CMAR, Floreat)
Subject: Aquatic Biogeochemistry Capability Review

Dear Anthony, John, Joanna, Julia,

I sent the email below to people identified as belonging to the broad biogeochemistry capability in CMAR. You were not included, due to some hiccups in the system. I'm sending it to you now with a revised, and unfortunately short, deadline of Monday 4 August. I apologise for the oversight and the tight deadline, and hope you can find time to respond.

Best Regards
John

Dear Colleagues,

I've been asked by the CMAR Capability Development Team to undertake a cross-Divisional review of CMAR's aquatic (marine) biogeochemistry capability. You will be aware that a review of CMAR capability has been underway for the last 12 months, and components of our aquatic biogeochemistry capability have been included in that review. However, those previous stages have tended to deal separately and differently with the parts of our capability playing into Climate / blue water (through CAWCR), and that playing into coastal.

Under my Terms of Reference, I've been asked to:

- Quantify the existing staff and infrastructure.
- Assess our capability against international standards.
- Assess interactions within CMAR and with other divisions.
- Assess the current and future needs for this capability by output Themes.
- Make recommendations about the future development of the capability.

Much of this has been covered in previous workshops and reports, and I'll draw heavily on those. But I want to give people identified as forming part of the biogeochemistry capability an opportunity for direct input. The attached questionnaire represents that opportunity.

I note that, like any such classification, "aquatic biogeochemistry" has a fuzzy boundary. The Team have agreed that, for the purposes of the review, we'll define "aquatic biogeochemistry" as referring to the study of the cycling, fate and impact of materials (major and minor elements, and pollutants or toxicants) in aquatic ecosystems, but typically focused on lower trophic levels. It is multi-disciplinary, including physics, chemistry and biology. It embraces field observations, lab and field process studies, and

2/03/2011
modelling. CMAR has a current formal set of major and sub-capabilities, but these map rather inconsistently against this definition. However we define the core capability, there will be related capabilities and disciplines (e.g. physical oceanography, genomics, ecology) which sit outside, but are essential to the success of the core. And there will be individuals who map partly in the core and partly outside. I propose to deal with this in my review by consider a core biogeochemistry capability interacting with a penumbra of related capabilities.

In any case, after taking into account the current map of staff to capabilities, and consultation with PLs and RGLs, you've been identified as having at least a toe hold in the core. So I'm offering you an opportunity to have input through the questionnaire. Of course it's not compulsory, and you're free to ignore it, but I hope you'll take some time to respond, as I think this represents an opportunity to have strategic input on some important issues. I've tried to frame the questions so as to allow you to address the Terms of Reference from the point of view of your research and area of expertise. I'm not looking for opinions about the capability as a whole, although you are asked to describe how collaboration with others affects your research.

While I'm encouraging you to respond, I'd also encourage you to keep your answers brief. Focus on the key points & issues from your perspective, rather than attempt to be comprehensive. That will save your time, and I have to assimilate and synthesize the responses. Dot points are fine. If you only want to respond to some questions, that's fine as well. I understand that CMAR is planning to develop more detailed strategic plans for each major capability area. This review is not a substitute for that, but I'd expect that your input here will provide an invaluable resource to support that future development.

I have a short time frame for my review, and am afraid I can only guarantee to consider responses received by COB Monday 4 August.

Well if you've persisted to this point, completing the questionnaire should be easy by comparison. Thanks in anticipation, and best regards,

John
Deletion
Morgan, Janet (CMAR, Hobart)

From: Wilson, Mick (CPR, North Ryde)
Sent: Friday, 1 August 2008 8:43 AM
To: Parslow, John (CMAR, Hobart)
Subject: RE: Input to CMAR Biogeochemistry Review

yes . Cheers

Professor Michael Wilson
Low Emission Transport Theme Leader
CSIRO Energy Transformed Flagship
Riverside Life Science Centre
11 Julius Avenue, North Ryde, NSW, 2113
Ph: (02) 9490 8432
Fax: (02) 9490 8212
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Energy Transformed Flagship | www.csiro.au

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From: Parslow, John (CMAR, Hobart)
Sent: Thursday, 31 July 2008 5:41 PM
To: Wilson, Mick (CPR, North Ryde)
Subject: RE: Input to CMAR Biogeochemistry Review

Hi Mick,

Yes that would be fine. I'll put 3 pm Monday in my calendar. Should I call your office number?

Thanks
John

From: Wilson, Mick (CPR, North Ryde)
Sent: Thursday, 31 July 2008 5:26 PM
To: Parslow, John (CMAR, Hobart)
Subject: RE: Input to CMAR Biogeochemistry Review

Could I put that off to 3pm on Monday for a phone hook up?

Professor Michael Wilson
Low Emission Transport Theme Leader

2/03/2011
From: Parslow, John (CMAR, Hobart)
Sent: Thursday, 31 July 2008 4:02 PM
To: Wilson, Mick (CPR, North Ryde)
Subject: RE: Input to CMAR Biogeochemistry Review

Thanks very much Mick. Let me know if you’d prefer to respond via email or through a phone interview.

Best Regards
John

From: Wilson, Mick (CPR, North Ryde)
Sent: Thursday, 31 July 2008 4:00 PM
To: Parslow, John (CMAR, Hobart)
Subject: RE: Input to CMAR Biogeochemistry Review

Happy to do this.

Professor Michael Wilson
Low Emission Transport Theme Leader
CSIRO Energy Transformed Flagship
Riverside Life Science Centre
11 Julius Avenue, North Ryde, NSW, 2113
Ph: (02) 9490 8432
Fax: (02) 9490 8212
Mobiles: 0458 789 063 and 0437 139 996
Email: Mick.Wilson@csiro.au
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The information contained in this e-mail may be confidential or privileged. Any unauthorised use or disclosure is prohibited. If you have received this e-mail in error, please delete it immediately and notify the sender by return email. Thank you. To the extent permitted by law, CSIRO does not represent, warrant and/or guarantee the integrity of this communication has been maintained nor the communication is free of error, virus, interception or interference.
From: Parslow, John (CMAR, Hobart)
Sent: Thursday, 31 July 2008 3:54 PM
To: Wilson, Mick (CPR, North Ryde)
Subject: Input to CMAR Biogeochemistry Review

Dear Mick,

I have been asked by CMAR OIC to undertake a review of CMAR's broad biogeochemistry capability. As part of this review, I've been specifically asked to consult with Theme Leaders on their anticipated future need for the capability. I am writing to seek your input for the Low Emissions Transport Theme. (I realise this capability is only involved in your theme in a small way, in the area of biofuels, and am interested in how you see the future needs in this area.) To assist, I've prepared two attached documents. One is a general overview of status and trends in international biogeochemical science and a summary of CMAR's capability. I hope that will help to give you a clear idea of the kind of capability I'm reviewing, and how it might be relevant to your theme. The second document is a questionnaire. Again, it's intended to act as a prompt for a dialogue about the contribution of the capability to your theme.

I'm afraid the first overview document is rather long, but it's written in a non-technical way, and I hope you might find it fairly easy to read, and of general interest. If you're pressed for time, Sections 1 and 6 are the most critical, followed by 5, 4 and then 2 & 3, although I hope it reads better in the order 1 to 6. (I should emphasize that this represents my own preliminary take on the science and capability at this point. Any comments you might have on this document are also most welcome.)

You may prefer to provide a brief written response, but if you'd prefer, I'm happy to go through the questionnaire with you by phone instead. I'd expect that might take 15 to 30 minutes. I'm afraid I need your response (either verbal or written) by COB Wed 6 August. I apologise for the time frame, but I have a looming deadline on the report.

I realise you're busy, and I do want to stress how much your input is appreciated. Getting the input capability and output needs aligned is obviously a key challenge in the matrix, and I hope this exercise will benefit your theme down the track.

Best Regards
John
From: Parslow, John (CMAR, Hobart)
Sent: Thursday, 31 July 2008 10:21 AM
To: Richardson, Anthony (CMAR, Cleveland); Keesing, John (CMAR, Floreat); Strzelecki, Joanna (CMAR, Floreat); Phillips, Julia (CMAR, Floreat)
Subject: Aquatic Biogeochemistry Capability Review

Dear Anthony, John, Joanna, Julia,

I sent the email below to people identified as belonging to the broad biogeochemistry capability in CMAR. You were not included, due to some hiccups in the system. I'm sending it to you now with a revised, and unfortunately short, deadline of Monday 4 August. I apologise for the oversight and the tight deadline, and hope you can find time to respond.

Best Regards
John

Dear Colleagues,

I've been asked by the CMAR Capability Development Team to undertake a cross-Divisional review of CMAR's aquatic (marine) biogeochemistry capability. You will be aware that a review of CMAR capability has been underway for the last 12 months, and components of our aquatic biogeochemistry capability have been included in that review. However, those previous stages have tended to deal separately and differently with the parts of our capability playing into Climate / blue water (through CAWCR), and that playing into coastal.

Under my Terms of Reference, I've been asked to:

- Quantify the existing staff and infrastructure.
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- Make recommendations about the future development of the capability.

Much of this has been covered in previous workshops and reports, and I'll draw heavily on those. But I want to give people identified as forming part of the biogeochemistry capability an opportunity for direct input. The attached questionnaire represents that opportunity.

I note that, like any such classification, "aquatic biogeochemistry" has a fuzzy boundary. The Team have agreed that, for the purposes of the review, we'll define "aquatic biogeochemistry" as referring to the study of the cycling, fate and impact of materials (major and minor elements, and pollutants or toxicants) in aquatic ecosystems, but typically focused on lower trophic levels. It is multi-disciplinary, including physics, chemistry and biology. It embraces field observations, lab and field process studies, and modelling. CMAR has a current formal set of major and sub-capabilities, but these map rather inconsistently against this definition. However we define the core capability, there will be related capabilities and disciplines (e.g. physical oceanography, genomics, ecology) which sit outside, but are essential to the success of the
core. And there will be individuals who map partly in the core and partly outside. I propose to deal with this in my review by consider a core biogeochemistry capability interacting with a penumbra of related capabilities.

In any case, after taking into account the current map of staff to capabilities, and consultation with PLs and RGLs, you've been identified as having at least a toe hold in the core. So I'm offering you an opportunity to have input through the questionnaire. Of course it's not compulsory, and you're free to ignore it, but I hope you'll take some time to respond, as I think this represents an opportunity to have strategic input on some important issues. I've tried to frame the questions so as to allow you to address the Terms of Reference from the point of view of your research and area of expertise. I'm not looking for opinions about the capability as a whole, although you are asked to describe how collaboration with others affects your research.

While I'm encouraging you to respond, I'd also encourage you to keep your answers brief. Focus on the key points & issues from your perspective, rather than attempt to be comprehensive. That will save your time, and I have to assimilate and synthesize the responses. Dot points are fine. If you only want to respond to some questions, that's fine as well. I understand that CMAR is planning to develop more detailed strategic plans for each major capability area. This review is not a substitute for that, but I'd expect that your input here will provide an invaluable resource to support that future development.

I have a short time frame for my review, and am afraid I can only guarantee to consider responses received by COB Monday 4 August.

Well if you've persisted to this point, completing the questionnaire should be easy by comparison. Thanks in anticipation, and best regards,

John
Morgan, Janet (CMAR, Hobart)

From: Doyle, Kieran (CSIRO P&C, Hobart)
Sent: Monday, 4 August 2008 8:48 AM
To: Parslow, John (CMAR, Hobart)
Subject: Re: BGC staff

Dear John

[Deletion]

Kieran

AR is staff so can include him.

From: Parslow, John (CMAR, Hobart)
To: Doyle, Kieran (CSIRO P&C, Hobart)
Sent: Mon Aug 04 08:38:00 2008
Subject: BGC staff

Dear Kieran,

It turns out some staff in WA who should have been included in the BGC capability group were overlooked on our first round, partly due to John Keesing's absence. These staff are:

Joanna Strzelecki
Julia Phillips
John Keesing

I'd also like to add Anthony Richardson to the group. He's a joint appointment with UQ, but I can't see his name on the staff list you sent me. Perhaps he's not in our staff database?

I'm hoping it won't be too much bother for you to rerun the spreadsheet you sent me a week ago, with staff allocations to themes, adding these new names? If Anthony's not in our database, it's ok to omit him.

I'm trying to extract feedback from theme leaders in the next few days. I hope to complete & circulate my draft report by COB Thursday. (Not sure how, but that's another matter.) In order to do that, I'll need your staff summaries & demographics by COB Wednesday. I presume we should make a time today or tomorrow to discuss the plots & summaries required?

Regards
John

2/03/2011
Hi John,

I will try to call you tomorrow (during a break in EMC) to have a chat with you. Our Sustainable Cities and Coasts Theme could potentially include some BGC activities but it doesn’t at the moment. Its focus is on urban infrastructure and planning and biophysical coastal impacts of climate change (sea level rise, storm surges, wave modelling etc). The Managing Species and Natural Ecosystems Theme would capture our very modest amount of BGC work.

Cheers

Andrew

Andrew Ash
Director
CSIRO Climate Adaptation Flagship
306 Carmody Rd
St Lucia
Qld 4067
AUSTRALIA
Ph 61-7-32142346 Fax: 61-7-32142308

From: Parslow, John (CMAR, Hobart)
Sent: Thursday, 31 July 2008 10:41 AM
To: Ash, Andrew (CA F/Ship, St. Lucia)
Subject: Input to CMAR Biogeochemistry Review

Dear Andrew,

I have been asked by CMAR OTC to undertake a review of CMAR’s broad biogeochemistry capability. As part of this review, I’ve been specifically asked to consult with Theme Leaders on their anticipated future need for the capability. I am writing to seek your input on future needs in the Climate Adaptation Flagship. I apologise for directing this to you as Flagship Director, but I thought you might be able to give an overview across the flagship. If you’d prefer to direct this to your theme leaders, that’s fine. Our (incomplete) records suggest our biogeochemistry capability is currently mapped for only a fraction of an FTE to Ecosystems and Natural Resources Theme. I’d expect the capability might be relevant to Liveable Cities, Coasts and Regions.

To assist, I’ve prepared two attached documents. One is a general overview of status and trends in international biogeochemical science and a summary of CMAR’s capability. I hope that will help to give you a clear idea of the kind of capability I’m reviewing, and how it might be relevant to your theme. The second document is a questionnaire. Again, it’s intended to act as a prompt for a dialogue about the contribution of the capability to your theme.

I’m afraid the first overview document is rather long, but it’s written in a non-technical way, and I hope you might find it fairly easy to read, and of general interest. If you’re pressed for time, Sections 1 and 6 are the most critical, followed by 5, 4 and then 2 & 3, although I hope it reads better in the order 1 to 6. (I should emphasize that this represents my own preliminary take on the science and capability at this point. Any comments you might have on this document are also most welcome.)

You may prefer to provide a brief written response, but if you’d prefer, I’m happy to go through the questionnaire with you by phone instead. I’d expect that might take 15 to 30 minutes. I’m afraid I need your response (either verbal or written) by COB Wed 6 August. I apologise for the time frame, but I have a looming deadline on the report.
I realise you're busy, and I do want to stress how much your input is appreciated. Getting the input capability and output needs aligned is obviously a key challenge in the matrix, and I hope this exercise will benefit CAF down the track.

Best Regards
John

2/03/2011
Hi John
I'm seeking confirmation of my answers to you from John Gunn. I should get back to you this arvo depending on when I can get 10 minutes of John's time.

In short, my preliminary/unofficial response is:
- Planned circulation is to the entire Leadership Forum OTC, RPLs, RGLs, selected Support Leaders,
- No individual names would be mentioned in that circulation, but would be welcome in a version restricted in distribution to the OTC, and
- Small skill areas? – even though you might infer names in small groups, I don't think we want to devalue the details of report with too much aggregation

Cheers
Rotho

Dr Peter C Rothlisberg, PhD
Acting Assistant Chief
CSIRO Marine and Atmospheric Research
Cleveland Laboratories
PO Box 120 Cleveland, Qld 4163 Australia
T +61 7 3826 7225; F +61 7 3826 7281
peter.rothlisberg@csiro.au

From: Parslow, John (CMAR, Hobart)
Sent: Monday, 4 August 2008 12:10 PM
To: Rothlisberg, Peter (CMAR, Cleveland)
Subject: BGC review

Dear Peter,

I'm trying to interview theme leaders in the first few days of this week, and hoping to distribute a draft report by COB Thursday. I'm not sure yet how this will affect the input from P&C.

A specific question came up in my discussion with one Theme Leader. Do you know what the planned circulation is for my report in CMAR. Will it be treated in confidence, and/or restricted in distribution. The Theme Leader made comments about individual staff or teams, but felt it would be counter-productive to have comments about individuals circulated widely. I clearly have to consider this in deciding how to frame my report & recommendations. I could frame the report in terms of skill areas, without mentioning names specifically, although in many cases our teams are small enough that it will be obvious who is being referred to.

In the long run, it will be healthy and arguably necessary to have a public and shared view about directions and priorities for the capability. But perhaps that's something for the Capability Team to develop after considering my input.

Regards
John

2/03/2011
Morgan, Janet (CMAR, Hobart)

From: Rothlisberg, Peter (CMAR, Cleveland)
Sent: Monday, 4 August 2008 2:46 PM
To: Parslow, John (CMAR, Hobart)
Subject: FW: BGC review

Hi John
Here's the endorsement I was looking for and expecting – with the additional suggestion of the "Confidential" watermark.
Cheers
Rotho

Dr Peter C Rothlisberg, PhD
Acting Assistant Chief
CSIRO Marine and Atmospheric Research
Cleveland Laboratories
PO Box 120 Cleveland, Qld 4163 Australia
T +61 7 3826 7225; F +61 7 3826 7281
peter.rothlisberg@csiro.au

From: Gunn, John (CMAR, Hobart)
Sent: Monday, 4 August 2008 2:37 PM
To: Rothlisberg, Peter (CMAR, Cleveland)
Cc: Domaradzki, Anne (CMAR, Hobart)
Subject: RE: BGC review

Rotho, agree with your summation and action, with suggestion that in confidence would be watermarked onto the documents.
J

From: Rothlisberg, Peter (CMAR, Cleveland)
Sent: Monday, 4 August 2008 12:58 PM
To: Gunn, John (CMAR, Hobart)
Subject: FW: BGC review
Importance: High

G'day John (G that is),
Before I reply to John P I thought I'd seek your opinion.

My reply would say the following:
- Planned circulation was to the entire Leadership Forum OTC, RPLs, RGLs, selected Support Leaders,
- No individual names would be mentioned in that circulation, but would be welcome in a version restricted in distribution to the OTC, and
- Small skill areas? – even though you might infer names in small groups, I don't think we want to devalue the details of report with too much aggregation

If my assumptions about circulation/content of John's report are correct, I'll do a whip around to the other Review authors (Alan B, Helen C and Mark G) with the same instructions and deadlines.

Cheers
Rotho

Dr Peter C Rothlisberg, PhD
Acting Assistant Chief

2/03/2011
From: Parslow, John (CMAR, Hobart)
Sent: Monday, 4 August 2008 12:10 PM
To: Rothlisberg, Peter (CMAR, Cleveland)
Subject: BGC review

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In the long run, it will be healthy and arguably necessary to have a public and shared view about directions and priorities for the capability. But perhaps that's something for the Capability Team to develop after considering my input.

Regards
John
Morgan, Janet (CMAR, Hobart)

From: Bax, Nic (CMAR, Hobart)
Sent: Wednesday, 6 August 2008 10:56 AM
To: Parslow, John (CMAR, Hobart)
Subject: RE: Input to CMAR Biogeochemistry Review
Attachments: BGC and Themes - MCBM.doc

Here we go

nic

From: Parslow, John (CMAR, Hobart)
Sent: Thursday, 31 July 2008 10:24 AM
To: Bax, Nic (CMAR, Hobart)
Subject: Input to CMAR Biogeochemistry Review

Dear Nic,

I have been asked by CMAR OIC to undertake a review of CMAR's broad biogeochemistry capability. As part of this review, I've been specifically asked to consult with Theme Leaders on their anticipated need for the capability. I am writing to seek your input as a potential user of this capability. I realise you've already been asked for input in late 2007, and kindly attended capability workshops at that time. I hope this represents a chance to update that input in the light of SIP3 decisions, and perhaps take a more strategic view of the capability and your needs for it. To that end, I've prepared two attached documents. One is a general overview of status and trends in international biogeochemical science and a summary of CMAR's capability. I hope that will help to give you a clear idea of the kind of capability I'm reviewing, and how it might be relevant to your theme. The second document is a questionnaire. Again, it's intended to act as a prompt for a dialogue about the contribution of the capability to your theme.

I'm afraid the first overview document is rather long, but it's written in a non-technical way, and I hope you might find it fairly easy to read, and of general interest. If you're pressed for time, Sections 1 and 6 are the most critical, followed by 5, 4 and then 2 & 3, although I hope it reads better in the order 1 to 6. (I should emphasize that this represents my own preliminary take on the science and capability at this point. Any comments you might have on this document are also most welcome.)

You may prefer to provide a brief written response, but if you'd prefer, I'm happy to go through the questionnaire with you by phone instead. I'd expect that might take 15 to 30 minutes. I'm afraid I need your response (either verbal or written) by COB Wed 6 August. I apologise for the time frame, but I have a looming deadline on the report. Obviously, it would be preferable if you have time to scan the documents prior to our discussion.

I realise you're busy, and I do want to stress how much your input is appreciated. Getting the input capability and output needs aligned is obviously a key challenge in the matrix, and I hope this exercise will benefit your theme down the track.

Best Regards
John
Using CMAR’s Biogeochemistry Capability - Questions for Theme Leaders

This is a request for your input on your theme’s projected needs for CMAR’s aquatic biogeochemistry capability over the next 5 years or so, to inform CMAR’s strategic capability planning. The capability and the underpinning science are described in an accompanying background document. The questions and options below are meant to serve as prompts in formulating your response, and are not intended to be prescriptive. I’d generally prefer some explanation/elaboration rather than yes/no answers, and would welcome any other comments you might have.

1. Does CMAR’s biogeochemistry capability (as described in the companion paper) have a role in your theme over the next 5 years?

   We don’t make much use of the biogeochemistry capability at the moment – this may be due to our having a primarily benthic (and often offshore) focus where data collection would often be prohibitively expensive. We presumably have made some use of biogeochemical expertise in describing marine systems for regional marine planning and development of SOE indicators, but it would have been ad hoc and expert opinion.

   We are initiating a program with Ausaid to map biodiversity assets (and threats) throughout Melanesia and Indonesia. Its conceivable that there would be role for biogeochemistry here, although I am not sure that the program would support even moderate field programs. Is there a capacity for rapid assessments of the biogeochemistry of tropical coastal areas – eg. to characterise the pollutants and determine the level of threat?

   The main opportunities would come if we have the resources to expand into the pelagic environment where processes may be as important as species diversity. For example we are currently undertaking a topographic map of the entire Australian slope using transit time on the National Facility. My plan is to link this topographic map with Bluelink to gain an understanding of the properties of different canyons and features around Australia. Biogeochemistry could be an important component of this as we try and estimate things like productivity. We are also interested in getting a better understanding of biodiversity as a process which could include working at the microbial level (or indeed at the level where the processes are driven/fastest). Given resources, capability (eg. genomics) and clients it may be difficult to develop this area.

2. What are the key application areas for the capability in your theme?
   See 1

3. What are the key skill areas you expect to use?
   1. Model-based estimates of productivity
   2. Rapid assessment in tropical environments
4. Do you see your needs for the capability in these areas increasing or decreasing over that period? (Estimates of the size of the increase or decrease (e.g. in FTEs) would be extremely useful.)
   a. Currently we have zero budgeted use of capability
   b. I could see it increasing to 0.25-1.0 FTE if the specific area of interest (e.g. rapid assessment) could be developed.
   c. There may be more scope for biogeochemistry in larger pelagic studies on ecosystem health that MCBM would be part of but might not lead. I sense that this area is probably being covered by others so is not an area that MCBM would lead. To some extent it is the climate impacts area that will probably be picked up by CAF (although perhaps not if they really focus on adaptation)

5. Are there constraints or obstacles which prevent your theme from using as much biogeochemistry capability as you would like? If so, what are the key constraints? E.g.
   • BGC could contribute more to theme goals, but is not a sufficient priority given theme size.
     a. True, we are resource-constrained and I am hesitant to diversify too much – i.e. a deferred a proposal from Rudy to start looking at the pelagic systems as defined through acoustics.
   • Fits my strategic goal, but clients are not prepared to co-invest in these application areas.
     a. Not a current constraint but could certainly constrain the developments discussed above.
   • CMAR has insufficient capacity in key areas. I would use more people if they were available in the following skill areas
     a. Do we have a rapid assessment capacity or interest?....
   • CMAR is completely lacking the key skill I need, which is ....
   • CMAR has the right people, but lacks the key CAPEX needed which is ....

6. Are there areas of the capability where you see a need for your theme to invest in strategic development of the capability and the underlying science?
   • If so, which areas?
     a. I doubt MCBM would have the capacity for this, given our expected usage.
   • Does CMAR have the right skill mix to carry out that strategic research?
     a. Haven’t investigated

7. Would you like to see increased collaboration between CMAR’s biogeochemistry capability and other research groups (inside or outside CSIRO) in your theme? If so, which groups?
   a. Don’t know much about it, but collaboration with IMOS would seem to be key. I am working with IMOS and DEWHA through the CERF Hub in an attempt to improve the relevance of future IMOS infrastructure to meet national environmental needs, including monitoring and exploration.
8. Other comments or suggestions?
   a. Linking with genomics so can jointly characterise the structure and function of the community would seem to be a key development in this area – especially when sample collection, or data collection can be automated.
Morgan, Janet (CMAR, Hobart)

From: Walker, Glen (CLW, Urbrae)
Sent: Wednesday, 6 August 2008 12:29 PM
To: Parslow, John (CMAR, Hobart)
Cc: Young, Bill (CLW, Black Mountain)
Subject: RE: Input to CMAR Biogeochemistry Review

John,

Thanks for the opportunity to respond to the CMAR biogeochemistry statement. I enjoyed reading the statement.

First off, it is worth stating that BBF is mostly about water quantity and managing and sharing water rather than water quality or ecological consequences (except with respect to salinity): These are in Healthy Water Ecosystems led by Bill Young. As such, our main interaction with CMAR has been through the climate sciences and the interaction with water run-off and groundwater recharge.

The main exception to this has been in Northern Australia where the WhC's involvement in TRACK has been managed through BBF and there has been some involvement with your group through the Ord. For these purposes, the requirements would be in line with HWE, recognising the increasing interest in northern Rivers and the impact of oceanic discharge on fisheries, etc.

It is also worth mentioning a couple of fringe areas:

1. Groundwater marine discharge: every so often there is interest by our groundwater staff in marine discharge from aquifers, but it is not a high priority
2. Our theme has major activity in groundwater-surface water discharge, again from the quantity perspective; but recognising overseas much of the work is about water quality and contribution to the food-web. Again, not a lot of activity in Australia.

regards
Glen

---

From: Parslow, John (CMAR, Hobart)
Sent: Thursday, 31 July 2008 3:19 PM
To: Walker, Glen (CLW, Urbrae)
Subject: Input to CMAR Biogeochemistry Review

Dear Glen,

I have been asked by CMAR OtC to undertake a review of CMAR's broad biogeochemistry capability. As part of this review, I've been specifically asked to consult with Theme Leaders on their anticipated future need for the capability. I am writing to seek your input as a user of this capability (to a small extent). To assist, I've prepared two attached documents. One is a general overview of status and trends in international biogeochemical science and a summary of CMAR's capability. I hope that will help to give you a clear idea of the kind of capability I'm reviewing, and how it might be relevant to your theme. The second document is a questionnaire. Again, it's intended to act as a prompt for a dialogue about the contribution of the capability to your theme.

I'm afraid the first overview document is rather long, but it's written in a non-technical way, and I hope you might find it fairly easy to read, and of general interest. If you're pressed for time, Sections 1 and 6 are the most critical, followed by 5, 4 and then 2 & 3, although I hope it reads better in the order 1 to 6. (I should emphasize that this represents my own preliminary take on the science and capability at this point. Any comments you might have on this document are also most welcome. I note this document focuses on CMAR...
capability, and mentions our collaboration with CLW's capability only briefly. Of course, I recognise that this collaboration is a key feature of our contribution to your theme.)

You may prefer to provide a brief written response, but if you'd prefer, I'm happy to go through the questionnaire with you by phone instead. I'd expect that might take 15 to 30 minutes. I'm afraid I need your response (either verbal or written) by COB Wed 6 August. I apologise for the timeframe, but I have a looming deadline on the report.

I realise you're busy, and I do want to stress how much your input is appreciated. Getting the input capability and output needs aligned is obviously a key challenge in the matrix, and I hope this exercise will benefit your theme down the track.

Best Regards
John
Morgan, Janet (CMAR, Hobart)

From: Rothlisberg, Peter (CMAR, Cleveland)
Sent: Wednesday, 6 August 2008 3:41 PM
To: Butler, Alan (CMAR, Hobart); Gibbs, Mark (CMAR, Cleveland); Cleugh, Helen (CMAR, Black Mountain); Parslow, John (CMAR, Hobart)
Cc: Bugden, Donna (CMAR, Cleveland); Gunn, John (CMAR, Hobart)
Subject: Capability Reviews for Leadership Forum

Colleagues,

At today’s Capability Development Team meeting we discussed the Reviews that you are preparing and how we’d like them to be transmitted to and discussed at the Forum. Some of the reports are proving to be very large and comprehensive and unlikely to be read by most participants; or needed in their entirety to direct or provoke useful discussion. So to enhance communication into and during the Forum we’d ask you to:

1. Include at the front of the Report an Executive Summary which will be sent to Forum participants;
2. The key points of the Executive Summary would be directions you see the core capability going (e.g. growing, shrinking, morphing or merging);
3. Prepare a 5 minute PowerPoint presentation to stimulate discussion at the Forum; and
4. As Reviewers be prepared to facilitate a 30 minute discussion of your Report.

The deadline for the Executive Summary would be COB Thursday 7 August to me, so we can transmit them to participants early Friday. Deadline for the full Report, including feedback gained during the Forum would be ASAP after the Forum, but before the Capability Team Retreat (now scheduled for 4&5 September) – say Friday 22 August.

On behalf of the Capability Development Team, thank you again for the hard work in preparing these Reviews and we look forward to fruitful discussions at the Forum.

Cheers
Rotho

Dr Peter C Rothlisberg, PhD
Acting Assistant Chief
CSIRO Marine and Atmospheric Research
Cleveland Laboratories
PO Box 120 Cleveland, Qld 4163 Australia
T +61 7 3826 7225; F +61 7 3826 7281
peter.rothlisberg@csiro.au
Morgan, Janet (CMAR, Hobart)

From: Walker, Glen (CLW, Urrbrae)
Sent: Wednesday, 6 August 2008 6:28 PM
To: Parslow, John (CMAR, Hobart)
Cc: Young, Bill (CLW, Black Mountain)
Subject: RE: Input to CMAR Biogeochemistry Review

John,

The staff who have an interest in marine discharge have been Jeff Turner (CLW Perth) who coordinated the international exercise at Cockburn Sound, Tony Smith in CLW Perth and Sebastian Lamontagne in CLW Adelaide who did some work in the Adelaide Coastal study.

In terms of TRACK and associated work, it'll transfer at some stage: it will be reviewed in December as part of the internal reviews leading up to SIP4. The only perturbation to level of activity relates to the Northern Australian Water Assessment, which has an ecological component for which Bill is our contact and probably will be associated with TRACK in some way.

Regards
Glen

From: Parslow, John (CMAR, Hobart)
Sent: Wednesday, 6 August 2008 12:09 PM
To: Walker, Glen (CLW, Urrbrae)
Cc: Young, Bill (CLW, Black Mountain)
Subject: RE: Input to CMAR Biogeochemistry Review

Hi Glen,

Thanks. It's interesting about the groundwater and marine discharge. I told Bill about my conversations with Tom Hatton a few years ago concerning impacts of groundwater discharge into Cockburn sound. IN general, groundwater keeps being raised as an issue, and one we don't have a good handle on. As you say, I suspect the receiving water impacts of ground water as well as surface water are really something for HWE and maybe WFO to think about. Perhaps it's something we should keep in mind when we talk about coupled catchment-coastal models.

I gather from your message and from Bill that we're likely to maintain our current level of engagement in your theme until the end of TRACK, and that subsequently our engagement in the biogeochemistry area will most likely move to Bill's theme?

Regards
John

From: Walker, Glen (CLW, Urrbrae)
Sent: Wednesday, 6 August 2008 12:29 PM
To: Parslow, John (CMAR, Hobart)
Cc: Young, Bill (CLW, Black Mountain)
Subject: RE: Input to CMAR Biogeochemistry Review

John,

Thanks for the opportunity to respond to the CMAR biogeochemistry statement. I enjoyed reading the statement.

1/03/2011
First off, it is worth stating that BBF is mostly about water quantity and managing and sharing water rather than water quality or ecological consequences (except with respect to salinity): These are in Healthy Water Ecosystems led by Bill Young. As such, our main interaction with CMAR has been through the climate sciences and the interaction with water run-off and groundwater recharge.

The main exception to this has been in Northern Australia where the WtHC's involvement in TRACK has been managed through BBF and there has been some involvement with your group through the Ord. For these purposes, the requirements would be in line with HWE, recognising the increasing interest in northern Rivers and the impact of oceanic discharge on fisheries, etc.

It is also worth mentioning a couple of fringe areas:

1. Groundwater marine discharge: every so often there is interest by our groundwater staff in marine discharge from aquifers, but it is not a high priority
2. Our theme has major activity in groundwater-surface water discharge, again from the quantity perspective; but recognising overseas much of the work is about water quality and contribution to the food-web. Again, not a lot of activity in Australia.

regards
Glen

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From: Parslow, John (CMAR, Hobart)
Sent: Thursday, 31 July 2008 3:19 PM
To: Walker, Glen (CLW, Urbrae)
Subject: Input to CMAR Biogeochemistry Review

Dear Glen,

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Best Regards
John
Morgan, Janet (CMAR, Hobart)

From: Carroll, Julie (CSIRO P&C, Cleveland)
Sent: Wednesday, 6 August 2008 7:02 PM
To: Parslow, John (CMAR, Hobart)
Subject: FW: Hobart Research program_Org charts_Apr 08.ppt
Attachments: G&T group structure; Hobart Research program_Org charts_Apr 08.ppt

Hi John

I think you already had these but just in case – here is the remaining ones
Regards
Julie

Julie Carroll
Senior People & Culture Adviser
CSIRO People & Culture
Division of Marine & Atmospheric Research
PO Box 120
Cleveland  Q  4163
T: 07 3826 7238  F: 07 3826 7222  M: 0438 720 512
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From: Powell, Pam (CSIRO P&C, Hobart)
Sent: Wednesday, 6 August 2008 10:31 AM
To: Carroll, Julie (CSIRO P&C, Cleveland)
Subject: FW: Hobart Research program_Org charts_Apr 08.ppt

Julie

Here is the latest set of charts, replace the G&T one with the attached. Note that the SSPM chart is wrong as Ron Thresher will move into that group. I think there will be a lot of movement in these charts.

Pam

From: Randall, Margaret (CMAR, Hobart)
Sent: Wednesday, 6 August 2008 10:17 AM
To: Powell, Pam (CSIRO P&C, Hobart)
Cc: Midgley, Paulette (CMAR, Hobart)
Subject: Hobart Research program_Org charts_Apr 08.ppt

Hi Pam

Paulette asked me to send this org chart to you.

Marg

1/03/2011
Dear G&T,

Attached you will find a diagram showing the structure of our research group. As you can see, the group is organised into teams just like last year.

I think teams are really important. Our group is quite large and diverse but people within our teams are more closely linked to each other, from a disciplinary point of view.

I hope that within teams, in your daily interactions and in regular team meetings, that you’ll be able to help each other develop as scientists. This might be working out what equipment you need, what training you might like to do and how you can get Themes to engage your capabilities. Your team leader is your friend.

Please make appointments to sign off stage 3 of your APAs from last year with your previous line manager (for most of you there is no change). Now is a good time to start drafting your new stage 1.

Cheers,
Stan

--
Stanley Robert Ph.D.
Research Group Leader - Genomics & Taxonomy
CSIRO Marine & Atmospheric Research
GPO Box 1538 (postal)
Castray Esplanade [street]
Hobart, Tasmania 7001
AUSTRALIA
Ph - 61-3-6232 5114
Morgan, Janet (CMAR, Hobart)

From: Moate, Toni (CMAR, Hobart)  
Sent: Thursday, 7 August 2008 12:01 AM  
To: Parslow, John (CMAR, Hobart)  
Cc: Carroll, Julie (CSIRO P&C, Cleveland)  
Subject: RE: BGC Processing - demographic reports  
Attachments: BGC.xls

Dear John

Attached is a quick set of tables and graphs that I've pulled together. The numbers are different as I haven't included the new positions in the demographics. Please let me know if these suit your needs, need tweaking, or are way off track (gulp).

Regards, Toni

Toni Moate CPA GAICD  
Assistant Chief - Operations / CMAR Change Partner  
CSIRO Marine and Atmospheric Research  
(03) 6232 5209, 0419 378671

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From: Carroll, Julie (CSIRO P&C, Cleveland)  
Sent: Wednesday, 6 August 2008 6:21 PM  
To: Parslow, John (CMAR, Hobart)  
Cc: Moate, Toni (CMAR, Hobart)  
Subject: BGC Processing - demographic reports  
Importance: High

Dear John

I have spoken to Toni Moate tonight and provided her with the 49 names that you have sent me (including the additional ones in the separate email). She is currently working on other demographic data / reports in preparation for the workshop next week and is happy to produce some reports for you – namely CSOF levels, sites, per capability, location, age profile, RS / RP ratio

She anticipates you will have these reports sometime tomorrow morning – I hope this is OK

Thanks for your patience John....and Toni thank you for your help

Regards
Julie

Julie Carroll  
Senior People & Culture Adviser  
CSIRO People & Culture  
Division of Marine & Atmospheric Research  
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1/03/2011
Deletion
Dear Anne,

Please find attached my Exec Summary for the BGC Review.

Regards
John
CMAR Capability Review – Aquatic Biogeochemistry

Executive Summary

The broad goals of the review are to:
(i) assess the status of aquatic biogeochemistry in CMAR; and
(ii) recommend strategies that the Division should adopt, in the context of its capability development process, to improve the quality of the capability and the science that it delivers.

In commissioning the review, the CMAR Capability Development Team recognised that aquatic biogeochemistry is spread across several of CMAR’s formal Capabilities and Sub-Capabilities. The workshops and formal reports delivered through the CMAR capability development project to date have been largely organised within these formal structures, and have not provided an integrated view of aquatic biogeochemistry across CMAR. This review is intended to remedy that, drawing on those earlier outputs and other source material.

The review involved 3 consultative steps:
- Staff were identified as belonging to the capability, after consultation with RPLs and RGLs.
- All staff so identified were sent a questionnaire, inviting them to provide input on their science and applications and related issues.
- A description of the capability was prepared, incorporating staff input, and sent to Theme Leaders currently utilising the capability, along with a questionnaire about their future need for the capability, and factors affecting this need.

For the purposes of this review, aquatic biogeochemistry is defined as “the study of the cycling, fate and impact of materials (major and minor elements, and pollutants or toxicants) in aquatic ecosystems (typically focused on lower trophic levels).” This field of study is necessarily multi-disciplinary, and in the marine domain, it effectively integrates across the classical disciplines of physical, chemical and biological oceanography. Within each of these disciplines, it embraces field observations, laboratory and field process studies, and modelling.

The review identified a core group of 49 CMAR staff whose research is partly or wholly directed at aquatic biogeochemistry as defined. But it’s important to keep in mind that there is a much larger group of CMAR staff in related capability areas whose research contributes to or benefits from biogeochemical studies.

The following Table provides a map of the staff across disciplines, RP & RS, and field / experimental vs modelling. These numbers include 4 new modelling staff approved or proposed for recruitment, as well as 2 postdocs at end of term. The Chemistry RP staff include SE&T Chemistry Support staff.
<table>
<thead>
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<th>Field / Experimental</th>
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Most physical oceanographers have not been mapped into the capability. But the biogeochemistry capability has the advantage of drawing on world-leading and/or world class physical oceanography in the climate and ocean forecasting domains. The biogeochemistry capability is generally at the leading edge in Australia, and much of it is world-class.

The ToR ask for an assessment of the composition and organization of the capability. I argue it can only be assessed, given a purpose. We could assess it as fit to meet current theme requirements. But theme requirements change, and their future needs are subject to high uncertainty. Moreover, the Division is required by CSIRO to deliver world-class or world-leading science. I have therefore taken a two-tier approach.

- Using input from staff, I’ve identified **5 key science areas** related to biogeochemistry, where we can expect **major advances in international science** in the next 5 years.
- I’ve then assessed what **change in capability** would be needed for CMAR to make a **world-class or world-leading contribution** in each of these areas.
- I’ve then used input from Theme Leaders to assess whether planned **investment** is likely to support **critical mass** in each of these areas.

I attach a brief description of each of the five key research areas, along with a summary assessment of our capability, and theme investment prospects, for each one.

Staff in the capability raised substantial generic concerns about our ability to coordinate and maintain sufficient critical mass and integration to deliver substantial contributions against most of these areas. Impediments include:

- Staff and capability are **fragmented** across many small projects;
- Capabilities are **fragmented across sites**, and this tends to lead to duplication;
- Capabilities have been **artificially fragmented across output areas** eg blue water vs coastal. This should be reversible in the matrix, but it’s not clear this is happening.
- We lack a **clear, coherent and shared vision** of what science needs to be done. (Theme leaders also cited this as a problem.)

According to the latest (incomplete) data on staff allocations to projects, staff in the capability are distributed across 14 themes. Themes 2 and 4 in WfO account for just over half of the total capability. Another 6.8 FTEs are mapped into 4 support and infrastructure themes: CMAR Support, Marine National Facility, IMOS and Collections. Another 7 FTEs are mapped across 9 research themes, at levels ranging from 2 down to 0.1 FTEs.
These data indicate a level of under-allocation, but the true level is uncertain, given inaccuracies in the data. My guess is that there is some level of real under-allocation, which could be in the vicinity of 5 to 10%.

Fig. 1. An incomplete (but best available) map of the capability across Themes

Feedback from theme leaders indicated high levels of uncertainty about future needs for the capability, and indeed in many cases high levels of uncertainty about future theme strategic directions, often driven by external earnings. The additional FTEs identified in Theme Leader’s best estimates amount to a net gain of about 17 FTEs. The major current users are forecasting a flat or slightly increasing need. The larger increases come from ET and FF themes, in the research area of intensive production. The other increases are small, 1 to 2 FTEs, and smeared across a number of environmental themes, mostly in the integrated biogeochemistry – ecology area.

A number of themes raised issues about modelling capacity – these should be addressed in the short-term by planned priority recruitments. Given increasing difficulty in recruiting talented experienced modellers, we might consider a more aggressive postdoc program.

A number of themes highlighted the desire to move (in part) from more classical shipborne process studies to automated observing platforms and networks. We need field scientists with the interest and quantitative skills to design and oversee those networks, and interpret and analyse the results. That will require a capability transition (by recruitment or retraining).

I’ve identified more specific capability and CAPEX issues for each of the key science areas in the Attachment. Gaps in specific areas such as microbial and zooplankton ecophysiology are likely to emerge if and when investments in new areas (climate impacts, intensive production) eventuate.
Key infrastructure issues are likely to emerge around observing platforms and supercomputers. Both have the potential to prevent us achieving world-leading or even world-class status in key science areas.

The 49 staff in the capability are distributed across 3 sites, 3 Research Programs, 7 Research Groups and 11+ Teams. A number of the staff are isolated, sitting alone or with one or two support staff in Research Groups. Fragmentation and lack of coordination have hindered our attempts to bring critical mass to bear on strategic research problems. Line management structures are only one factor contributing to that fragmentation. I’m not convinced that changing the line management structure is the answer to these problems. However we rearrange it, we will enhance some links at the expense of others.

Instead I propose that we use strategic science areas of the kind I’ve proposed here as a logical basis for coordinating and planning our science, and for interacting with Theme Leaders. We could implement this by formally identifying these areas, selecting a few senior scientists as a leadership team for each one, and giving them the responsibility of working with other contributing scientists to develop a science plan, engage with Theme Leaders, and oversee project development. They would also ensure that the science in the area is coordinated across participating sites, teams, etc, to avoid duplication and reinvention.

The case for doing this rests on two grounds.
1. We need to take responsibility on the input side for strategic planning and coordination of the science as well as the capability. All of the feedback I’ve had in this review, from both the input and the output side, suggests this is true. The science continues on longer time frames than themes, spans across themes, and theme leaders are looking to the input side for coordinated and strategic science proposals.
2. The people needed to do this strategic science won’t fall neatly into any line management structure. They’ll need to come from across Programs, sites and even divisions. Individuals may be involved in more than one strategic science initiative. This means we can’t force these strategic science areas into line management structures (Research Groups and Teams).

If we accept these arguments, then I think we have to accept that this additional tier is necessary. I don’t think this need necessarily carry a huge additional management cost. I’d argue that this just formalises and empowers science leaders to do what they should be doing anyway, and provides them some structure to do it in. If you were optimistic, you might argue that, by making the rules of engagement a little clearer, we make their job easier.

I think the potential for these strategic science areas to involve staff from more than one division could turn out to be a major strength. It could for example provide a practical mechanism for implementing the strategic collaborations with CLW, CMIS and ICT discussed above.
Summary Assessment of Proposed “Big-S” Science Areas

Operational Coastal and Ocean Biogeochemical Forecasting

Description. The international community plans to extend ocean forecasting capability from eddy-resolving regional models to inshore coastal, and from physics to biogeochemistry (e.g. in the transition from GODEA to CODAE).

CMAR potential. World-class, if not world-leading. We can build on BlueLink 1 and 2. Collaborative opportunities: sensor and sensor network, statistical methods, ocean colour. Modelling capacity adequate. Question observation and supercomputer infrastructure, observational skills.

Theme Investment. Planned investments in WFO Theme 2 and 4 are adequate. Could be enhanced depending on outcome from Theme 2 Due Diligence Study.

Integrating Biomarker, Isotope and Genomic Research

Description. These techniques in combination promise to deliver new insights into ecophysiological processes, both in the field and in the laboratory. They also offer new observing tools and diagnostic indicators.

CMAR Potential. World-class, if we can coordinate and bring critical mass to bear from our existing capacity. We need to select one or two high-profile high-value targets among many diverse applications.

Theme Investment. Likely to be spread over many Themes at low levels per Theme. Imposes further challenges for focus and critical mass. Link to Environmental Genomics?

Integrated biogeochemical and ecosystem models (and observations).

Description. The traditional boundary between biogeochemical and ecosystem models, drawn at the herbivore level, is arbitrary, and its existence is counter-productive for important applications from both sides. There is now a major international IGBP research program, IMBER, with the objective of integrating across this boundary in ocean ecosystems, and LOICZ shares this goal for coastal ecosystems.

CMAR Potential. World-leading, building on our ecosystem modelling. The big challenge is to find clever ways to move across spatial scales. This provides a strong link to the statistical methods needed for Ocean Forecasting.

Theme Investment. Recognised as important, but specific investment may be small and diffuse. Might be best to fold this into a strategic science area built around our ecosystem modelling.

Impacts of Climate Change and Acidification on Marine Ecosystems

Description. The potential impacts of climate change, and especially acidification, on marine ecosystems are now recognized as serious and potentially catastrophic. These are hot international research topics.

CMAR Potential. World-class in the physics and chemistry, with reservations about our observation infrastructure. Strong modelling capability in the biogeochemistry and ecology, but particularly weak in historical observations. Could leap-frog into world-class position with a major investment in modern observing infrastructure.

Theme Investment. Barely adequate investment in Theme 2 for physics and chemistry, with redirection from Southern Ocean carbon cycle feedbacks. Minimal investment (2
FTEs) from CAF. Given the seriousness of this issue, the prospective level of investment across CSIRO is disappointing, to say the least.

**Enhancing Primary Production**

**Description.** The common science challenge is to translate knowledge of biogeochemistry in general, and phytoplankton ecophysiology in particular, into practical tools to help design and manage highly perturbed (eco)systems for organic matter production and composition. This applies across large-scale ocean fertilisation, biofuel from microalgae and intensive aquaculture production.

**CMAR Potential.** World-class, building on experimental, field and modelling strengths. We lack capacity in bacteria, and are thin in zooplankton. Would collaborate for engineering, processing (for biofuel).

**Theme Investment.** Potential for 10 FTEs in 5 years across biofuel, aquaculture. Ocean fertilisation prospects unclear.
Hi Mark, Alan,

The full report is not quite complete, but here's the Exec Summary.

Cheers

John
CMAR Capability Review – Aquatic Biogeochemistry

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- We lack a clear, coherent and shared vision of what science needs to be done. (Theme leaders also cited this as a problem.)

According to the latest (incomplete) data on staff allocations to projects, staff in the capability are distributed across 14 themes. Themes 2 and 4 in WFO account for just over half of the total capability. Another 6.8 FTEs are mapped into 4 support and infrastructure themes: CMAR Support, Marine National Facility, IMOS and Collections. Another 7 FTEs are mapped across 9 research themes, at levels ranging from 2 down to 0.1 FTEs.
These data indicate a level of under-allocation, but the true level is uncertain, given inaccuracies in the data. My guess is that there is some level of real under-allocation, which could be in the vicinity of 5 to 10%.

Fig. 1. An incomplete (but best available) map of the capability across Themes

Feedback from theme leaders indicated high levels of uncertainty about future needs for the capability, and indeed in many cases high levels of uncertainty about future theme strategic directions, often driven by external earnings. The additional FTEs identified in Theme Leader’s best estimates amount to a net gain of about 17 FTEs. The major current users are forecasting a flat or slightly increasing need. The larger increases come from ET and FF themes, in the research area of intensive production. The other increases are small, 1 to 2 FTEs, and smeared across a number of environmental themes, mostly in the integrated biogeochemistry – ecology area.

A number of themes raised issues about modelling capacity – these should be addressed in the short-term by planned priority recruitments. Given increasing difficulty in recruiting talented experienced modellers, we might consider a more aggressive postdoc program.

A number of themes highlighted the desire to move (in part) from more classical shipborne process studies to automated observing platforms and networks. We need field scientists with the interest and quantitative skills to design and oversee those networks, and interpret and analyse the results. That will require a capability transition (by recruitment or retraining).

I’ve identified more specific capability and CAPEX issues for each of the key science areas in the Attachment. Gaps in specific areas such as microbial and zooplankton ecophysiology are likely to emerge if and when investments in new areas (climate impacts, intensive production) eventuate.
Key infrastructure issues are likely to emerge around observing platforms and supercomputers. Both have the potential to prevent us achieving world-leading or even world-class status in key science areas.

The 49 staff in the capability are distributed across 3 sites, 3 Research Programs, 7 Research Groups and 11+ Teams. A number of the staff are isolated, sitting alone or with one or two support staff in Research Groups. Fragmentation and lack of coordination have hindered our attempts to bring critical mass to bear on strategic research problems. Line management structures are only one factor contributing to that fragmentation. I’m not convinced that changing the line management structure is the answer to these problems. However we rearrange it, we will enhance some links at the expense of others.

Instead I propose that we use strategic science areas of the kind I’ve proposed here as a logical basis for coordinating and planning our science, and for interacting with Theme Leaders. We could implement this by formally identifying these areas, selecting a few senior scientists as a leadership team for each one, and giving them the responsibility of working with other contributing scientists to develop a science plan, engage with Theme Leaders, and oversee project development. They would also ensure that the science in the area is coordinated across participating sites, teams, etc, to avoid duplication and reinvention.

The case for doing this rests on two grounds.
1. We need to take responsibility on the input side for strategic planning and coordination of the science as well as the capability. All of the feedback I’ve had in this review, from both the input and the output side, suggests this is true. The science continues on longer time frames than themes, spans across themes, and theme leaders are looking to the input side for coordinated and strategic science proposals.
2. The people needed to do this strategic science won’t fall neatly into any line management structure. They’ll need to come from across Programs, sites and even divisions. Individuals may be involved in more than one strategic science initiative. This means we can’t force these strategic science areas into line management structures (Research Groups and Teams).

If we accept these arguments, then I think we have to accept that this additional tier is necessary. I don’t think this need necessarily carry a huge additional management cost. I’d argue that this just formalises and empowers science leaders to do what they should be doing anyway, and provides them some structure to do it in. If you were optimistic, you might argue that, by making the rules of engagement a little clearer, we make their job easier.

I think the potential for these strategic science areas to involve staff from more than one division could turn out to be a major strength. It could for example provide a practical mechanism for implementing the strategic collaborations with CLW, CMIS and ICT discussed above.
Summary Assessment of Proposed “Big-S” Science Areas

Operational Coastal and Ocean Biogeochemical Forecasting
Description. The international community plans to extend ocean forecasting capability from eddy-resolving regional models to inshore coastal, and from physics to biogeochemistry (e.g. in the transition from GODAE to CODAE).
CMAR potential. World-class, if not world-leading. We can build on BlueLink 1 and 2. Collaborative opportunities: sensor and sensor network, statistical methods, ocean colour. Modelling capacity adequate. Question observation and supercomputer infrastructure, observational skills.
Theme Investment. Planned investments in WFO Theme 2 and 4 are adequate. Could be enhanced depending on outcome from Theme 2 Due Diligence Study.

Integrating Biomarker, Isotope and Genomic Research
Description. These techniques in combination promise to deliver new insights into ecophysiological processes, both in the field and in the laboratory. They also offer new observing tools and diagnostic indicators.
CMAR Potential. World-class, if we can coordinate and bring critical mass to bear from our existing capacity. We need to select one or two high-profile high-value targets among many diverse applications.
Theme Investment. Likely to be spread over many Themes at low levels per Theme. Imposes further challenges for focus and critical mass. Link to Environmental Genomics?

Integrated biogeochemical and ecosystem models (and observations).
Description. The traditional boundary between biogeochemical and ecosystem models, drawn at the herbivore level, is arbitrary, and its existence is counter-productive for important applications from both sides. There is now a major international IGBP research program, IMBER, with the objective of integrating across this boundary in ocean ecosystems, and LOICZ shares this goal for coastal ecosystems.
CMAR Potential. World-leading, building on our ecosystem modelling. The big challenge is to find clever ways to move across spatial scales. This provides a strong link to the statistical methods needed for Ocean Forecasting.
Theme Investment. Recognised as important, but specific investment may be small and diffuse. Might be best to fold this into a strategic science area built around our ecosystem modelling.

Impacts of Climate Change and Acidification on Marine Ecosystems
Description. The potential impacts of climate change, and especially acidification, on marine ecosystems are now recognized as serious and potentially catastrophic. These are hot international research topics.
CMAR Potential. World-class in the physics and chemistry, with reservations about our observation infrastructure. Strong modelling capability in the biogeochemistry and ecology, but particularly weak in historical observations. Could leap-frog into world-class position with a major investment in modern observing infrastructure.
Theme Investment. Barely adequate investment in Theme 2 for physics and chemistry, with redirection from Southern Ocean carbon cycle feedbacks. Minimal investment (2
FTEs) from CAF. Given the seriousness of this issue, the prospective level of investment across CSIRO is disappointing, to say the least.

**Enhancing Primary Production**

**Description.** The common science challenge is to translate knowledge of biogeochemistry in general, and phytoplankton ecophysiology in particular, into practical tools to help design and manage highly perturbed (eco)systems for organic matter production and composition. This applies across large-scale ocean fertilisation, biofuel from microalgae and intensive aquaculture production.

**CMAR Potential.** World-class, building on experimental, field and modelling strengths. We lack capacity in bacteria, and are thin in zooplankton. Would collaborate for engineering, processing (for biofuel).

**Theme Investment.** Potential for 10 FTEs in 5 years across biofuel, aquaculture. Ocean fertilisation prospects unclear.
Hi Rotho

John has asked me to send this to you (from his computer) so I'm hoping that this is the latest version.

Cheers
Anne

For John
MBOPM

Executive Summary

This capability focuses on the study of the cycling, fate and impact of materials (major and minor elements, and pollutants or toxicants) in aquatic ecosystems (typically focused on lower trophic levels), ranging from estuarine to coastal and oceanic waters.

It is by necessity multi-disciplinary, integrating across the classical disciplines of physical, chemical and biological oceanography. Within each of these disciplines, it embraces field observations, laboratory and field process studies, and modelling. Staff in this capability work closely with a number of other CMAR capabilities – most notably MSEEM, SOPM and CESM, and with freshwater and estuarine biogeochemists and hydro-dynamicists in CIW.

From January 2009, all CMAR staff with a primary focus in this domain will be grouped within the MBOPM core capability – ensuring that we optimize the synergies of working from estuaries to oceans and local to global scales. We recognize that for the potential of this group to be realized, significant investment in research infrastructure (super-computing, sensors and sensor networks)

For this capability to maintain and grow its international reputation it needs to work with output domains to focus efforts on a few major areas. We have reviewed areas for which exciting opportunities exist over the next decade and believe the most prospective (given existing capability mix, national priorities and international trends) are in the areas of:

- Operational Coastal and Ocean Biogeochemical Forecasting
- Integrating Biomarker, Isotope and Genomic Research
- Integrated biogeochemical and ecosystem models (and observations).
- Impacts of Climate Change and Acidification on Marine Ecosystems
- Enhancing Primary Production

Some of these are already foci (or project areas) for Flagship themes, others are yet to be developed. Unless there is significant growth in resourcing for this area, we believe that only 2-3 of these areas should be pursued, as the current fractionation of biogeochemical research across 14 Themes (11 of which use <2 FTE of MBOPM capability) works against the impact of the science and the capability.

CMAR analysis of capability strengths and weaknesses has lead to XX recent priority hires in MBOPM in 2008. Following this recruitment, we see little likelihood for further growth over the next 3 years. Resizing of the capability in out-years will depend on uptake of some of the potential science growth areas, and we plan to work closely with Output Leaders to influence investment into these science areas.

While growth is not supported, there is a need to reshape the MBOPM capability over the next 3 years, through building up some components and downsizing others. The marine environmental genomics area requires senior leadership to guide development
of this area and its integration into the broader environmental and climate science undertaken by CMAR staff.

National and international trends (towards the use of automated sensor networks and platforms), also suggests that we will have an increasing need for field scientists who can support a strong shift towards automated and remote field measurements. Our current observational capability lacks the skills to support this shift in emphasis and we will move to overcome this shortcoming. The need is not necessarily for scientists to be involved in sensor development. Rather, it is for people who understand and know the systems being observed, and the nature and limitations of the sensors used to observe them. They are also quantitative scientists who are capable of analysing and interpreting the observations, and build international reputations around those interpretations. They will understand numerical models, and work hand-in-hand with modellers, but building and running numerical models is not their primary role.

1. Description of the Core Capability and its science base

Core Capability: Marine Biogeochemical Observations, Processes and Modelling (MBOPM)

Components: Ocean carbon fluxes and cycles, Oceanic Biogeochemical modelling, Coastal Modelling, Organic Geochemistry, Phytoplankton Eco-Physiology, Environmental Genomics, Micronutrients and macronutrients.

Skill base for Capability Area: TBA????????????????

Related Capabilities in CMAR: MSEEM, SOPM, CSEM

Number of staff as of 1 July 2008: TBA?????????????????

Number of staff x Site: TBA?????????????

What is the unifying/core science focus for staff in this Core Capability

MBOPM focuses on the study of the cycling, fate and impact of materials (major and minor elements, and pollutants or toxicants) in aquatic ecosystems (typically focused on lower trophic levels).

It is by necessity multi-disciplinary, and in the marine domain, it effectively integrates across the classical disciplines of physical, chemical and biological oceanography. Within each of these disciplines, it embraces field observations, laboratory and field process studies, and modelling.

In 2008, as has been the case for a number of years, the capability is spread (in many cases thinly) across a wide number of portfolios and thematic areas in CSIRO. Arguably, the fractionated deployment of MBOPM capability across so many projects and themes hinders CSIRO’s contributions to understanding of the biogeochemical components of Australian oceanic, coastal and aquatic systems. Thus, a key strategic goal for CMAR/MBOPM is to influence CSIRO output portfolio priorities in the
broad area of marine biogeochemistry. We believe this us best achieved through clear articulation of where the capability is most effectively focussed to increase the impact of output portfolios such as the WFO, CAF and WHC Flagships, as well as CMAR’s own Climate and Atmosphere theme.

What are likely to be the major trends in science in this capability over the next 3, 6, 12 years?

Having analysed international trends and the current skill mix and science applications of the capability group, Parslow (2008) identified five major science areas where CSIRO might focus its capability in order to contribute significantly to international advances in marine biogeochemistry over the next 5 to 10 years:

a) Operational Coastal and Ocean Biogeochemical Forecasting
The international community plans to extend ocean forecasting capability from eddy-resolving regional models to inshore coastal, and from physics to biogeochemistry (e.g. in the transition from GODAE to CODAE).

b) Integrating Biomarker, Isotope and Genomic Research
These techniques in combination promise to deliver new insights into ecophysiological processes, both in the field and in the laboratory. They also offer new observing tools and diagnostic indicators.

c) Integrated biogeochemical and ecosystem models (and observations).
The traditional boundary between biogeochemical and ecosystem models, drawn at the herbivore level, is arbitrary, and its existence is counter-productive for important applications from both sides. There is now a major international IGBC research program, IMBER, with the objective of integrating across this boundary in ocean ecosystems, and LOICZ shares this goal for coastal ecosystems. The opportunity for integration of the CMAR’s MBOPM capability with our leading edge ecosystem and earth system modelling capabilities is exciting and provides a compelling vision for science and capability development over the next 10 years.

d) Impacts of Climate Change and Acidification on Marine Ecosystems
The potential impacts of climate change, and acidification, on marine ecosystems are now recognized as serious and potentially catastrophic. These are hot international research topics, with great relevance to Australia’s marine systems.

e) Enhancing Primary Production
The science challenge is to translate knowledge of biogeochemistry in general, and phytoplankton ecophysiology in particular, into practical tools to help design and manage highly perturbed (eco)systems for organic matter production and decomposition. This applies across large-scale ocean fertilisation, biofuel from microalgae and intensive aquaculture production.

How well could CMAR/CSIRO tackle these challenges with existing capability/capacity? SWOT analysis.

Clearly each of these areas involve major (and difficult) science challenges, and as with many of our science fields, we may/will need to consider how many CSIRO
wants to tackle, and importantly how we might best partner with others (nationally and internationally) to achieve the quality and depth of science required. In developing a strategic plan for the MBOPM we have considered how well CMAR is currently placed from a capability/capacity perspective to work effectively on these challenges. A summary of these considerations is provided below, with detailed results of workshops and interviews with key players provided in Appendix 1.

Physics
CMAR’s ocean and coastal physical science capability is particularly strong. Only a small proportion of CMAR’s capability in physical oceanography is mapped formally into the MBOPM capability, but it’s worth looking briefly at the broader physical capability, because it plays such an important underpinning role for biogeochemical science. At ocean basin scales, CMAR has world-leading and/or world-class strength in physical oceanographic observations. We are world leaders in Southern Ocean studies, and play a regional lead role in studies of the Indian Ocean and Indonesian Throughflow, and the Tasman and Coral Seas. We play a well-recognised role in the international ARGO program, and in the science of altimetry. We have played a long-term leading role in maintaining Regional Ocean Observations through ships of opportunity.

We have a long history of oceanographic field studies at continental shelf scales, including the major boundary currents around Australia. Most recently, we have played a lead role in forming a national partnership to successfully bid for NCRIS funding for an Australian Integrated Marine Observing System (IMOS). A substantial fraction of that investment is going towards enhancing our observations of Australia’s continental shelves and boundary currents, and their interactions with basin scale circulation.

Our physical modelling capability at ocean basin scales is also particularly strong. The CSIRO-BoM partnership CAWCR maintains an international reputation as one of a small number of credible producers of global coupled ocean-atmosphere climate models for IPCC scenarios and for studies of climate variability. We are valued partners in the development of the MOM community ocean model. Over the last 5 years, the BlueLink program has given us world-class ranking in the development of eddy-resolving, data-assimilating ocean forecasting models. The BlueLink modelling system is in itself a critically important platform for biogeochemical studies around Australia.

Our coastal physical oceanographic capability has been through something of a dip (at least in terms of numbers) over the last decade. Nonetheless, we have through this period developed a very strong and sophisticated coastal modelling suite, which has been adopted by other partners in Australia. Our coastal physical modelling capability has been recently enhanced through improved integration between offshore and inshore, primarily as a result of BlueLink extending its operational forecasting capability inshore. This has seen the development of the relocatable, local atmosphere-ocean modelling system ROAM, and plans for a national high-resolution continental shelf model (Ribbon model). It has also seen our modellers assisting in the implementation of coastal processes into the MOM community model. The BlueLink data-assimilation scheme (BODAS) has just been implemented in our coastal circulation models.
We have maintained a small but effective effort in sediment modelling, primarily to address the role of turbidity in biogeochemical systems. BlueLink is driving an expansion in our capability in wave observations and modelling, and wave-current interactions, especially in near-shore areas, and this is likely to be extended to coastal geomorphology.

We have few dedicated observational scientists in coastal physical oceanography. Our coastal modellers have experience in making and interpreting field measurements. Moreover, the support group in CMAR provides extremely strong expertise in maintenance and deployment of instruments and sensors, in mooring design, and in advanced platforms such as ARGO, across blue water and coastal scales. CMAR has a large and growing pool of oceanographic instruments, and access to others through national (IMOS) and international collaboration.

The bottom line here is that CMAR has the capability to implement state-of-the-art circulation models, supported by state-of-the-art observations, at scales ranging from ocean basin to estuaries. CMAR (with BoM) is seen in international circles as being at the forefront of attempts to develop a seamless nested ocean forecasting capability across these scales.

**Chemistry and Biology**

CMAR has a strong observational capability in chemical oceanography at both ocean basin and coastal scales. We have an internationally recognised ability to make high precision measurements of inorganic carbon parameters, and have made an important contribution to knowledge of these fields in the oceans around Australia, especially in the Southern Ocean. This capability should play an important role in monitoring and understanding regional variation in ocean acidification and carbonate saturation. We have internationally recognised expertise in measurements of vertical fluxes of sedimenting material, and have maintained an important time series of sediment traps for the Southern Ocean. We have a long history of ultra-clean sample collection and analysis at sea, and with the recent acquisition of ICP-MS facilities, capacity to make an important contribution to knowledge of regional micronutrient distributions. We support routine hydrochemistry through the national facility, and have the ability to measure very low (nM) levels of micronutrients in oligotrophic mixed layers.

CMAR has a strong capability in organic chemistry, and specifically in the identification and measurement of biomarkers, including pigments and lipids. There is the potential to link this to our capability in natural isotope measurement, to provide a powerful tool for source discrimination and historical reconstruction, as discussed above. These techniques are used in paleo-oceanography, but have recently been applied mostly in studies of the sources, cycling and fate of organic matter and nutrients in coastal marine systems, and in estuaries, rivers and floodplains. CMAR has some capability and experience in measuring exchanges of dissolved material across the water-sediment interface, both in situ and in cores in the laboratory. Our trace metal capability has been used to understand cycling of metals as both micronutrients and pollutants in coastal waters and sediments.

CMAR has particular expertise in phytoplankton ecology and physiology, with strong links into the international community, especially around the study of Harmful Algal
Bloom. This expertise is supported by an internationally recognised algal collection, and culturing facilities. We've made an important contribution to measurements of primary production, especially in the open ocean, including the use of new techniques such as fast-repetition rate fluorometry. We have the leading national laboratory for measurements of phytoplankton pigments and bio-optical properties. We have expertise in phytoplankton taxonomy, and access to flow cytometers to efficiently count and sort field and laboratory samples. As noted earlier, our expertise in phytoplankton physiology and composition has been heavily directed towards aquaculture production over the last 10 years, and is now being directed towards biofuel production. Laboratory phytoplankton experiments have also been directed towards the autecology and physiology of species of environmental significance, especially toxic or harmful bloom species.

By comparison, our capability in zooplankton, bacteria and benthic primary producers is limited, being restricted to one or two scientists in each case. This is augmented by one or two additional scientists studying zooplankton along with micro-phytoplankton as part of fisheries ecology and trophodynamics. CMAR is building core capability (field studies and modelling) of the role of benthic biota and processes in coastal and shelf biogeochemical cycles through the WAMSI NODE 1 project in SW WA.

CMAR is also building capability in the field of environmental genomics, and its application to biogeochemical processes. We see this as an essential future direction for both the characterization of oceanic/coastal communities and ecosystems and in the understanding of system dynamics.

Most of our capability in biological oceanography is currently deployed in the coastal domain. At both coastal and ocean scales, modern biological oceanographic field studies require a large team with a diverse mix of specialist skills and experience. We have relied heavily on collaboration with other agencies (Australian and international) in conducting major multi-disciplinary field programs and experiments, both in the open ocean (such as the Fe fertilization experiment SOIFEE in the Southern Ocean), and in coastal studies. CMAR has a good record of collaboration with CLW biogeochemistry capability (field and modelling) in estuaries and in rivers.

Biogeochemical Modelling
CMAR has a world-class biogeochemical modelling capability. Our “blue-water” modellers have implemented ocean carbon cycles within global coupled climate models, and used these to investigate global climate feedbacks and impacts. These models are represented in international intercomparison experiments and in IPCC reports, and will be further developed through ACCESS.

The coastal modelling community is not so international in character, but our modellers are well recognized internationally, and our models compare well with the international state-of-the-art. Our coastal biogeochemical models have been at the forefront in benthic-pelagic coupling, in incorporating multiple functional groups, and in coupling to 3-D hydrodynamic models. Our coastal modelling has also had a strong applied flavour, so the group has a lot of experience in the formulation of management scenarios, and the analysis and visualisation of model output to support decision-making. The group has had strong software support, and pioneered web-based applications for model visualisation and delivery.
Biogeochemical models tend to integrate physical, chemical and biological processes, so we don’t usually distinguish “chemical” from “biological” modellers. We do lack experience in models which deal with specialized chemical processes (e.g. with speciation and equilibria for complex mixtures of trace metals).

CMAR is just beginning to develop its capability in data assimilation and model-data fusion for biogeochemistry. In doing this, we are drawing on the strong experience in data assimilation in physical models gained through BlueLink, but also on increased collaboration with CMIS.

As discussed above, CMAR’s biogeochemical modellers enjoy the benefits of a very strong underpinning physical modelling capability, but they also have the opportunity to support and interact with a world-leading ecosystem modelling capability, in the form of the Atlantis and In Vitro modelling suites. We would expect the biogeochemical and ecosystem models to become more closely integrated over time.

Taking these strengths and weaknesses into account, our evaluation of CMAR’s potential to address the five major challenges is as follows:

a) Operational Coastal and Ocean Biogeochemical Forecasting
World-class, if not world-leading. We can build on BlueLink 1 and 2. Collaborative opportunities exist across CSIRO in sensor and sensor network, statistical methods, ocean colour interpretation. Modelling capacity adequate. There is some question as to whether our observational and supercomputer infrastructure is sufficient.

b) Integrating Biomarker, Isotope and Genomic Research
World-class, if we can co-ordinate and bring critical mass to bear from our existing capacity. There is a need to select one or two high-profile high-value targets among many diverse applications, and depending on which are chosen there may be a need to recruit senior capability and build infrastructure around specific science areas.

c) Integrated biogeochemical and ecosystem models (and observations).
World-class, if we can coordinate and bring critical mass to bear from our existing capacity. Once again, to be world-class, we will need to select one or two high-profile high-value targets among many diverse applications.

d) Impacts of Climate Change and Acidification on Marine Ecosystems
World-class in the physics and chemistry; gaps in observation infrastructure; strong modelling capability in the biogeochemistry and ecology, but particularly weak in historical observations. Could leap-frog into world-class position with a major investment in modern observing infrastructure.

e) Enhancing Primary Production
World-class, building on experimental, field and modelling strengths. We lack capacity in bacterial ecology/physiology, and thin line zooplankton. Opportunities in large-scale culturing and production would require collaborations in engineering, processing (for biofuel).
In summary, the MBOPM “science opportunity” is great and our capability is strong in many areas. However, there are critical gaps in technology/infrastructure and in some capability areas. As we describe below, we are also significantly overstretched (i.e. lack capacity) in other, existing capability areas (see below).

The right size and right shape for this core capability over the next 10 years will largely be determined by CSIRO portfolio choices of major science foci, but we’d argue that the best strategy for portfolio leaders will be to focus on/invest meaningfully in advancing a few major science areas, rather than spreading MBOPM capability thinly/sub-optimally across a large number of projects and portfolios.

[By comparison with other Proformae this section is very long. From a SWOT perspective it’s long on Strengths and Opportunities, thin on Weaknesses and doesn’t mention Threats at all.]

2. Analyses of Current and Future Capability Deployment across CSIRO’s portfolios

Where is the Capability Area currently deployed?

SIP3 (September 2008) staff allocations to projects show staff in the capability are distributed across 14 Themes (Figure 1). Themes 2 and 4 in WfO account for just over half of the total capability. Another 6.8 FTEs are mapped into 4 support and infrastructure Themes: CMAR Support, Marine National Facility, IMOS and Collections. Another 7 FTEs are mapped across 9 research Themes, at levels ranging from 2 down to 0.1 FTEs.

![Figure 1. Staff allocation by Theme, based on preliminary project data under SIP3.](image_url)

What is its likely future deployment over the current 3 year SIP cycle?
Views on the future deployment of this capability have been collected through stakeholder workshops, a questionnaire and discussions with theme leaders in CMAR and the WfO, WHC, and FF flagships. As one might expect with an annual SIP cycle, ET-initiated reviews of portfolios (in WfO a review of SAFE, MCBM and Marine Nation is currently under way) and a lack of clarity around the “home” of coastal research in CSIRO, these projections of future needs/deployment of MBOPM capability are somewhat uncertain.

WfO

Three of the WfO themes – Marine Nation, SAFE and Marine Conservation and Biodiversity Management – are currently being externally review following questions from the CSIRO Executive Team Science Sub Committee on their points of differentiation and focus. The review is considering future directions for these Themes and their relationships with other WfO themes. Early indications from this review suggest a likely refocussing of the Theme portfolios away from individual client/sectoral interests and towards agreed major national/international science goals/challenges. Clarity around this reshaping of the portfolios will develop over the latter months of 2008, and we’d expect the division to be heavily engaged in discussions about the science directions and capability requirements. Based on pre-review discussions, our understanding of MBOPM future deployments is as follows:

**Marine Nation (currently 13 FTEs)**

The Theme hopes to grow through increasing external income. However, it attaches higher priority to growth in some other areas (e.g. socioeconomics) than to biogeochemistry. It expects to maintain the current effort level in biogeochemistry, but hopes to reshape that capability to meet priority needs. The Theme sees a particularly strong need for models and observing systems which can be rapidly deployed to meet management needs, and subsequently be refined over time. This requires an improved capacity to quantify model uncertainty and error. The Theme sees a potential shortfall in modelling capacity short term, if current client engagement succeeds. [This should be addressed by CMAR’s priority recruitment plans.] The Theme would like to see better integration between biogeochemical and ecosystem models.

The Theme is currently making major strategic investments in capability development, in field process studies such as WAMSI Node 1, in sensor networks and in models. The Theme will continue some level of investment in process studies, but this will need to be sharply focused. It does not see a future in large regional ecosystem studies, unless these are focused on Theme priorities and goals.

The Theme would encourage more collaboration with CLW on coupled catchment-to-coast models and observing networks, with ICT on sensor networks and AUVs, and with CMIS on error analysis.

The theme sees climate change as an important driver, but is unlikely to have the capacity to support a major marine climate impacts research program. The theme leader indicated that Marine Nation might take on ocean fertilisation as a research area in the future.

**SAFE and MCBM— (0.1 FTEs).**

**MBOPM**
These themes currently use a negligible amount of CMAR's biogeochemical capability. Both see room for an increase to small amounts – 1 to 2 FTEs each. In the case of SAFE, the need is for better integration of biogeochemistry into ecosystem models used for ecosystem-based fisheries management. In the case of MCBM, biogeochemistry is seen as providing information about processes supporting and/or threatening biodiversity. There is potential to use biogeochemistry to support productivity estimates in the pelagic domain, and rapid assessment of biodiversity in tropical environments.

**Ocean Dynamics (13 FTEs)**

The Theme is not expecting major growth, and expects that its appropriation and external funding envelopes, and total FTEs, will remain fairly flat. That said, the theme is conducting a due diligence project aimed at evaluating the potential for development of a new Coastal Assessment and Prediction system. If this study provides a favourable assessment, one might expect new appropriation investment in the biogeochemical modelling area in the SIP4 round.

In the absence of new SIP4 funding, the Theme expects its investment in biogeochemistry to increase slightly. It has negotiated with CMAR to absorb one additional biogeochemical modeller in SIP3. The Theme's biogeochemistry is undergoing a shift in emphasis from studies of carbon cycle feedbacks to attribution of changes in marine systems due to climate and acidification. It expects that trend to continue, although there is currently considerable uncertainty around the future priorities in ACCSP, and any successor to the ACE CRC. The Theme is encountering some difficulty in developing a strategic approach to marine climate impacts within the current CSIRO climate structure.

The Theme expects BlueLink 3 to include ocean biogeochemical forecasting, and that could be augmented by coastal forecasting, depending on the outcome of the Due Diligence Study.

The Theme currently has a heavy commitment to biogeochemical observations and process studies, and a relatively small investment in modelling. It is looking to increase its investment in modelling, but also direct more of its field effort towards automated and remote observations, to support both climate attribution and ocean forecasting. The Theme sees potential infrastructure constraints in supercomputing and automated observing platforms and sensors.

**WfHC**

*Healthy Water Ecosystems (HWE) and Better Basin Futures (BBF) (Total 2.8 FTEs)*

WfHC is currently using 2.8 CMAR FTEs, both field and modelling, to support studies of estuarine and freshwater aquatic systems. This work is expected to be consolidated into HWE, with the movement of the Tropical Rivers and Coastal Knowledge (TRACK) projects into HWE later this year.
changes in the use of CMAR’s FTEs will essentially depend on shifts in biological capability in regional case studies. He sees an ongoing need for access to the biomarker and isotope skills, and to hydrodynamic and biogeochemical modelling. Hydrodynamic modelling capability is currently a constraint across CLW and CMAR, and CMAR is addressing this in its current priority appointments. He would like to access CMAR’s aquatic ecosystem modelling capability as well.

He has a strategic interest, shared with WfO Theme 4, in the development of coupled catchment-to-coast models. [A workshop on this is planned for early November, with participants from both Divisions and both Flagships].

**Petascale Computational and Simulation Science Platform – John Taylor (1.6 FTEs)**

This platform incorporates the old Terabyte Science Theme. It supports a strategic CMIS-CMAR project on development of Bayesian hierarchical approaches to error estimation and analysis in biogeochemical models. It is also keen to support development of scalable model codes which run on massively parallel supercomputers. Biogeochemical modelling has been chosen as a demonstration case study for its strategic goals.

Capacity has been an issue here, as CMAR has struggled to recruit a postdoc funded from this project. The Platform could potentially fund another person with suitable modelling and computational skills.

Although the total effort is small, this project has facilitated collaboration with CMIS in a key strategic area for biogeochemical modelling.

**Climate Adaptation Flagship – (0.2 FTEs).**

At present, the flagship uses just 0.2 FTEs of CMAR’s capability, in the Ecosystems Theme. There appears to be some potential to grow that, but probably only to about 2 FTEs.

Like SAFE, CAF is interested primarily in coupled biogeochemical-ecosystem modelling. The first priority is in the area of climate impacts on estuarine and coastal ecosystems. There are discussions underway with SAFE about a SE Australian initiative. There are other projects under development in SE Qld / Moreton Bay. There is little prospect of CAF investing in climate impacts research for open ocean ecosystems.

CAF sees potential for more integration of the coastal storm surge / inundation / erosion modelling with biogeochemistry and ecology. (It should be possible to do this through BlueLink and ROAM.)

CAF also sees the need for better catchment to coast integration in dealing with climate impacts, and sees this as a joint task for WfHC, WfO, CAF. The GBR might provide an opportunity for an integrated project across all flagships.

**Energy Transformed Flagship,**
CMAR is currently developing a project in this theme in the area of biofuel from microalgae. The Theme Leader is quite bullish on the prospects for this area, and sees it as one of the key medium- to long-range contenders for a serious contribution to biofuel. He thinks the Theme could see up to 20 FTEs invested in this area after 5 years, across biogeochemistry, engineering and processing, with 30% or more coming from CMAR biogeochemistry. He notes strong interest in co-investment from the private sector. Co-production of fuel with other products (feedstock, industrial or pharmaceuticals) is likely to be important.

The Theme Leader sees the key challenge and requirement from CMAR’s biogeochemistry as capacity to inform the design of large-scale production systems which control the growth environment to deliver high output of constant composition. Modelling and automated observations will have an important part to play. He sees genetic modification as potentially important, but likely following the mass production challenge.

**CMAR**

Climate and Atmosphere (C&A) Theme (0.6 FTEs)

The C&A Theme is using 0.6 FTEs to put the marine carbon cycle into global models in ACCESS. This has the potential to grow this by about 1 FTE or higher if the ocean carbon cycle assumed higher priority (e.g. if evidence of anomalies in ocean uptake appears).

The Theme will continue to focus on global coupled carbon model at coarse resolution over the next 5 years. This is limited by supercomputer capacity. The Theme will look for synergies with WFO eddy-resolving biogeochemical modelling. In the long run, ACCESS is seen as a cross-scale cross-theme modelling platform.

The potential for more synergies across atmospheric, terrestrial and marine biogeochemistry are likely to become apparent as we study the interactions in the coupled global models.

**Food Futures**

Breed Engineering (0.4 FTEs)

A possible growing focus on intensive production systems in aquaculture may drive increased need for MBOPM capability. The Theme expects to start with 1 postdoc at Cleveland, potentially growing to 3 FTEs at 5 years.

**Conclusions**

There is clearly considerable uncertainty in virtually all Themes about the direction of their science, and the quantity and composition of the skills required to deliver it, on a 5 year time scale. This is perhaps to be expected—Themes operate in a dynamic external and internal funding environment, and are supposed to respond nimbly to that environment. However, in looking across the CMAR capability areas, this lack of clarity on future directions for MBOPM science seems greater than for many other

**MBOPM**
areas. The challenge for capability leaders is to plan and manage capability in the long term through those fluctuations and uncertainties.

If we added up all the additional FTEs identified in Theme Leader responses, we get a net gain of about 17 FTEs. It would be very optimistic to think these would all materialise. It might be more realistic to suppose we might realise half that number, an increase of around 8 or 9 FTEs. Out of the total, major contributors include ET and FF flagships, in the research area of intensive production. The other increases are spread across a number of environmental themes, mostly in the integrated biogeochemistry-ecology area.

The discussion above seemed very heavy on the 1 year outlook not even out to 3 year, with the exception of ET and to a lesser extent FF. There should now be a sub-section here about the 3 to 6 and longer (2020) portfolio science directions. All Proforma have struggled here but have a go – Get on your crystal all gazing glasses.

3. Analysis of the current and future size and shape of the Capability Area?

At times this long section gets close to being a Workforce Plan, not a Strat Cap Plan.

Given the uncertainty about output Portfolio Theme science future growth scenarios (reviews, dependencies for capability pull on successful completions of existing science projects, external earnings etc.) in projecting the future MBOPM capability needs we have returned to the major prospective science areas of the previous section, and asked which of these we can expect to be sustainable given Theme plans.

Operational Coastal and Ocean Biogeochemical Forecasting already attracts strong strategic support in WIO Dynamic Ocean and Marine Nation Themes, and some support from the Petascale Platform. It fits the priority need in Marine Nation for readily implemented models (at least with a flexible interpretation), and could grow substantially in Dynamic Ocean, depending on the current Due Diligence Study. But this area is likely to be supported at critical mass regardless of the outcome of the Due Diligence Study.

There is clearly a strong demand for Integrated biogeochemical and ecosystem models and observations, across the environmental Themes. It could be a challenge to co-ordinate this and deliver critical mass targeted at strategic science goals, given that this demand is spread thin, and individual Themes may have tactical requirements. Our assessment of the way forward is to let the ecosystem modelling, which is attracting strong demand and strategic investment in its own right, drive this science area, and ensure key biogeochemical capability is available to engage. This approach acknowledges there may be a decreased draw on observational capability in this area.
If the medium- to long-term “possibilities” around biofuels and aquaculture production become reality, CMAR would need to grow capability in the Enhancing Primary Production research area to critical mass (e.g. around 10 FTES). While WFO themes are hesitant to commit at this stage to investment in ocean fertilization research, they are not ruling it out. If this area became a focus following the WFO Theme reviews, this research area will grow beyond critical mass.

While there is likely sufficient investment in WFO Theme 2 to support Impacts of Climate Change and Acidification on Marine Ecosystems, and potentially some additional support from CAF and/or SAFE, we think there is cause for concern about the overall level of investment in this area, given the potential extent of the problem. We’re particularly concerned that the proposed investment seems unlikely to support an adequate observation program. To put it bluntly, it appears that the economic and social value attached to our marine ecosystems is sufficiently low, at least compared with coastal infrastructure (for example), that as a nation we’re prepared to let impacts of climate change and acidification on our marine ecosystems proceeds on an out-of-sight, out-of-mind basis, except perhaps in some iconic systems like the GBR. That seems to be an almost: inevitable consequence of the way research priorities are being set nationally and within CSIRO. There may be opportunities to change this situation, through IMOS and successors to the ACE CRC, but it will require leadership.

Although most Themes seem prepared to support the Integrating Biomarker, Isotope and Genomic Research science area, the level of investment in each Theme is low. This will make it especially challenging to maintain the strategic focus needed to achieve world-class results. CMAR believe there is an opportunity to focus more seriously on marine environmental genomics. Based on input from international reviewers at the WFO Three Theme Review, the opportunity may even be a necessity if we are to keep pace with international efforts in understanding the roles of microbes in the marine environment. Clearly this is an area where CMAR as a capability home with views on the future directions of marine science needs to work closely with Portfolio Leaders to establish the required level of support for this area of science.

Conclusions
Given recent priority hires and lack of clarity about further growth potential for this capability, MBOPM will not be targeted for growth over the next 3 years, beyond the priority appointments already committed. Growth in the out-years will depend on uptake of some of the potential science growth areas, and we plan to work closely with Output Leaders to influence investment into these science areas.

There is a need to reshape the MBOPM capability over the next 3 years, through building up some components and downsizing others.

Modelling – statistical capability
In response to strong calls from Output Portfolio Leaders, we have increased the MBOPM hydrodynamic and biogeochemical modelling capacity (including programming support) by 22 FTES in 2008. This is seen as sufficient for the work anticipated over the next few years. However, the potential loss of senior leadership in this area makes development and/or recruitment of potential leaders in this component of the MBOPM capability a high priority.
We recognize the need to continue to strengthen the statistics in our biogeochemical modelling. This may be possible through our relationship with CMIS, but this will require explicit conversations to avoid unmet expectations/needs. If CMIS chooses not to deploy their capability in this area, we may need to examine this a priority recruitment area.

**Environmental Genomics**

The inclusion of environmental genomics capability within MBOPM is intended to provide impetus for development of critical mass in this area over the next 5 to 3 years. To fast track development of a compelling science proposition for output portfolio leaders in WiO and WhHC, we will recruit a senior leader to work with our existing research scientists.

**Observational/Field capability (across physics, chemistry and biology)**

Our analysis of national and CSIRO environmental theme requirements and international trends (towards the use of automated sensor networks and platforms), suggests that we will have an increasing need for field scientists who can support a strong shift towards automated and remote field measurements.

Our current observational capability lacks the skills to support that move. The need is not necessarily for scientists to be involved in sensor development. Rather, it is for people who understand and know the systems being observed, and the nature and limitations of the sensors used to observe them. They are also quantitative scientists who are capable of analysing and interpreting the observations, and build international reputations around those interpretations. They will understand numerical models, and work hand-in-hand with modellers, but building and running numerical models is not their primary role.

We have excellent role models among our physical oceanographers, but lack those people in the chemical and biological domains. We are consequently struggling to find people to scientifically direct and exploit aspects of IMOS, or to sit alongside and collaborate with the technologists involved in sensor and sensor network development. Similarly, we have failed to exploit ocean colour data to anywhere near the extent we might have expected 10 years ago. It's worth noting that people with these skills are often capable of working across disciplines.

Most of the environmental themes are looking to reduce their investment in classical ship-based process studies, and increase their investment on observing networks. We will need to make a corresponding transition in the kind of capability we provide. That may be achieved by retraining, or may require recruitment. Given the critical role SE&T plays in supporting our field observations, we probably need to look hard at the capability mix in our support as well research groups in terms of our ability to support new observing systems.

We note that CMAR currently lacks expertise in the ecophysiology of bacteria and zooplankton – capability that is associated with research domains such as intensive production and marine climate impacts which are currently potential growth areas.

Our judgement is that in the next three years we will seek to partner with other agencies and universities where this capability is required, rather than recruit and
extend our capability base. Subject to internal investment in these areas over this period, this decision will be reviewed at the end of the three years.

4. Key Internal (One-CSIRO) Relationships: dependencies/partnerships/brief SWOT

- **Divisions** - CLW and CMAR aquatic biogeochemists have worked together on a number of projects over the last decade, principally in estuarine and coastal systems. CLW also has a strong coastal remote sensing capability with whom CMAR biogeochemists and remote sensing researchers have collaborated. Given recent retirements in this capability area in both CLW and CMAR, the leadership of the two divisions have agreed to work together in the development and shaping of this shared capability area.

CMIS also have relevant expertise in environmental modelling and remote sensing. CMAR has recently developed a collaborative relationship with CMIS through their XXXXX Theme.

- **Flagships** - WFO is likely to remain the most important output portfolio for this capability. The flagship is currently working with clients to evaluate the possibility of a Bluering III collaboration, and is also undertaking a due diligence study on the prospects for a significant investment in a national coastal modelling framework.

- Platforms - current, future ideas

5. Key External Relationships: Dependencies/partnerships and collaborations/competition/brief SWOT

- Other R&D providers (Unis and Publicly Funded Research Agencies)
- Federal, state and local government clients
- Industry clients and stakeholders
- International linkages
- Funding agencies

6. Infrastructure needs

Supercomputing remains a vexed issue for CSIRO. While we may have agreed on an upgrade for the joint BoM-CSIRO facility, the fact remains that CSIRO and Australia are not anywhere near the forefront in terms of global supercomputing. That’s an issue, if we’re serious about world-class research. The situation is considerably worse for research groups operating at the next level down. The Petascale Platform is at least bringing a computation/simulation science perspective to the table, but it remains to be seen whether there’s a mechanism to get the investment needed.

The other major infrastructure issue is investment in observing platforms and instruments. Initiatives such as the sensor cluster may result in low-cost sensors
somewhere down the track, but for the next 5 years, and perhaps the next 10, most sensors will continue to be very expensive. If we want to conduct world-class research to demonstrate sensor networks and data-assimilating models, we will need to make investments at scales comparable to those being made in world-leading studies overseas. That may require an order of magnitude increase over current investment levels. That could be affordable in principle (it’s well within the IMOS budget), but it would require a more geographically focused deployment than IMOS has achieved to date.

If we want to stay world-class in our existing science areas, there will be a need to maintain and upgrade the wide variety of existing laboratory and field equipment. There are some CAPEX gaps which are more specific to particular problems. For example, if research into intensive production proceeds, we’ll need to consider how to access mesocosm and pilot plant facilities.

Database, programming and visualisation needs – hardware, software and human resources

2. Workforce Planning [NB to be undertaken post-retreat, from information provided above]
   - Changes in size and shape of skill base – Staff retention, Recruitment, retraining, redundancy projections
   - Annual implementation of Section 3 above at Research Group; team and individual levels
   - 1-3, 3-6, 6-9, 9-12 time horizons (increasing granularity)
   - Leadership
   - Career Planning
   - Staff Development (Learning and Development budgets, project budgets and Capability Development Fund).
Hi Alan and Rotho

I’ve found this on this computer - but I don’t think he has had any conversations to anyone about it.

I’ll probably be in trouble for sending it but what the heck it’s Friday - live dangerously.

Cheers

Anne
### CMAR and CAWCR Core Capabilities and Components


| | Fisheries stock assessment | Habitat and ecosystem characterisation & modelling | Fisheries MSE | Multiple use management MSE | Ecosystem & trophic modelling | Risk assessment | Environmental Genomics | Micro & Macro nutrients | Satellite remote sensing | Model evaluation | Micrometeorology | Observing system technologies

| | | | | | | | | | Data management, programming and visualisation* | Leadership

* This is included as a platform capability for CMAR, in recognition that the same skills are distributed across the division's Programs and Research Groups.

25th February 2008
From: Butler, Alan (CMAR, Hobart)
Sent: Wednesday, 15 October 2008 4:47 PM
To: Morell, Matthew (PI, Black Mountain); Preston, Nigel (CMAR, Cleveland); Smith, David (CMAR, Hobart); Bax, Nic (CMAR, Hobart); De La Mare, Bill (CMAR, Cleveland); Butler, Alan (CMAR, Hobart); Condie, Scott (CMAR, Hobart); Parslow, John (CMAR, Hobart); Randall, Margaret (CMAR, Hobart); Robert, Stan (CMAR, Hobart); Volkman, John (CMAR, Hobart)
Cc: Gunn, John (CMAR, Hobart); Moltmann, Tim (CMAR, Hobart); Rothlisberg, Peter (CMAR, Cleveland); Gibbs, Mark (CMAR, Cleveland)
Subject: CMAR's Capability Process

Folks,

Over the last couple of weeks I have consulted in various ways with each of you about the capability plan CMAR is developing. Formally, the consultation period began this week (having been delayed a bit) but I am on the road this week – that’s why I started early. Thanks for the very helpful comments you have already provided.

I am now attaching the most recent versions of some documents. You might like to have a glance at relevant ones. In many cases the recent changes will make no difference to your views but in some cases you might want another conversation. Please contact Margaret Randall to work out how and when we can do that.

Attachments:

1. We have nine identified “capabilities”. Attached are revised copies of the documents (variously referred to as “templates” and “pro formas”) prepared for the key ones I’m directly concerned with, and the main ones that concern the Southern Marine Systems Program:

   AGNP*

   SOPM* - “it’s my job to consolidate comments on these two

   MBOPM - comments to be consolidated by John Gunn but I’m happy to receive feedback and pass it on

   MSERAEM - only an executive summary is attached because I think the version I have may not be the latest. Mark Gibbs is handling this one; Mark, would you please send the official Version 1 to these addressees? Thanks.

2. Attached are executive summaries for the remaining five capabilities (ALOA, CESM, OOAP, SPCVCC, WEP).
I was planning also to attach an overview of the capability process and of the capability plan - you haven't seen this before and it should put the whole exercise into better perspective. But its production has been delayed (by forces from outside the division!). I'll send it asap.

I will be getting together with SMS RGLs early next week. Others, please contact Marg if you'd like to talk.

Cheers,

Alan.

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MBOPM

Executive Summary

This capability focuses on the study of the cycling, fate and impact of materials (major and minor elements, and pollutants or toxicants) in aquatic ecosystems (typically focused on lower trophic levels), ranging from estuarine to coastal and oceanic waters.

It is by necessity multi-disciplinary, integrating across the classical disciplines of physical, chemical and biological oceanography. Within each of these disciplines, it embraces field observations, laboratory and field process studies, and modelling. Staff in this capability work closely with a number of other CMAR capabilities – most notably MSEEM, SOPM and CESM, and with freshwater and estuarine biogeochemists and hydro-dynamicists in CLW.

From January 2009, all CMAR staff with a primary focus in this domain will be grouped within the MBOPM core capability – ensuring that we optimize the synergies of working from estuaries to oceans and local to global scales. We recognize that for the potential of this group to be realized, significant investment is required in research infrastructure (super-computing, sensors and sensor networks, and a variety of platforms for them, e.g. a modern research vessel, moorings, autonomous floats and vehicles).

For this capability to maintain and grow its international reputation it needs to work with output domains to focus efforts on a few major areas. We have reviewed areas for which exciting opportunities exist over the next decade and believe the most prospective (given existing capability mix, national priorities and international trends) are in the areas of:

- Operational Coastal and Ocean Biogeochemical Forecasting
- Integrating Biomarker, Isotope and Genomic Research
- Integrated biogeochemical and ecosystem models (and observations).
- Impacts of Climate Change and Acidification on Marine Ecosystems
- Enhancing Primary Production

Some of these are already foci (or project areas) for Flagship themes, others are yet to be developed. Unless there is significant growth in resourcing for this area, we believe that only 2-3 of these areas should be pursued, as the current fractionation of biogeochemical research across 14 Themes (11 of which use <2 FTE of MBOPM capability) works against the impact of the science and the capability.

CMAR analysis of capability strengths and weakness has led to 5 recent priority hires in MBOPM in 2008. Following this recruitment, we see little likelihood for further growth over the next 3 years. Resizing of the capability in out-years will depend on uptake of some of the potential science growth areas, and we plan to work closely with Output Leaders to influence investment into these science areas.
While growth is not supported, there is a need to reshape the MBOPM capability over the next 3 years, through building up some components and downsizing others. The marine environmental genomics area requires senior leadership to guide development of this area and its integration into the broader environmental and climate science undertaken by CMAR staff.

National and international trends (towards the use of automated sensor networks and platforms), also suggests that we will have an increasing need for field scientists who can support a strong shift towards automated and remote field measurements. Our current observational capability lacks the skills to support this shift in emphasis and we will move to overcome this shortcoming. The need is not necessarily for scientists to be involved in sensor development. Rather, it is for people who understand and know the systems being observed, and the nature and limitations of the sensors used to observe them. They are also quantitative scientists who are capable of analysing and interpreting the observations, and build international reputations around those interpretations. They will understand numerical models, and work hand-in-hand with modellers, but building and running numerical models is not their primary role.

1. Description of the Core Capability and its science base

Core Capability: Marine Biogeochemical Observations, Processes and Modelling (MBOPM)
Components: Ocean carbon fluxes and cycles, Oceanic Biogeochemical modelling, Coastal Modelling, Organic Geochemistry, Phytoplankton Eco-Physiology, Environmental Genomics, Micronutrients and macronutrients.
Skill base for Capability Area: TBA?????????????????????
Related Capabilities in CMAR: MSEEM, SOPM, CSEM
Number of staff as of 1 July 2008: TBA????????????????????
Number of staff x Site: TBA????????????????

What is the unifying/core science focus for staff in this Core Capability

MBOPM focuses on the study of the cycling, fate and impact of materials (major and minor elements, and pollutants or toxicants) in aquatic ecosystems (typically focused on lower trophic levels).

It is by necessity multi-disciplinary, and in the marine domain, it effectively integrates across the classical disciplines of physical, chemical and biological oceanography. Within each of these disciplines, it embraces field observations, laboratory and field process studies, and modelling.

In 2008, as has been the case for a number of years, the capability is spread (in many cases thinly) across a wide number of portfolios and thematic areas in CSIRO. Arguably, the fractionated deployment of MBOPM capability across so many projects
and themes hinders CSIRO’s contributions to understanding of the biogeochemical components of Australian oceanic, coastal and aquatic systems. Thus, a key strategic goal for CMAR/MBOPM is to influence CSIRO output portfolio priorities in the broad area of marine biogeochemistry. We believe this us best achieved through clear articulation of where the capability is most effectively focussed to increase the impact of output portfolios such as the WfO, CAF and WfHC Flagships, as well as CMAR’s own Climate and Atmosphere theme.

*What are likely to be the major trends in science in this capability over the next 3, 6, 12 years?*

Having analysed international trends and the current skill mix and science applications of the capability group, Parslow (2008) identified five major science areas where CSIRO might focus its capability in order to contribute significantly to international advances in marine biogeochemistry over the next 5 to 10 years:

a) **Operational Coastal and Ocean Biogeochemical Forecasting**
The international community plans to extend ocean forecasting capability from eddy-resolving regional models to inshore coastal, and from physics to biogeochemistry (e.g. in the transition from GODAE to CODAE).

b) **Integrating Biomarker, Isotope and Genomic Research**
These techniques in combination promise to deliver new insights into ecophysiological processes, both in the field and in the laboratory. They also offer new observing tools and diagnostic indicators.

c) **Integrated biogeochemical and ecosystem models (and observations).**
The traditional boundary between biogeochemical and ecosystem models, drawn at the herbivore level, is arbitrary, and its existence is counter-productive for important applications from both sides. There is now a major international IGBP research program, IMBER, with the objective of integrating across this boundary in ocean ecosystems, and LOICZ shares this goal for coastal ecosystems. The opportunity for integration of the CMAR’s MBOPM capability with our leading edge ecosystem and earth system modelling capabilities is exciting and provides a compelling vision for science and capability development over the next 10 years.

d) **Impacts of Climate Change and Acidification on Marine Ecosystems**
The potential impacts of climate change, and acidification, on marine ecosystems are now recognized as serious and potentially catastrophic. These are hot international research topics, with great relevance to Australia’s marine systems.

e) **Enhancing Primary Production**
The science challenge is to translate knowledge of biogeochemistry in general, and phytoplankton ecophysiology in particular, into practical tools to help design and manage highly perturbed (eco)systems for organic matter production and microbial transformation. This applies across large-scale ocean fertilisation, biofuel from microalgae and intensive aquaculture production.

*How well could CMAR/CSIRO tackle these challenges with existing capability/capacity? SWOT analysis.*
Clearly each of these areas involve major (and difficult) science challenges, and as with many of our science fields, we may/will need to consider how many CSIRO wants to tackle, and importantly how we might best partner with others (nationally and internationally) to achieve the quality and depth of science required. In developing a strategic plan for the MBOPM we have considered how well CMAR is currently placed from a capability/capacity perspective to work effectively on these challenges. A summary of these considerations is provided below.

Physics
CMAR’s ocean and coastal physical science capability is particularly strong. Only a small proportion of CMAR’s capability in physical oceanography is mapped formally into the MBOPM capability, but it’s worth looking briefly at the broader physical capability, because it plays such an important underpinning role for biogeochemical science. At ocean basin scales, CMAR has world-leading and/or world-class strength in physical oceanographic observations. We are world leaders in Southern Ocean studies, and play a regional lead role in studies of the Indian Ocean and Indonesian Throughflow, and the Tasman and Coral Seas. We play a well-recognised role in the international ARGO program, and in the science of altimetry. We have played a long-term leading role in maintaining regional ocean observations through ships of opportunity.

We have a long history of oceanographic field studies at continental shelf scales, including the major boundary currents around Australia. Most recently, we have played a lead role in forming a national partnership to successfully bid for NCRIS funding for an Australian Integrated Marine Observing System (IMOS). A substantial fraction of that investment is going towards enhancing our observations of Australia’s continental shelves and boundary currents, and their interactions with basin scale circulation.

Our physical modelling capability at ocean basin scales is also particularly strong. The CSIRO-BoM partnership CAWCR maintains an international reputation as one of a small number of credible producers of global coupled ocean-atmosphere climate models for IPCC scenarios and for studies of climate variability. We are valued partners in the development of the MOM community ocean model. Over the last 5 years, the BlueLink program has given us world-class ranking in the development of eddy-resolving, data-assimilating ocean forecasting models. The BlueLink modelling system is in itself a critically important platform for biogeochemical studies around Australia.

Our coastal physical oceanographic capability has been through something of a dip (at least in terms of numbers) over the last decade. Nonetheless, we have through this period developed a very strong and sophisticated coastal modelling suite, which has been adopted by other partners in Australia. Our coastal physical modelling capability has been recently enhanced through improved integration between offshore and inshore, primarily as a result of BlueLink extending its operational forecasting capability inshore. This has seen the development of the relocatable, local atmosphere-ocean modelling system ROAM, and plans for a national high-resolution continental shelf model (Ribbon model). It has also seen our modellers assisting in the implementation of coastal processes into the MOM community model. The BlueLink
data-assimilation scheme (BODAS) has just been implemented in our coastal circulation models.

We have maintained a small but effective effort in sediment modelling, primarily to address the role of turbidity in biogeochemical systems. BlueLink is driving an expansion in our capability in wave observations and modelling, and wave-current interactions, especially in near-shore areas, and this is likely to be extended to coastal geomorphology.

We have few dedicated observational scientists in coastal physical oceanography. Our coastal modellers have experience in making and interpreting field measurements. Moreover, the support group in CMAR provides extremely strong expertise and experience in maintenance and deployment of instruments and sensors, in mooring design, and in advanced platforms such as ARGO, across blue water and coastal scales. CMAR has a large and growing pool of oceanographic instruments, and access to others through national (IMOS) and international collaboration.

The bottom line here is that CMAR has the capability to implement state-of-the-art circulation models, supported by state-of-the-art observations, at scales ranging from ocean basin to estuaries. CMAR (with BoM) is seen in international circles as being at the forefront of attempts to develop a seamless nested ocean forecasting capability across these scales.

**Chemistry and Biology**
CMAR has a strong observational capability in chemical oceanography at both ocean basin and coastal scales. We have an internationally recognised ability to make high precision measurements of inorganic carbon parameters, and have made an important contribution to knowledge of these fields in the oceans around Australia, especially in the Southern Ocean. This capability should play an important role in monitoring and understanding regional variation in ocean acidification and carbonate saturation. We have internationally recognised expertise in measurements of vertical fluxes of sedimenting material, and have maintained an important time series of sediment traps for the Southern Ocean. We have a long history of ultra-clean sample collection and analysis at sea, and with the recent acquisition of ICP-MS facilities, capacity to make an important contribution to knowledge of regional micronutrient distributions. We support routine hydrochemistry through the national facility, and have the ability to measure very low (nM) levels of macronutrients in oligotrophic mixed layers.

CMAR has a strong capability in organic chemistry, and specifically in the identification and measurement of biomarkers, including pigments and lipids. There is the potential to link this to our capability in natural isotope measurement, to provide a powerful tool for source discrimination and historical reconstruction, as discussed above. These techniques are used in paleo-oceanography, but have recently been applied mostly in studies of the sources, cycling and fate of organic matter and nutrients in coastal marine systems, and in estuaries, rivers and floodplains. CMAR has some capability and experience in measuring exchanges of dissolved material across the water-sediment interface, both in situ and in cores in the laboratory. Our trace metal capability has been used to understand cycling of metals as both micronutrients and pollutants in coastal waters and sediments.
CMAR has particular expertise in phytoplankton ecology and physiology, with strong links into the international community, especially around the study of Harmful Algal Blooms. This expertise is supported by an internationally recognised algal collection, and culturing facilities. We've made an important contribution to measurements of primary production, especially in the open ocean, including the use of new techniques such as fast-repetition rate fluorometry. We have the leading national laboratory for measurements of phytoplankton pigments and bio-optical properties. We have expertise in phytoplankton taxonomy, and access to flow cytometers to efficiently count and sort field and laboratory samples. As noted earlier, our expertise in phytoplankton physiology and composition has been heavily directed towards aquaculture production over the last 10 years, and is now being directed towards biofuel production. Laboratory phytoplankton experiments have also been directed towards the autecology and physiology of species of environmental significance, especially toxic or harmful bloom species.

By comparison, our capability in zooplankton, bacteria and benthic primary producers is limited, being restricted to one or two scientists in each case. This is augmented by one or two additional scientists studying zooplankton along with micro-nekton as part of fisheries ecology and trophodynamics. CMAR is building core capability (field studies and modelling) of the role of benthic biota and processes in coastal and shelf biogeochemical cycles through the WAMSI NODE 1 project in SW WA.

CMAR is also building capability in the field of environmental genomics, and its application to biogeochemical processes. We see this as an essential future direction for both the characterization of oceanic/coastal communities and ecosystems and in the understanding of system dynamics.

Most of our capability in biological oceanography is currently deployed in the coastal domain. At both coastal and ocean scales, modern biological oceanographic field studies require a large team with a diverse mix of specialist skills and experience. We have relied heavily on collaboration with other agencies (Australian and international) in conducting major multi-disciplinary field programs and experiments, both in the open ocean (such as the Fe fertilization experiment SOIRÉE in the Southern Ocean), and in coastal studies. CMAR has a good record of collaboration with CLW biogeochemistry capability (field and modelling) in estuaries and in rivers.

**Biogeochemical Modelling**
CMAR has a world-class biogeochemical modelling capability. Our “blue-water” modellers have implemented ocean carbon cycles within global coupled climate models, and used these to investigate global climate feedbacks and impacts. These models are represented in international intercomparison experiments and in IPCC reports, and will be further developed through ACCESS.

The coastal modelling community is not so international in character, but our modellers are well recognized internationally, and our models compare well with the international state-of-the-art. Our coastal biogeochemical models have been at the forefront in benthic-pelagic coupling, in incorporating multiple functional groups, and in coupling to 3-D hydrodynamic models. Our coastal modelling has also had a strong applied flavour, so the group has a lot of experience in the formulation of management scenarios, and the analysis and visualisation of model output to support
decision-making. The group has had strong software support, and pioneered web-based applications for model visualisation and delivery.

Biogeochemical models tend to integrate physical, chemical and biological processes, so we don’t usually distinguish “chemical” from “biological” modellers. We do lack experience in models which deal with specialized chemical processes (e.g. with speciation and equilibria for complex mixtures of trace metals).

CMAR is just beginning to develop its capability in data assimilation and model-data fusion for biogeochemistry. In doing this, we are drawing on the strong experience in data assimilation in physical models gained through BlueLink, but also on increased collaboration with CMIS.

As discussed above, CMAR’s biogeochemical modellers enjoy the benefits of a very strong underpinning physical modelling capability, but they also have the opportunity to support and interact with a world-leading ecosystem modelling capability, in the form of the Atlantis and In Vitro modelling suites. We would expect the biogeochemical and ecosystem models to become more closely integrated over time.

Taking these strengths and weaknesses into account, our evaluation of CMAR’s potential to address the five major challenges is as follows:

a) **Operational Coastal and Ocean Biogeochemical Forecasting**
World-class, if not world-leading. We can build on BlueLink 1 and 2. Collaborative opportunities exist across CSIRO in: sensor and sensor network, statistical methods, ocean colour interpretation. Modelling capacity adequate. There is some question as to whether our observational and supercomputer infrastructure is sufficient.

b) **Integrating Biomarker, Isotope and Genomic Research**
World-class, if we can co-ordinate and bring critical mass to bear from our existing capacity. There is a need to select one or two high-profile high-value targets among many diverse applications, and depending on which are chosen there may be a need to recruit senior capability and build infrastructure around specific science areas.

c) **Integrated biogeochemical and ecosystem models (and observations).**
World-class, if we can coordinate and bring critical mass to bear from our existing capacity. Once again, to be world-class, we will need to select one or two high-profile high-value targets among many diverse applications.

d) **Impacts of Climate Change and Acidification on Marine Ecosystems**
World-class in the physics and chemistry; gaps in observation infrastructure; strong modelling capability in the biogeochemistry and ecology, but particularly weak in historical observations. Could leap-frog into world-class position with a major investment in modern observing infrastructure.

e) **Enhancing Primary Production**
World-class, building on experimental, field and modelling strengths. We lack capacity in bacterial ecology/physiology, and are thin in zooplankton. Opportunities in large-scale culturing and production would require collaborations in engineering, processing (for biofuel).
In summary, the MBOPM “science opportunity” is great and our capability is strong in many areas. However, there are critical gaps in technology/infrastructure and in some capability areas. As we describe below, we are also significantly overstretched (i.e. lack capacity) in other, existing capability areas (see below).

The right size and right shape for this core capability over the next 10 years will largely be determined by CSIRO portfolio choices of major science foci, but we’d argue that the best strategy for portfolio leaders will be to focus on/invest meaningfully in advancing a few major science areas, rather than spreading MBOPM capability thinly/sub-optimally across a large number of projects and portfolios.

2. Analyses of Current and Future Capability Deployment across CSIRO’s portfolios

Where is the Capability Area currently deployed?

SIP3 (September 2008) staff allocations to projects show staff in the capability are distributed across 14 Themes (Figure 1). Themes 2 and 4 in WfO account for just over half of the total capability. Another 6.8 FTEs are mapped into 4 support and infrastructure Ythemes: CMAR Support, Marine National Facility, IMOS and Collections. Another 7 FTEs are mapped across 9 research Themes, at levels ranging from 2 down to 0.1 FTEs.

![Figure 1. Staff allocation by Theme, based on preliminary project data under SIP3.](image)

What is its likely future deployment over the current 3 year SIP cycle?

Views on the future deployment of this capability have been collected through stakeholder workshops, a questionnaire and discussions with theme leaders in CMAR and the WfO, WfHC, and FF flagships. As one might expect with an annual SIP
cycle, ET-initiated reviews of portfolios (in WFO a review of SAFE, MCBM and Marine Nation is currently under way) and a lack of clarity around the “home” of coastal research in CSIRO, these projections of future needs/deployment of MBOPM capability are somewhat uncertain.

**WFO**

Three of the WFO themes – Marine Nation, SAFE and Marine Conservation and Biodiversity Management – are currently being externally review following questions from the CSIRO Executive Team Science Sub Committee on their points of differentiation and focus. The review is considering future directions for these Themes and their relationships with other WFO themes. Early indications from this review suggest a likely refocussing of the Theme portfolios away from individual client/sectoral interests and towards agreed major national/international science goals/challenges. Clarity around this reshaping of the portfolios will develop over the latter months of 2008, and we’d expect the division to be heavily engaged in discussions about the science directions and capability requirements. Based on pre-review discussions, our understanding of MBOPM future deployments is as follows:

**Marine Nation (currently 13 FTEs)**
The Theme hopes to grow through increasing external income. However, it attaches higher priority to growth in some other areas (e.g. socioeconomics) than to biogeochemistry. It expects to maintain the current effort level in biogeochemistry, but hopes to reshape that capability to meet priority needs. The Theme sees a particularly strong need for models and observing systems which can be rapidly deployed to meet management needs, and subsequently be refined over time. This requires an improved capacity to quantify model uncertainty and error. The Theme sees a potential shortfall in modelling capacity short term, if current client engagement succeeds. [This should be addressed by CMAR’s priority recruitment plans.] The Theme would like to see better integration between biogeochemical and ecosystem models.

The Theme is currently making major strategic investments in capability development, in field process studies such as WAMSI Node 1, in sensor networks and in models. The Theme will continue some level of investment in process studies, but this will need to be sharply focused. It does not see a future in large regional ecosystem studies, unless these are focused on Theme priorities and goals.

The Theme would encourage more collaboration with CLW on coupled catchment-to-coast models and observing networks, with ICT on sensor networks and AUVs, and with CMIS on error analysis.

The theme sees climate change as an important driver, but is unlikely to have the capacity to support a major marine climate impacts research program. The theme leader indicated that Marine Nation might take on ocean fertilisation as a research area in the future.

**SAFE and MCBM – (0.1 FTEs).**

These themes currently use a negligible amount of CMAR’s biogeochemical capability. Both see room for an increase to small amounts – 1 to 2 FTEs each. In the case of SAFE, the need is for better integration of biogeochemistry into ecosystem
models used for ecosystem-based fisheries management. In the case of MCBM, biogeochemistry is seen as providing information about processes supporting and/or threatening biodiversity. There is potential to use biogeochemistry to support productivity estimates in the pelagic domain, and rapid assessment of biodiversity in tropical environments.

Ocean Dynamics (13 FTEs)
The Theme is not expecting major growth, and expects that its appropriation and external funding envelopes, and total FTEs, will remain fairly flat. That said, the theme is conducting a due diligence project aimed at evaluating the potential for development of a new Coastal Assessment and Prediction system. If this study provides a favourable assessment, one might expect new appropriation investment in the biogeochemical modelling area in the SIP4 round.

In the absence of new SIP4 funding, the Theme expects its investment in biogeochemistry to increase slightly. It has negotiated with CMAR to absorb one additional biogeochemical modeller in SIP3. The Theme’s biogeochemistry is undergoing a shift in emphasis from studies of carbon cycle feedbacks to attribution of changes in marine systems due to climate and acidification. It expects that trend to continue, although there is currently considerable uncertainty around the future priorities in ACCSP, and any successor to the ACE CRC. The Theme is encountering some difficulty in developing a strategic approach to marine climate impacts within the current CSIRO climate structure.

The Theme expects BlueLink 3 to include ocean biogeochemical forecasting, and that could be augmented by coastal forecasting, depending on the outcome of the Due Diligence Study.

The Theme currently has a heavy commitment to biogeochemical observations and process studies, and a relatively small investment in modelling. It is looking to increase its investment in modelling, but also direct more of its field effort towards automated and remote observations, to support both climate attribution and ocean forecasting. The Theme sees potential infrastructure constraints in supercomputing and automated observing platforms and sensors.

WfHC

Healthy Water Ecosystems (HWE) and Better Basin Futures (BBF) (Total 2.8 FTEs)

WfHC is currently using 2.8 CMAR FTES, both field and modelling, to support studies of estuarine and freshwater aquatic systems. This work is expected to be consolidated into HWE, with the movement of the Tropical Rivers and Coastal Knowledge (TRACK) projects into HWE later this year.

Bill Young sees the biogeochemical capability in CLW and CMAR as a common pool, and is prepared to draw from either according to availability and skills. Future changes in the use of CMAR’s FTEs will essentially depend on shifts in sourcing between CMAR and CLW. Biogeochemical capability is used in HWE in regional case studies. He sees an ongoing need for access to the biomarker and isotope skills,
and to hydrodynamic and biogeochemical modelling. Hydrodynamic modelling capacity is currently a constraint across CLW and CMAR, and CMAR is addressing this in its current priority appointments. He would like to access CMAR’s aquatic ecosystem modelling capability as well.

He has a strategic interest, shared with WfO Theme 4, in the development of coupled catchment-to-coast models. [A workshop on this is planned for early November, with participants from both Divisions and both Flagships].

**Petascale Computational and Simulation Science Platform – John Taylor (1.6 FTEs)**

This platform incorporates the old Terabyte Science Theme. It supports a strategic CMIS-CMAR project on development of Bayesian hierarchical approaches to error estimation and analysis in biogeochemical models. It is also keen to support development of scalable model codes which run on massively parallel supercomputers. Biogeochemical modelling has been chosen as a demonstration case study for its strategic goals.

Capacity has been an issue here, as CMAR has struggled to recruit a postdoc funded from this project. The Platform could potentially fund another person with suitable modelling and computational skills.

Although the total effort is small, this project has facilitated collaboration with CMIS in a key strategic area for biogeochemical modelling.

**Climate Adaptation Flagship – (0.2 FTEs).**

At present, the flagship uses just 0.2 FTEs of CMAR’s capability, in the Ecosystems Theme. There appears to be some potential to grow that, but probably only to about 2 FTEs

Like SAFE, CAF is interested primarily in coupled biogeochemical-ecosystem modelling. The first priority is in the area of climate impacts on estuarine and coastal ecosystems. There are discussions underway with SAFE about a SE Australian initiative. There are other projects under development in SE Qld / Moreton Bay. There is little prospect of CAF investing in climate impacts research for open ocean ecosystems.

CAF sees potential for more integration of the coastal storm surge / inundation / erosion modelling with biogeochemistry and ecology. (It should be possible to do this through BlueLink and ROAM.)

CAF also sees the need for better catchment to coast integration in dealing with climate impacts, and sees this as a joint task for WfHC, WfO, CAF. The GBR might provide an opportunity for an integrated project across flagships.

**Energy Transformed Flagship,**

*Low Emissions Transport (currently <1 FTE)*
CMAR is currently developing a project in this theme in the area of biofuel from microalgae. The Theme Leader is quite bullish on the prospects for this area, and sees it as one of the key medium- to long-range contenders for a serious contribution to biofuel. He thinks the Theme could see up to 20 FTEs invested in this area after 5 years, across biogeochemistry, engineering and processing, with 30% or more coming from CMAR biogeochemistry. He notes strong interest in co-investment from the private sector. Co-production of fuel with other products (feedstock, industrial or pharmaceuticals) is likely to be important.

The Theme Leader sees the key challenge and requirement from CMAR’s biogeochemistry as capacity to inform the design of large-scale production systems which control the growth environment to deliver high output of constant composition. Modelling and automated observations will have an important part to play. He sees genetic modification as potentially important, but likely following the mass production challenge.

**CMAR**
Climate and Atmosphere (C&A) Theme (0.6 FTEs)

The C&A Theme is using 0.6 FTEs to put the marine carbon cycle into global models in ACCESS. This has the potential to grow this by about 1 FTE or higher if the ocean carbon cycle assumed higher priority (e.g. if evidence of anomalies in ocean uptake appears).

The Theme will continue to focus on global coupled carbon model at coarse resolution over the next 5 years. This is limited by supercomputer capacity. The Theme will look for synergies with WfO eddy-resolving biogeochemical modelling. In the long run, ACCESS is seen as a cross-scale cross-Theme modelling platform.

The potential for more synergies across atmospheric, terrestrial and marine biogeochemistry are likely to become apparent as we study the interactions in the coupled global models.

**Food Futures**
Breed Engineering (0.4 FTEs)

A possible growing focus on intensive production systems in aquaculture may drive increased need for MBOPM capability. The Theme expects to start with 1 postdoc at Cleveland, potentially growing to 3 FTEs at 5 years.

**Conclusions**

There is clearly considerable uncertainty in virtually all Themes about the direction of their science, and the quantity and composition of the skills required to deliver it, on a 5 year time scale. This is perhaps to be expected – Themes operate in a dynamic external and internal funding environment, and are supposed to respond nimbly to that environment. However, in looking across the CMAR capability areas, this lack of clarity on future directions for MBOPM science seems greater than for many other areas. The challenge for capability leaders is to plan and manage capability in the long term through those fluctuations and uncertainties.
If we added up all the additional FTEs identified in Theme Leader responses, we get a net gain of about 17 FTEs. It would be very optimistic to think these would all materialise. It might be more realistic to suppose we might realise half that number, an increase of around 8 or 9 FTEs. Out of the total, the major current users are forecasting a flat or slightly increasing need. The major contributions come from ET and FF flagships, in the research area of intensive production. The other increases are spread across a number of environmental themes, mostly in the integrated biogeochemistry-ecology area.

3. Analysis of the current and future size and shape of the Capability Area?

Given the uncertainty about output Portfolio/Theme science future growth scenarios (reviews, dependencies for capability pull on successful completions of existing science projects, external earnings etc.) in projecting the future MBOPM capability needs we have returned to the major prospective science areas of the previous section, and asked which of these we can expect to be sustainable given Theme plans.

Operational Coastal and Ocean Biogeochemical Forecasting already attracts strong strategic support in WfO Dynamic Ocean and Marine Nation Themes, and some support from the Petascale Platform. It fits the priority need in Marine Nation for readily implemented models (at least with a flexible interpretation), and could grow substantially in Dynamic Ocean, depending on the current Due Diligence Study. But this area is likely to be supported at critical mass regardless of the outcome of the Due Diligence Study.

There is clearly a strong demand for Integrated biogeochemical and ecosystem models and observations, across the environmental Themes. It could be a challenge to co-ordinate this and deliver critical mass targeted at strategic science goals, given that this demand is spread thin, and individual Themes may have tactical requirements. Our assessment of the way forward is to let the ecosystem modelling, which is attracting strong demand and strategic investment in its own right, drive this science area, and ensure key biogeochemical capability is available to engage. This approach acknowledges there may be a decreased draw on observational capability in this area.

If the medium- to long-term “possibilities” around biofuels and aquaculture production become reality, CMAR would need to grow capability in the Enhancing Primary Production research area to critical mass (i.e. around 10 FTEs). While WfO themes are hesitant to commit at this stage to investment in ocean fertilization research, they are not ruling it out. If this area became a focus following the WfO Theme reviews, this research area will grow beyond critical mass.

While there is likely sufficient investment in WfO Theme 2 to support Impacts of Climate Change and Acidification on Marine Ecosystems, and potentially some additional support from CAF and/or SAFE, we think there is cause for concern about the overall level of investment in this area, given the potential extent of the problem. We’re particularly concerned that the proposed investment seems unlikely to support an adequate observation program. To put it bluntly, it appears that the economic and social value attached to our marine ecosystems is sufficiently low, at least compared
with coastal infrastructure (for example), that as a nation we’re prepared to let impacts of climate change and acidification on our marine ecosystems proceed on an out-of-sight, out-of-mind basis, except perhaps in some iconic systems like the GBR. That seems to be an almost inevitable consequence of the way research priorities are being set nationally and within CSIRO. There may be opportunities to change this situation, through IMOS and successors to the ACE CRC, but it will require leadership.

Although most Themes seem prepared to support the Integrating Biomarker, Isotope and Genomic Research science area, the level of investment in each Theme is low. This will make it especially challenging to maintain the strategic focus needed to achieve world-class results. CMAR believe there is an opportunity to focus more seriously on marine environmental genomics. Based on input from international reviewers at the WFO Three Theme Review the opportunity may even be a necessity if we are to keep pace with international efforts in understanding the roles of microbes in the marine environment. Clearly this is an area where CMAR as a capability home with views on the future directions of marine science needs to work closely with Portfolio Leaders to establish the required level of support for this area of science.

Conclusions
Given recent priority hires and lack of clarity about further growth potential for this capability, MBOPM will not be targeted for growth over the next 3 years, beyond the priority appointments already committed. Growth in the out-years will depend on uptake of some of the potential science growth areas, and we plan to work closely with Output Leaders to influence investment into these science areas.

There is a need to reshape the MBOPM capability over the next 3 years, through building up some components and downsizing others.

Modelling – statistical capability
In response to strong calls from Output Portfolio Leaders, we have increased the MBOPM hydrodynamic and biogeochemical modelling capacity (including programming support) by ?? FTEs in 2008. This is seen as sufficient for the work anticipated over the next few years. However, the potential loss of senior leadership in this area makes development and/or recruitment of potential leaders in this component of the MBOPM capability a high priority.

We recognize the need to continue to strengthen the statistics in our biogeochemical modelling. This may be possible through our relationship with CMIS, but this will require explicit conversations to avoid unmet expectations/needs. If CMIS chooses not to deploy their capability in this area, we may need to examine this a priority recruitment area.

Environmental Genomics
The inclusion of environmental genomics capability within MBOPM is intended to provide impetus for development of critical mass in this area over the next 3 to 5 years. To fast track development of a compelling science proposition for output portfolio leaders in WFO and WfHC, we will recruit a senior leader to work with our existing research scientists.

Observational/Field capability (across physics, chemistry and biology).
Our analysis of national and CSIRO environmental Theme requirements and international trends (towards the use of automated sensor networks and platforms), suggests that we will have an increasing need for field scientists who can support a strong shift towards automated and remote field measurements.

Our current observational capability lacks the skills to support that move. The need is not necessarily for scientists to be involved in sensor development. Rather, it is for people who understand and know the systems being observed, and the nature and limitations of the sensors used to observe them. They are also quantitative scientists who are capable of analysing and interpreting the observations, and build international reputations around those interpretations. They will understand numerical models, and work hand-in-hand with modellers, but building and running numerical models is not their primary role.

We have excellent role models among our physical oceanographers, but lack those people in the chemical and biological domains. We are consequently struggling to find people to scientifically direct and exploit aspects of IMOS, or to sit alongside and collaborate with the technologists involved in sensor and sensor network development. Similarly, we have failed to exploit ocean colour data to anywhere near the extent we might have expected 10 years ago. It’s worth noting that people with these skills are often capable of working across disciplines.

Most of the environmental Themes are looking to reduce their investment in classical process studies, and increase their investment on observing networks. We will need to make a corresponding transition in the kind of capability we provide. That may be achieved by retraining, or may require recruitment. Given the critical role SE&T plays in supporting our field observations, we probably need to look hard at the capability mix in our support as well research groups in terms of our ability to support new observing systems.

We note that CMAR currently lacks expertise in the ecophysiology of bacteria and zooplankton – capability that is associated with research domains such as intensive production and marine climate impacts which are currently potential growth areas. Our judgement is that in the next three years we will seek to partner with other agencies and universities where this capability is required, rather than recruit and extend our capability base. Subject to internal investment in these areas over this period, this decision will be reviewed at the end of the three years.

4. Key Internal (One-CSIRO) Relationships : dependencies/partnerships/brief SWOT
- Divisions –
  CLW and CMAR aquatic biogeochemists have worked together on a number of projects over the last decade, principally in estuarine and coastal systems. CLW also has a strong coastal remote sensing capability with whom CMAR biogeochemists and remote sensing researchers have collaborated. Given recent retirements in this capability area in both CLW and CMAR, the leadership of the two divisions have agreed to work together in the development and shaping of this shared capability area.
CMIS also have relevant expertise in environmental modelling and remote sensing. CMAR has recently developed a collaborative relationship with CMIS through their XXXXX Theme.

- Flagships –
  WFO is likely to remain the most important output portfolio for this capability. The flagship is currently working with clients to evaluate the possibility of a Bluelink III collaboration, and is also undertaking a due diligence study on the prospects for a significant investment in a national coastal modelling framework.

- Platforms – current, future ideas

5. Key External Relationships : Dependencies/partnerships and collaborations/competition/brief SWOT
   - Other R&D providers (Unis and Publicly Funded Research Agencies)
   - Federal, state and local government clients
   - Industry clients and stakeholders
   - International linkages
   - Funding agencies

6. Infrastructure needs

Supercomputing remains a vexed issue for CSIRO. While we may have agreed on an upgrade for the joint BoM-CSIRO facility, the fact remains that CSIRO and Australia are not anywhere near the forefront in terms of global supercomputing. That’s an issue, if we’re serious about world-class research. The situation is considerably worse for research groups operating at the next level down. The Petascale Platform is at least bringing a computation / simulation science perspective to the table, but it remains to be seen whether there’s a mechanism to get the investment needed.

The other major infrastructure issue is investment in observing platforms and instruments. Initiatives such as the sensor cluster may result in low-cost sensors somewhere down the track, but for the next 5 years, and perhaps the next 10, most sensors will continue to be very expensive. If we want to conduct world-class research to demonstrate sensor networks and data-assimilating models, we will need to make investments at scales comparable to those being made in world-leading studies overseas. That may require an order of magnitude increase over current investment levels. That could be affordable in principle (it’s well within the IMOS budget), but it would require a more geographically focused deployment than IMOS has achieved to date.

If we want to stay world-class in our existing science areas, there will be a need to maintain and upgrade the wide variety of existing laboratory and field equipment. There are some CAPEX gaps which are more specific to particular problems. For example, if research into intensive production proceeds, we’ll need to consider how to access mesocosm and pilot plant facilities.
Database, programming and visualisation needs – hardware, software and human resources ????????????????????????????????????
From: Vollman, John (CMAR, Hobart)
Sent: Tuesday, 28 October 2008 4:04 PM
To: Parslow, John (CMAR, Hobart)
Subject: RE: substitution

Hi John,

I forwarded your comments about the capability doc which I share. These were sent up the line, but any response is unknown at this stage.

Cheers

John

Dr John Vollman
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john.vollman@csiro.au

From: Parslow, John (CMAR, Hobart)
Sent: Tuesday, 29 October 2008 4:03 PM
To: Vollman, John (CMAR, Hobart)
Subject: RE: substitution

Hi John,

Given that was the only SAP request I received, it wasn't too onerous.

I've sent the training request from Alan out to team leaders, and asked them to send suggestions back to Paulette. I assume you'll collate and respond to Alan.

No other burning issues I'm aware of. Alan circulated some later drafts of the capability statements. I expressed (again) my uneasiness about the discrepancy in approach between the biegeochemistry statement (written by me and then amended by John Gunn) and the other statements prepared by RGLs & PLs.

Cheers

John

PS Just discovered I hadn't sent this. We discussed most of it this morning.

From: Vollman, John (CMAR, Hobart)
Sent: Tuesday, 28 October 2008 9:45 AM
To: Parslow, John (CMAR, Hobart)
Subject: substitution

Hi John,

Thanks for filling in as RGL. I've just desubstituted you, so hopefully you won't get any more SAP approvals redirected. Do you approve that?

Cheers

John

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Hi Tim

I've been through the document and made a number of small changes (in green on my version). I and others think that the document stands out from other capability documents in making a number of strong assertions about direction that have not been rigorously discussed. There are three statements that I would particularly challenge (see imbedded comments):

1. That "we" need to choose 2-3 of the 5 nominated areas. In fact there is a lot of commonality between them and many require a similar skill set. I would argue that the (internal and external) markets will decide where the emphasis will be and we should be focussing on ensuring that we have the capability to meet the need. I've suggested some new wording in the comment.

2. There is a bald statement that no growth is targeted for the next 3 years, but the following text points out a number of possible growth areas. I simply can't see how this need (if it eventuates) can be met solely from reshaping.

3. The notion that the ecosystem modelling should drive our decision making really goes against the grain. We should certainly aim for better linking and integration (and are doing so), but it is demonstrably clear that our biogeochemical modelling and measurement expertise has strong stakeholder and real client support in its own right (although widely distributed across CSIRO as currently structured).

Best regards
John Volkman

p.s. I've copied in John Parslow who was responsible for creating much of the original text that was recycled into this document and would certainly have a view on these matters.

Dr John Volkman
Research Group Leader
From: Butler, Alan (CMAR, Hobart)
Sent: Friday, 31 October 2008 11:55 AM
To: Volkman, John (CMAR, Hobart)
Cc: Moltmann, Tim (CMAR, Hobart)
Subject: MBOPM revision

Hi John,

We (JG in South Africa and I in Hawaii) are engaged in a last-minute rush to revise the MBOPM proforma before it goes on the www for staff consultation (by COB today).

Attached is a copy with some recent tracked changes by me. If you have time to have a look that would be good, since you know the client engagement area much better than I do. If you have any comments, please get them back to Tim Moltmann.

Many thanks,

Al.

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Executive Summary

This capability focuses on the study of the cycling, fate and impact of materials (major and minor elements, and pollutants or toxicants) in aquatic ecosystems (typically focused on lower trophic levels), ranging from estuarine to coastal and oceanic waters.

It is by necessity multi-disciplinary, integrating across the classical disciplines of physical, chemical and biological oceanography. Within each of these disciplines, it embraces field observations, laboratory and field process studies, and modelling. Staff in this capability work closely with a number of other CMAR capabilities – most notably MSEEM, SOPM and CESM, and with freshwater and estuarine biogeochemists and modellers in CLW.

From January 2009, all CMAR staff with a primary focus in this domain will be grouped within the MBOPM core capability – ensuring that we optimize the synergies of working from estuaries to oceans and local to global scales. We recognize that for the potential of this group to be realized, significant investment is required in research infrastructure (super-computing, sensors and sensor networks, and a variety of platforms for them, e.g. a modern research vessel, moorings, autonomous floats and vehicles).

For this capability to maintain and grow its international reputation it needs to work with output domains to focus efforts on a few major areas. We have reviewed areas for which exciting opportunities exist over the next decade and believe the most prospective (given existing capability mix, national priorities and international trends) are in the areas of:

- Operational Coastal and Ocean Biogeochemical Forecasting
- Integrating Biomarker, Isotope and Genomic Research
- Integrated biogeochemical and ecosystem models (and observations).
- Impacts of Climate Change and Acidification on Marine Ecosystems
- Enhancing Primary Production

Some of these are already foci (or project areas) for Flagship themes, others are embryonic. Unless there is significant growth in resourcing for this area, we believe that only 2-3 of these areas should be pursued, as the current fractionation of biogeochemical research across 14 Themes (11 of which use <2 FTE of MBOPM capability) works against the impact of the science and the capability.

CMAR analysis of capability strengths and weaknesses has led to 5 recent priority hires in MBOPM in 2008. Following this recruitment, we see little likelihood for further growth over the next 3 years. Resizing of the capability in out-years will depend on uptake of some of the potential science growth areas, and we plan to work closely with Output Leaders to influence investment into these science areas.
While growth is not supported, there is a need to reshape the MBOPM capability over the next 3 years, through building up some components and downsizing others. The marine environmental genomics area requires senior leadership to guide development of this area and its integration into the broader environmental and climate science undertaken by CMAR staff.

National and international trends (towards the use of automated sensor networks and platforms), also suggests that we will have an increasing need for field scientists who can support a strong shift towards automated and remote field measurements. Our current observational capability lacks the skills to support this shift in emphasis and we will move to overcome this shortcoming. The need is not necessarily for scientists to be involved in sensor development. Rather, it is for people who understand and know the systems being observed, and the nature and limitations of the sensors used to observe them. They are also quantitative scientists who are capable of analysing and interpreting the observations, and build international reputations around those interpretations. They will understand numerical models, and work hand-in-hand with modellers, but building and running numerical models is not their primary role.

1. Description of the Core Capability and its science base

Core Capability: Marine Biogeochemical Observations, Processes and Modelling (MBOPM)
Components: Ocean carbon fluxes and cycles, oceanic biogeochemical modelling, coastal biogeochemical modelling, organic geochemistry, phytoplankton ecophysiology, environmental genomics, micronutrients and macronutrients.
Related Capabilities in CMAR: MSEEM, SOPM, CSEM
Number of staff as of 1 July 2008: TBA
Number of staff x Site: TBA

What is the unifying/core science focus for staff in this Core Capability

MBOPM focuses on the study of the cycling, fate and impact of materials (major and minor elements, and pollutants or toxicants) in aquatic ecosystems (typically focused on lower trophic levels).

It is by necessity multi-disciplinary, and in the marine domain, it effectively integrates across the classical disciplines of physical, chemical and biological oceanography. Within each of these disciplines, it embraces field observations, laboratory and field process studies, and modelling.

In 2008, as has been the case for a number of years, the capability is spread (in many cases thinly) across a wide number of portfolios and thematic areas in CSIRO. Arguably, the fractionated deployment of MBOPM capability across so many projects and themes hinders CSIRO's ability to concentrate effort on the biogeochemical components of Australian oceanic, coastal and aquatic systems. However, it is equally true that there is a strong demand for these skills across a wide range of output areas within CSIRO's broader portfolio which would have to be met from elsewhere in CSIRO if a key strategic goal for CMAR/MBOPM is to influence CSIRO output portfolio priorities in the broad area of marine biogeochemistry. We believe this
best achieved through clear articulation of where the capability is most effectively focussed to increase the impact of output portfolios such as the WFO, CAP and WHHC Flagships, as well as CMAR’s own Climate and Atmosphere theme.

What are likely to be the major trends in science in this capability over the next 3, 6, 12 years?

Having analysed international trends and the current skill mix and science applications of the capability group, Parslow (2008) identified five major science areas where CSIRO might focus its capability in order to contribute significantly to international advances in marine biogeochemistry over the next 5 to 10 years:

a) Operational Coastal and Ocean Biogeochemical Forecasting
The international community plans to extend ocean forecasting capability from eddy-resolving regional models to inshore coastal, and from physics to biogeochemistry (e.g. in the transition from GODAE to CODAE).

b) Integrating Biomarker, Isotope and Genomic Research
These techniques in combination promise to deliver new insights into ecophysiological processes, both in the field and in the laboratory, and to enhanced understanding of organic matter sources and cycling. They also offer new observing tools and diagnostic indicators.

c) Integrated biogeochemical and ecosystem models (and observations).
The traditional boundary between biogeochemical and ecosystem models, drawn at the herbivore level, is arbitrary, and its existence is counter-productive for important applications from both sides. There is now a major international IGBP research program, IMBER, with the objective of integrating across this boundary in ocean ecosystems, and LOICZ shares this goal for coastal ecosystems. The opportunity for integration of the CMAR’s MBOPM capability with our leading edge ecosystem and earth system modelling capabilities is exciting and provides a compelling vision for science and capability development over the next 10 years.

d) Impacts of Climate Change and Acidification on Marine Ecosystems
The potential impacts of climate change, and acidification, on marine ecosystems are now recognized as serious and potentially catastrophic. These are hot international research topics, with great relevance to Australia’s marine systems.

e) Enhancing Primary Production
The science challenge is to translate knowledge of biogeochemistry in general, and phytoplankton ecophysiology in particular, into practical tools to help design and manage highly perturbed (eco)systems for organic matter production and microbial transformation. This applies across large-scale ocean fertilisation, biofuel from microalgae and intensive aquaculture production.

How well could CMAR/CSIRO tackle these challenges with existing capability/capacity? SWOT analysis.

Clearly each of these areas involve major (and difficult) science challenges, and as with many of our science fields, we may/will need to consider how many CSIRO
wants to tackle, and importantly how we might best partner with others (nationally and internationally) to achieve the quality and depth of science required. In developing a strategic plan for the MBOPM we have considered how well CMAR is currently placed from a capability/capacity perspective to work effectively on these challenges. A summary of these considerations is provided below.

**Physics**
CMAR’s ocean and coastal physical science capability is particularly strong. Only a small proportion of CMAR’s capability in physical oceanography is mapped formally into the MBOPM capability, but it’s worth looking briefly at the broader physical capability, because it plays such an important underpinning role for biogeochemical science. At ocean basin scales, CMAR has world-leading and/or world-class strength in physical oceanographic observations. We are world leaders in Southern Ocean studies, and play a regional lead role in studies of the Indian Ocean and Indonesian Throughflow, and the Tasman and Coral Seas. We play a well-recognised role in the international ARGO program, and in the science of altimetry. We have played a long-term leading role in maintaining regional ocean observations through ships of opportunity.

We have a long history of oceanographic field studies at continental shelf scales, including the major boundary currents around Australia. Most recently, we have played a lead role in forming a national partnership to successfully bid for NCRIS funding for an Australian Integrated Marine Observing System (IMOS). A substantial fraction of that investment is going towards enhancing our observations of Australia’s continental shelves and boundary currents, and their interactions with basin scale circulation.

Our physical modelling capability at ocean basin scales is also particularly strong. The CSIRO-BoM partnership CAWCR maintains an international reputation as one of a small number of credible producers of global coupled ocean-atmosphere climate models for IPCC scenarios and for studies of climate variability. We are valued partners in the development of the MOM community ocean model. Over the last 5 years, the BlueLink program has given us world-class ranking in the development of eddy-resolving, data-assimilating ocean forecasting models. The BlueLink modelling system is in itself a critically important platform for biogeochemical studies around Australia.

Our coastal physical oceanographic capability has been through something of a dip (at least in terms of numbers) over the last decade. Nonetheless, we have through this period developed a very strong and sophisticated coastal modelling suite, which has been adopted by other partners in Australia. Our coastal physical modelling capability has been recently enhanced through improved integration between offshore and inshore, primarily as a result of BlueLink extending its operational forecasting capability inshore. This has seen the development of the relocatable, local atmosphere-ocean modelling system ROAM, and plans for a national high-resolution continental shelf model (Ribbon model). It has also seen our modellers assisting in the implementation of coastal processes into the MOM community model. The BlueLink data-assimilation scheme (BODAS) has just been implemented in our coastal circulation models.
We have maintained a small but effective effort in sediment modelling, primarily to address the role of turbidity in biogeochemical systems. BlueLink is driving an expansion in our capability in wave observations and modelling, and wave-current interactions, especially in near-shore areas, and this is likely to be extended to coastal geomorphology.

We have few dedicated observational scientists in coastal physical oceanography. Our coastal modellers have experience in making and interpreting field measurements. Moreover, the support group in CMAR provides extremely strong expertise and experience in maintenance and deployment of instruments and sensors, in mooring design, and in advanced platforms such as ARGO, across blue water and coastal scales. CMAR has a large and growing pool of oceanographic instruments, and access to others through national (IMOS) and international collaboration.

The bottom line here is that CMAR has the capability to implement state-of-the-art circulation models, supported by state-of-the-art observations, at scales ranging from ocean basin to estuaries. CMAR (with BoM) is seen in international circles as being at the forefront of attempts to develop a seamless nested ocean forecasting capability across these scales.

**Chemistry and Biology**
CMAR has a strong observational capability in chemical oceanography at both ocean basin and coastal scales. We have an internationally recognised ability to make high precision measurements of inorganic carbon parameters, and have made an important contribution to knowledge of these fields in the oceans around Australia, especially in the Southern Ocean. This capability should play an important role in monitoring and understanding regional variation in ocean acidification and carbonate saturation. We have internationally recognised expertise in measurements of vertical fluxes of sedimenting material, and have maintained an important time series of sediment traps for the Southern Ocean. We have a long history of ultra-clean sample collection and analysis at sea, and with the recent acquisition of ICP-MS facilities, capacity to make an important contribution to knowledge of regional micronutrient distributions. We support routine hydrochemistry through the national facility, and have the ability to measure very low (nM) levels of macronutrients in oligotrophic mixed layers.

CMAR has a strong capability in organic chemistry, and specifically in the identification and measurement of biomarkers, including pigments and lipids. There is the potential to link this to our capability in natural isotope measurement, to provide a powerful tool for source discrimination and historical reconstruction, as discussed above. These techniques are used in paleo-oceanography, but have recently been applied mostly in studies of the sources, cycling and fate of organic matter and nutrients in coastal marine systems, and in estuaries, rivers and floodplains. CMAR has some capability and experience in measuring exchanges of dissolved material across the water-sediment interface, both in situ and in sediment cores in the laboratory. Our trace metal capability has been used to understand cycling of metals as both micronutrients and pollutants in coastal waters and sediments.

CMAR has particular expertise in phytoplankton ecology and physiology, with strong links into the international community, especially around the study of Harmful Algal Blooms. This expertise is supported by an internationally recognised algal collection,
and culturing facilities. We’ve made an important contribution to measurements of primary production, especially in the open ocean, including the use of new techniques such as fast-repetition rate fluorometry. We have the leading national laboratory for measurements of phytoplankton pigments and bio-optical properties. We have expertise in phytoplankton taxonomy, and access to flow cytometers to efficiently count and sort field and laboratory samples. As noted earlier, our expertise in phytoplankton physiology and composition has been heavily directed towards aquaculture production over the last 10 years, and is now being utilised in biofuel production and, increasingly, in support of ecological studies of coastal eutrophication. Laboratory phytoplankton experiments have also been directed towards the autecology and physiology of species of environmental significance, especially toxic or harmful bloom species.

By comparison, our capability in zooplankton, bacteria and benthic primary producers is limited, being restricted to one or two scientists in each case. This is augmented by one or two additional scientists studying zooplankton along with micro-nekton as part of fisheries ecology and trophodynamics. CMAR is building core capability (field studies and modelling) of the role of benthic biota and processes in coastal and shelf biogeochemical cycles through the WAMSI NODE 1 project in SW WA.

CMAR is also building capability in the field of environmental genomics, and its application to biogeochemical processes. We see this as an essential future direction for both the characterization of oceanic/coastal communities and ecosystems and in the understanding of system dynamics.

Most of our capability in biological oceanography is currently deployed in the coastal domain. At both coastal and ocean scales, modern biological oceanographic field studies require a large team with a diverse mix of specialist skills and experience. We have relied heavily on collaboration with other agencies (Australian and international) in conducting major multi-disciplinary field programs and experiments, both in the open ocean (such as the Fe fertilization experiment SOIRIE in the Southern Ocean), and in coastal studies. CMAR has a good record of collaboration with CLW biogeochemistry capability (field and modelling) in estuaries and in rivers.

**Biogeochemical Modelling**

CMAR has a world-class biogeochemical modelling capability. Our “blue-water” modellers have implemented ocean carbon cycles within global coupled climate models, and used these to investigate global climate feedbacks and impacts. These models are represented in international intercomparison experiments and in IPCC reports, and will be further developed through ACCESS.

The coastal modelling community is not so international in character, but our modellers are well recognized internationally, and our models compare well with the international state-of-the-art. Our coastal biogeochemical models have been at the forefront in benthic-pelagic coupling, in incorporating multiple functional groups, and in coupling to 3-D hydrodynamic models. Our coastal modelling has also had a strong applied flavour, so the group has a lot of experience in the formulation of management scenarios, and the analysis and visualisation of model output to support decision-making. The group has had strong software support, and pioneered web-based applications for model visualisation and delivery.
Biogeochemical models tend to integrate physical, chemical and biological processes, so we don’t usually distinguish "chemical" from "biological" modellers. We do lack experience in models which deal with specialized chemical processes (e.g. with speciation and equilibria for complex mixtures of trace metals).

CMAR is just beginning to develop its capability in data assimilation and model-data fusion for biogeochemistry. In doing this, we are drawing on the strong experience in data assimilation in physical models gained through BlueLink, but also on increased collaboration with CMIS.

As discussed above, CMAR’s biogeochemical modellers enjoy the benefits of a very strong underpinning physical modelling capability, but they also have the opportunity to support and interact with a world-leading ecosystem modelling capability, in the form of the Atlantis and In Vitro modelling suites. We would expect the biogeochemical and ecosystem models to become more closely integrated over time.

Taking these strengths and weaknesses into account, our evaluation of CMAR’s potential to address the five major challenges is as follows:

a) **Operational Coastal and Ocean Biogeochemical Forecasting**
   World-class, if not world-leading. We can build on BlueLink 1 and 2. Collaborative opportunities exist across CSIRO in sensors, and sensor networks, statistical methods, and ocean colour interpretation. Our modelling capacity adequate, but there is some question as to whether our observational and supercomputer infrastructure is sufficient.

b) **Integrating Biomarker, Isotope and Genomic Research**
   World-class, if we can co-ordinate and bring critical mass to bear from our existing capacity. There is a need to select one or two high-profile high-value targets among many diverse applications, and depending on which are chosen there may be a need to recruit senior capability and build infrastructure around specific science areas.

c) **Integrated biogeochemical and ecosystem models (and observations)**.
   World-class, if we can coordinate and bring critical mass to bear from our existing capacity. Once again, to be world-class, we will need to select one or two high-profile high-value targets among many diverse applications.

d) **Impacts of climate change and acidification on marine ecosystems**
   World-class in the physics and chemistry; gaps in observation infrastructure; strong modelling capability in the biogeochemistry and ecology, but particularly weak in historical observations. Could leap-frog into world-class position with a major investment in modern observing infrastructure.

e) **Enhancing Primary Production**
   World-class, building on experimental, field and modelling strengths. We lack capacity in bacterial ecology/physiology, and are thin in zooplankton. Opportunities in large-scale culturing and production would require collaborations in engineering, processing (for biofuel).
In summary, the MBOPM “science opportunity” is great and our capability is strong in many areas. However, there are critical gaps in technology/infrastructure and in some capability areas. As we describe below, we are also significantly overstretched (i.e. lack capacity) in other, existing capability areas (see below).

The right size and right shape for this core capability over the next 10 years will largely be determined by CSIRO portfolio choices of major science foci, but we’d argue that the best strategy for portfolio leaders will be to focus on/invest meaningfully in advancing a few major science areas, rather than spreading MBOPM capability thinly/sub-optimally across a large number of projects and portfolios.

2. Analyses of Current and Future Capability Deployment across CSIRO’s portfolios

Where is the Capability Area currently deployed?

SIP3 (September 2008) staff allocations to projects show staff in the capability are distributed across 14 Themes (Figure 1). Themes 2 and 4 in WFO account for just over half of the total capability. Another 6.8 FTEs are mapped into 4 support and infrastructure Themes: CMAR Support, Marine National Facility, IMOS and Collections. Another 7 FTEs are mapped across 9 research Themes, at levels ranging from 2 down to 0.1 FTEs.

![Figure 1. Staff allocation by Theme, based on preliminary project data under SIP3.](image)

What is its likely future deployment over the current 3 year SIP cycle?

Views on the future deployment of this capability have been collected through stakeholder workshops, a questionnaire and discussions with theme leaders in CMAR and the WFO, WHIC, and FF flagships. As one might expect with an annual SIP cycle, ET-initiated reviews of portfolios (in WFO a review of SAFE, MCBM and
Marine Nation is currently under way) and a lack of clarity around the “home” of coastal research in CSIRO, these projections of future needs/deployment of MBOPM capability are somewhat uncertain.

**WiO**

Three of the WiO themes – Marine Nation, SAFE and Marine Conservation and Biodiversity Management – are currently being externally reviewed following questions from the CSIRO Executive Team Science Sub Committee on their points of differentiation and focus. The review is considering future directions for these Themes and their relationships with other WiO themes. Early indications from this review suggest a likely refocussing of the Theme portfolios away from individual client/sectoral interests and towards agreed major national/international science goals/challenges. Clarity around this reshaping of the portfolios will develop over the latter months of 2008, and we’d expect the Division to be heavily engaged in discussions about the science directions and capability requirements. Based on pre-review discussions, our understanding of MBOPM future deployments is as follows:

**Marine Nation (currently 13 FTEs)**
The Theme hopes to grow through increasing external income. However, it attaches higher priority to growth in some other areas (e.g. socioeconomics) than to biogeochemistry. It expects to maintain the current effort level in biogeochemistry, but hopes to reshape that capability to meet priority needs. The Theme sees a particularly strong need for models and observing systems which can be rapidly deployed to meet management needs, and subsequently be refined over time. This requires an improved capacity to quantify model uncertainty and error. The Theme sees a potential shortfall in modelling capacity short term, if current client engagement succeeds. [This should be addressed by CMAR’s priority recruitment plans.] The Theme would like to see better integration between biogeochemical and ecosystem models.

The Theme is currently making major strategic investments in capability development, in field process studies such as WAMSI Node 1, in sensor networks and in models. The Theme will continue some level of investment in process studies, but this will need to be sharply focused. It does not see a future in large regional ecosystem studies, unless these are focused on Theme priorities and goals.

The Theme would encourage more collaboration with CLW on coupled catchment-to-coast models and observing networks, with ICT on sensor networks and AUVs, and with CMIS on error analysis.

The Theme sees climate change as an important driver, but is unlikely to have the capacity to support a major marine climate impacts research program. The theme leader indicated that Marine Nation might take on ocean fertilisation as a research area in the future.

**SAFE and MCBM (0.1 FTEs).**

These themes currently use a negligible amount of CMAR’s biogeochemical capability. Both see room for an increase to small amounts – 1 to 2 FTEs each. In the case of SAFE, the need is for better integration of biogeochemistry into ecosystem models used for ecosystem-based fisheries management. In the case of MCBM,
biogeochemistry is seen as providing information about processes supporting and/or
threatening biodiversity. There is potential to use biogeochemistry to support
productivity estimates in the pelagic domain, and rapid assessment of biodiversity in
tropical environments.

Ocean Dynamics (13 FTEs)
The Theme is not expecting major growth, and expects that its appropriation and
external funding envelopes, and total FTEs, will remain fairly flat. That said, the
theme is conducting a due diligence project aimed at evaluating the potential for
development of a new Coastal Assessment and Prediction system. If this study
provides a favourable assessment, one might expect new appropriation investment in
the biogeochemical modelling area in the SIP4 round.

In the absence of new SIP4 funding, the Theme expects its investment in
biogeochemistry to increase slightly. It has negotiated with CMAR to absorb one
additional biogeochemical modeller in SIP3. The Theme’s biogeochemistry is
undergoing a shift in emphasis from studies of carbon cycle feedbacks to attribution
of changes in marine systems due to climate and acidification. It expects that trend to
continue, although there is currently considerable uncertainty around the future
priorities in ACCSP, and any successor to the ACE CRC. The Theme is encountering
some difficulty in developing a strategic approach to marine climate impacts within
the current CSIRO climate structure.

The Theme expects BlueLink 3 to include ocean biogeochemical forecasting, and that
could be augmented by coastal forecasting, depending on the outcome of the Due
Diligence Study.

The Theme currently has a heavy commitment to biogeochemical observations and
process studies, and a relatively small investment in modelling. It is looking to
increase its investment in modelling, but also direct more of its field effort towards
automated and remote observations, to support both climate attribution and ocean
forecasting. The Theme sees potential infrastructure constraints in supercomputing
and automated observing platforms and sensors.

WFHC
Healthy Water Ecosystems (HWE) and Better Basin Futures (BBF) (Total 2.8 FTEs)

WFHC is currently using 2.8 CMAR FTEs, both field and modelling, to support
studies of estuarine and freshwater aquatic systems. This work is expected to be
consolidated into HWE, with the movement of the Tropical Rivers and Coastal
Knowledge (TRACK) projects into HWE later this year.

Bill Young sees the biogeochemical capability in CLW and CMAR as a common
pool, and is prepared to draw from either according to availability and skills. Future
changes in the use of CMAR’s FTEs will essentially depend on shifts in sourcing
between CMAR and CLW. Biogeochemical capability is used in HWE in regional
case studies. He sees an ongoing need for access to the biomarker and isotope skills,
and to hydrodynamic and biogeochemical modelling. Hydrodynamic modelling
capacity is currently a constraint across CLW and CMAR, and CMAR is addressing this in its current priority appointments. He would like to access CMAR’s aquatic ecosystem modelling capability as well.

He has a strategic interest, shared with WfO Theme 4, in the development of coupled catchment-to-coast models. [A workshop on this is planned for early November, with participants from both Divisions and both Flagships].

Petascale Computational and Simulation Science Platform – John Taylor (1.6 FTEs)
This platform incorporates the old Terabyte Science Theme. It supports a strategic CMIS-CMAR project on development of Bayesian hierarchical approaches to error estimation and analysis in biogeochemical models. It is also keen to support development of scalable model codes which run on massively parallel supercomputers. Biogeochemical modelling has been chosen as a demonstration case study for its strategic goals.

Capacity has been an issue here, as CMAR has struggled to recruit a postdoc funded from this project. The Platform could potentially fund another person with suitable modelling and computational skills.

Although the total effort is small, this project has facilitated collaboration with CMIS in a key strategic area for biogeochemical modelling.

Climate Adaptation Flagship (0.2 FTEs).

At present, the flagship uses just 0.2 FTEs of CMAR’s capability, in the Ecosystems Theme. There appears to be some potential to grow that, but probably only to about 2 FTEs

Like SAFE, CAF is interested primarily in coupled biogeochemical-ecosystem modelling. The first priority is in the area of climate impacts on estuarine and coastal ecosystems. There are discussions underway with SAFE about a SE Australian initiative. There are other projects under development in SE Qld / Moreton Bay. There is little prospect of CAF investing in climate impacts research for open ocean ecosystems.

CAF sees potential for more integration of the coastal storm surge / inundation / erosion modelling with biogeochemistry and ecology. (It should be possible to do this through BlueLink and ROAM.)

CAF also sees the need for better catchment to coast integration in dealing with climate impacts, and sees this as a joint task for WfHC, WfO, CAF. The GBR might provide an opportunity for an integrated project across flagship.

Energy Transformed Flagship,

Low Emissions Transport (currently 0 FTE)

CMAR is currently engaged in a project in this theme in the area of biofuel from microalgae. The Theme Leader is quite bullish on the prospects for this area, and sees
it as one of the key medium- to long-range contenders for a serious contribution to biofuel. He thinks the Theme could see up to 20 FTEs invested in this area after 5 years, across biogeochemistry, engineering and processing, with 30% or more coming from CMAR biogeochemistry. He notes strong interest in co-investment from the private sector. Co-production of fuel with other products (feedstock, industrial or pharmaceuticals) is likely to be important.

The Theme Leader sees the key challenge and requirement from CMAR’s biogeochemistry as capacity to choose appropriate microbial species and inform the design of large-scale production systems which control the growth environment to deliver high output of predictable biochemical composition. Modelling and automated observations will have an important part to play. He sees genetic modification as potentially important, but likely following the mass production challenge.

**CMAR**

**Climate and Atmosphere (C&A) Theme (0.6 FTEs)**

The C&A Theme is using 0.6 FTEs to put the marine carbon cycle into global models in ACCESS. This has the potential to grow by about 1 FTE or higher if the ocean carbon cycle assumed higher priority (e.g. if evidence of anomalies in ocean uptake appears).

The Theme will continue to focus on global coupled carbon model at coarse resolution over the next 5 years. This is limited by supercomputer capacity. The Theme will look for synergies with WIO eddy-resolving biogeochemical modelling. In the long run, ACCESS is seen as a cross-scale cross-Theme modelling platform.

The potential for more synergies across atmospheric, terrestrial and marine biogeochemistry are likely to become apparent as we study the interactions in the coupled global models.

**Food Futures**

Breed Engineering (0.4 FTEs)

A growing focus on intensive production systems in aquaculture will likely drive increased need for MBOPM capability, particularly in the areas of optimised production in grow-out ponds and large-scale production of bioflocs as feedstocks. The Theme expects to start with 1 postdoc at Cleveland, potentially growing to 3 FTEs at 5 years.

**Conclusions**

There is clearly considerable uncertainty in virtually all Themes about the direction of their science, and the quantity and composition of the skills required to deliver it, on a 5 year time scale. This is perhaps to be expected, Themes operate in a dynamic external and internal funding environment, and are supposed to respond nimbly to that environment. However, in looking across the CMAR capability areas, this lack of clarity on future directions for MBOPM science seems greater than for many other areas. The challenge for capability leaders is to plan and manage capability in the long term through those fluctuations and uncertainties.
If we added up all the additional FTEs identified in Theme Leader responses, we get a net gain of about 17 FTEs. It would be very optimistic to think these would all materialise. It might be more realistic to suppose we might realise half that number, an increase of around 8 or 9 FTEs. Out of the total, the major current users are forecasting a flat or slightly increasing need. The major contributions come from ET and FF flagships, in the research area of intensive production. The other increases are spread across a number of environmental themes, mostly in the integrated biogeochemistry-ecology area.

3. Analysis of the current and future size and shape of the Capability Area?

Given the uncertainty about output Portfolio/Theme science future growth scenarios (reviews, dependencies for capability pull on successful completions of existing science projects, external earnings etc.) in projecting the future MBOPM capability needs we have returned to the major prospective science areas of the previous section, and asked which of these we can expect to be sustainable given Theme plans.

Operational Coastal and Ocean Biogeochemical Forecasting already attracts strong strategic support in WfO Dynamic Ocean and Marine Nation Themes, and some support from the Petascale Platform. It fits the priority need in Marine Nation for readily implemented models (at least with a flexible interpretation), and could grow substantially in Dynamic Ocean, depending on the current Due Diligence Study. But this area is likely to be supported at critical mass regardless of the outcome of the Due Diligence Study.

There is clearly a strong demand for Integrated biogeochemical and ecosystem models and observations, across the environmental Themes. It could be a challenge to co-ordinate this and deliver critical mass targeted at strategic science goals, given that this demand is spread thin, and individual Themes may have tactical requirements. Our assessment of the way forward is to let the ecosystem modelling, which is attracting strong demand and strategic investment in its own right, drive this science area, and ensure key biogeochemical capability is available to engage. This approach acknowledges there may be a decreased draw on observational capability in this area.

If the medium- to long-term “possibilities” around biofuels and aquaculture production become reality, CMAR would need to grow capability in the Enhancing Primary Production research area to critical mass (i.e. around 10 FTEs). While WfO themes are hesitant to commit at this stage to investment in ocean fertilization research, they are not ruling it out. If this area became a focus following the WfO Theme reviews, this research area will grow beyond critical mass.

While there is likely sufficient investment in WfO Theme 2 to support Impacts of Climate Change and Acidification on Marine Ecosystems, and potentially some additional support from CAF and/or SAFE, we think there is cause for concern about the overall level of investment in this area, given the potential extent of the problem. We’re particularly concerned that the proposed investment seems unlikely to support an adequate observation program. To put it bluntly, it appears that the economic and social value attached to our marine ecosystems is sufficiently low, at least compared.
with coastal infrastructure (for example), that as a nation we’re prepared to let impacts of climate change and acidification on our marine ecosystems proceed on an out-of-sight, out-of-mind basis, except perhaps in some iconic systems like the GBR. That seems to be an almost inevitable consequence of the way research priorities are being set nationally and within CSIRO. There may be opportunities to change this situation, through IMOS and successors to the ACE CRC, but it will require leadership.

Although most Themes seem prepared to support the Integrating Biomarker, Isotope and Genomic Research science area, the level of investment in each Theme is low. This will make it especially challenging to maintain the strategic focus needed to achieve world-class results. CMAR believe there is an opportunity to focus more seriously on marine environmental genomics. Based on input from international reviewers at the WfO Three Theme Review the opportunity may even be a necessity if we are to keep pace with international efforts in understanding the roles of microbes in the marine environment. Clearly this is an area where CMAR as a capability home with views on the future directions of marine science needs to work closely with Portfolio Leaders to establish the required level of support for this area of science.

Conclusions
Given recent priority hires and lack of clarity about further growth potential for this capability, MBOPM will not be targeted for growth over the next 3 years, beyond the priority appointments already committed. Growth in the out-years will depend on uptake of some of the potential science growth areas, and we plan to work closely with Output Leaders to influence investment into these science areas.

There is a need to reshape the MBOPM capability over the next 3 years, through building up some components and downsizing others.

Modelling – statistical capability
In response to strong calls from Output Portfolio Leaders, we have increased the MBOPM hydrodynamic and biogeochemical modelling capacity (including programming support) by 2 FTEs in 2008 (a hydrodynamics position is still unfilled). This is seen as sufficient for the work anticipated over the next few years. However, the potential loss of senior leadership in this area makes development and/or recruitment of potential leaders in this component of the MBOPM capability a high priority.

We recognize the need to continue to strengthen the statistics in our biogeochemical modelling. This may be possible through our relationship with CMIS, but this will require explicit conversations to avoid unmet expectations/needs. If CMIS chooses not to deploy their capability in this area, we may need to examine this as a priority recruitment area.

Environmental Genomics
The inclusion of environmental genomics capability within MBOPM is intended to provide impetus for development of critical mass in this area over the next 3 to 5 years. To fast track development of a compelling science proposition for output portfolio leaders in WfO and WfHC, we will recruit a senior leader to work with our existing research scientists.
Observational/Field capability (across physics, chemistry and biology).
Our analysis of national and CSIRO environmental Theme requirements and
international trends (towards the use of automated sensor networks and platforms),
suggests that we will have an increasing need for field scientists who can support a
strong shift towards automated and remote field measurements.

Our current observational capability lacks the skills to support that move. The need is
not necessarily for scientists to be involved in sensor development. Rather, it is for
people who understand and know the systems being observed, and the nature and
limitations of the sensors used to observe them. They are also quantitative scientists
who are capable of analysing and interpreting the observations, and build international
reputations around those interpretations. They will understand numerical models, and
work hand-in-hand with modellers, but building and running numerical models is not
their primary role.

We have excellent role models among our physical oceanographers, but lack those
people in the chemical and biological domains. We are consequently struggling to
find people to scientifically direct and exploit aspects of IMOS, or to sit alongside and
collaborate with the technologists involved in sensor and sensor network
development. Similarly, we have failed to exploit ocean colour data to anywhere near
the extent we might have expected 10 years ago. It’s worth noting that people with
these skills are often capable of working across disciplines.

Most of the environmental Themes are looking to reduce their investment in classical
process studies, and increase their investment on observing networks. We will need to
make a corresponding transition in the kind of capability we provide. That may be
achieved by retraining, or may require recruitment. Given the critical role SE&T plays
in supporting our field observations, we probably need to look hard at the capability
mix in our support as well research groups in terms of our ability to support new
observing systems.

We note that CMAR currently lacks expertise in the ecophysiology of bacteria and
zooplankton – capability that is associated with research domains such as intensive
production and marine climate impacts which are currently potential growth areas.
Our judgement is that in the next three years we will seek to partner with other
agencies and universities where this capability is required, rather than recruit and
extend our capability base. Subject to internal investment in these areas over this
period, this decision will be reviewed at the end of the three years.

4. Key Internal (One-CSIRO) Relationships: dependencies/partnerships/brief
SWOT
- Divisions –
  CLW and CMAR aquatic biogeochemists have worked together on a number of
projects over the last decade, principally in estuarine and coastal systems. CLW
also has a strong coastal remote sensing capability with whom CMAR
biogeochemists and remote sensing researchers have collaborated. Given recent
retirements in this capability area in both CLW and CMAR, the leadership of the
two divisions have agreed to work together in the development and shaping of this
shared capability area.
CMIS also have relevant expertise in environmental modelling and remote sensing. CMAR has recently developed a collaborative relationship with CMIS through their XXXXXX Theme.

- **Flagships**
  WIO is likely to remain the most important output portfolio for this capability. The flagship is currently working with clients to evaluate the possibility of a Bluelink III collaboration, and is also undertaking a due diligence study on the prospects for a significant investment in a national coastal modelling framework.

- **Platforms – current, future ideas**
  A key area for the future is the use of genomic techniques to study biogeochemical processes – especially microbiological processes – on scales and with a rapidity not hitherto achievable. Increasingly, these studies will use autonomous sensing devices, deployed on a range of moorings, autonomous robots (e.g. Argo floats, gliders) and ship-deployed platforms. The very exciting prospect is that data about biogeochemical processes will become part of the suite of routinely monitored data available from ocean observing systems, and leading to Operational Coastal and Ocean Biogeochemical Forecasting. The development of the autonomous genomics-based sensors themselves is a matter of collaboration between the MBOPM capability and other labs around the world. But this vision is critically dependent on the development of the platforms. The Marine National Facility (Research Vessel) is fundamental; we also depend on the continued development of towed, mooring-mounted and autonomous platforms and their communication mechanisms.

5. **Key External Relationships : Dependencies/partnerships and collaborations/ competition/brief SWOT**

- Other R&D providers (Unis and Publicly Funded Research Agencies)
  Members of the capability have a number of individual contacts and collaborations with various universities in Australia and overseas. These are mainly collaborations and partnerships; there are very few, quite local instances in which universities could be said to be our competitors. AIMS has been a collaborator and has the potential to be a competitor, but we see AIMS’s development of a new Centre for Marine Microbiology and Genetics Research, and our development of microbial genomics as complementary and anticipate a valuable collaboration. We have had preliminary discussions which will be further pursued later this year. State agencies, again, may be competitors or collaborators. We have had effective collaboration, for example, with SARDI and TAFI in relation to the environmental impacts of aquaculture; we anticipate increasing interactions with Queensland DPI regarding the development of novel approaches to aquaculture production.

- Federal, state and local government clients
  State agencies have been our clients for studies of biogeochemical processes and the impacts of human activities on a range of scales (e.g. Port Phillip Bay, Gippsland Lakes, the Clarence River, the Derwent/Tasman complex).
  We have worked less frequently with Federal agencies as clients, although DEWHA is always a potential client and there has been considerable
discussion with GBRMPA about approaches to water quality in the GBR lagoon.

Local government should be a major client for our work, since so many of the biogeochemical consequences of human activities in coastal systems fall under their management. Their needs, almost invariably, are not only for a biogeochemical study producing a model of hydrodynamics, nutrient flows and biological responses, but for integrated management informed by such science. CSIRO (across several divisions but strongly in CMAR, combining our MBOPM, MSERAEM and SOPM capabilities) has relevant expertise and has articulated the vision a number of times, but it has been difficult to engage with local governments on a scale where we can best contribute. Exceptions arise when a number of local councils, often with State agencies, form some kind of consortium (e.g. Adelaide Coastal Waters; Port Phillip Bay; South-east Queensland). For CSIRO really to have impact in the coastal arena, it is necessary for Australia to find some way of extending these limited examples.

- Industry clients and stakeholders
  
  We have industry clients for some of the above (e.g. environmental impacts of aquaculture; increasingly regarding microbial aspects of aquaculture production itself, and occasionally with other industries) but much of it is in the “public good” arena and the clients are agencies at all levels of government.

- International linkages
  
  Members of the capability have been well connected internationally for a long time (e.g. LOICZ, IMBER) and are strong contributors to international conferences (e.g. ASLO). However, there is certainly scope and need to develop more formal involvement in these international programs. They have strong contacts and growing collaborations regarding the development of novel genomics-based sensors. BGC will become increasingly a critical part of Ocean Observing, and so it is important that these international connections are nurtured.

- Funding agencies
  
  Whilst some of our funding has come from R&D Corporations, much of it comes directly from either the industrial client or the relevant State of Commonwealth agency. As noted above, the area in which our MBOPM capability (coupled with others) has perhaps the most to offer is coastal environmental management, but this is unfortunately the most difficult to fund because of the plethora of responsible agencies.

6. Infrastructure needs

Supercomputing remains a vexed issue for CSIRO. While we may have agreed on an upgrade for the joint BoM-CSIRO facility, the fact remains that CSIRO and Australia are not anywhere near the forefront in terms of global supercomputing. That’s an issue, if we’re serious about world-class research. The situation is considerably worse for research groups operating at the next level down. The Petascale Platform is at least bringing a computation / simulation science perspective to the table, but it remains to be seen whether there’s a mechanism to get the investment needed.
The other major infrastructure issue is investment in observing platforms and instruments. Initiatives such as the sensor cluster may result in low-cost sensors somewhere down the track, but for the next 5 years, and perhaps the next 10, most sensors will continue to be very expensive. If we want to conduct world-class research to demonstrate sensor networks and data-assimilating models, we will need to make investments at scales comparable to those being made in world-leading studies overseas. That may require an order of magnitude increase over current investment levels. That could be affordable in principle (it's well within the IMOS budget), but it would require a more geographically focused deployment than IMOS has achieved to date.

If we want to stay world-class in our existing science areas, there will be a need to maintain and upgrade the wide variety of existing laboratory and field equipment. There are some CAPEX gaps which are more specific to particular problems. For example, if research into intensive production proceeds, we'll need to consider how to access mesocosm and pilot plant facilities.

As this research area moves increasingly into the Ocean Observing realm (and eventually to Operational Coastal and Ocean Biogeochemical Forecasting), large amounts of data will be generated and it is important that CMAR manages this well, and makes information widely accessible using web-based tools. Thus, this capability area has a strong interest in the current divisional review of data, visualisation and programming.
Hi all.

Here's my attempt at taking JV's comments on board while not losing the essence of where JG is coming from.

I'll leave it at that for now. If there is another version over the weekend, we'll put it on the intranet on Monday.

Thanks, Tim

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Moltmann, Tim
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From: Moltmann, Tim (CMAR, Hobart)
Sent: Friday, 31 October 2008 3:58 PM
To: Volkman, John (CMAR, Hobart)
CC: Butler, Alan (CMAR, Hobart); Parslow, John (CMAR, Hobart); Gunn, John (CMAR, Hobart)
Subject: FW: MBOPM revision
Thanks John (V).

Will look to take on your feedback in the interests of making this draft constructively provocative.

Have out John G in the loop as well.

Regards, Tim

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From: Volkman, John (CMAR, Hobart)
Sent: Friday, 31 October 2008 3:52 PM
To: Butler, Alan (CMAR, Hobart)
Cc: Moltmann, Tim (CMAR, Hobart); Parslow, John (CMAR, Hobart)
Subject: RE: MBOPM revision

Hi Tim,

I've been through the document and made a number of small changes (in green on my version). I and others think that the document stands out from other capability documents in making a number of strong assertions about direction that have not been rigorously discussed. There are three statements that I would particularly challenge (see imbedded comments):

1. That “we” need to choose 2-3 of the 5 nominated areas. In fact there is a lot of commonality between them and many require a similar skill set. I would argue that the (internal and external) markets will decide where the emphasis will be and we should be focussing on ensuring that we have the capability to meet the need. I've suggested some new wording in the comment.

2. There is a bald statement that no growth is targeted for the next 3 years, but the following text points out a number of possible growth areas. I simply can't see how this need (if it eventuates) can be met solely from reshaping.

3. The notion that the ecosystem modelling should drive our decision making really goes against the grain. We should certainly aim for better linking and integration (and are doing so), but it is demonstrably clear that our biogeochemical modelling and measurement expertise has strong stakeholder and real client support in its own right (although widely distributed across CSIRO as currently structured).

Best regards
John Volkman

p.s. I've copied in John Parslow who was responsible for creating much of the original text that was recycled into this document and would certainly have a view on these matters.

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1/03/2011
Hi John,

We (JG in South Africa and I in Hawaii) are engaged in a last-minute rush to revise the MBOPM proforma before it goes on the www for staff consultation (by COB today).

Attached is a copy with some recent tracked changes by me. If you have time to have a look that would be good, since you know the client engagement area much better than I do. If you have any comments, please get them back to Tim Moltmann.

Many thanks,

Al.

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CMAR Capability Development Plan
MBOPM

Executive Summary

This capability focuses on the study of the cycling, fate and impact of materials
(major and minor elements, and pollutants or toxicants) in aquatic ecosystems
(typically focused on lower trophic levels), ranging from estuarine to coastal and
oceanic waters.

It is by necessity multi-disciplinary, integrating across the classical disciplines of
physical, chemical and biological oceanography. Within each of these disciplines, it
embraces field observations, laboratory and field process studies, and modelling. Staff
in this capability work closely with a number of other CMAR capabilities – most
notably MSEE, SOPM and CESM, and with freshwater and estuarine
biogeochemists and modellers in CLW.

From January 2009, all CMAR staff with a primary focus in this domain will be
grouped within the MBOPM core capability – ensuring that we optimize the synergies
of working from estuaries to oceans and local to global scales. We recognize that for
the potential of this group to be realized, significant investment is required in research
infrastructure (super-computing, sensors and sensor networks, and a variety of
platforms for them, e.g. a modern research vessel, moorings, autonomous floats and
vehicles).

For this capability to maintain and grow its international reputation it needs to work
with output domains to focus efforts on a few major areas. We have reviewed areas
for which exciting opportunities exist over the next decade and believe the most
prospective (given existing capability mix, national priorities and international trends)
are in the areas of:

- Operational Coastal and Ocean Biogeochemical Forecasting
- Integrating Biomarker, Isotope and Genomic Research
- Integrated biogeochemical and ecosystem models (and observations).
- Impacts of Climate Change and Acidification on Marine Ecosystems
- Enhancing Primary Production

Some of these are already foci (or project areas) for Flagship themes, others are
embryonic. Unless there is significant, externally-funded growth in resourcing for this
capability, it may be that not all of these areas can be pursued by CMAR, as the
current fractionation of biogeochemical research across 14 Themes (11 of which use
<2 FTE of MBOPM capability) works against the impact of the science and the
capability.

CMAR analysis of capability strengths and weaknesses has led to 5 recent priority
hires in MBOPM in 2008. Following this burst of recruitment, it is unlikely that there
will be a similar level of growth over the next 3 years as the bigger opportunities are
on longer time horizons. Resizing of the capability in out-years will depend on
uptake of some of the potential science growth areas, and we plan to work closely with Output Leaders to influence investment into these science areas.

While growth is not supported, there is a need to reshape the MBOPM capability over the next 3 years, through building up some components and downsizing others. The marine environmental genomics area requires senior leadership to guide development of this area and its integration into the broader environmental and climate science undertaken by CMAR staff.

National and international trends (towards the use of automated sensor networks and platforms), also suggests that we will have an increasing need for field scientists who can support a strong shift towards automated and remote field measurements. Our current observational capability lacks the skills to support this shift in emphasis and we will move to overcome this shortcoming. The need is not necessarily for scientists to be involved in sensor development. Rather, it is for people who understand and know the systems being observed, and the nature and limitations of the sensors used to observe them. They are also quantitative scientists who are capable of analysing and interpreting the observations, and build international reputations around those interpretations. They will understand numerical models, and work hand-in-hand with modellers, but building and running numerical models is not their primary role.
1. Description of the Core Capability and its science base

Core Capability: Marine Biogeochemical Observations, Processes and Modelling (MBOPM)


Related Capabilities in CMAR: MSEEM, SOPM, CSEM

Number of staff as of 1 July 2008: TBA

Number of staff x Site: TBA

What is the unifying/core science focus for staff in this Core Capability

MBOPM focuses on the study of the cycling, fate and impact of materials (major and minor elements, and pollutants or toxicants) in aquatic ecosystems (typically focused on lower trophic levels).

It is by necessity multi-disciplinary, and in the marine domain, it effectively integrates across the classical disciplines of physical, chemical and biological oceanography. Within each of these disciplines, it embraces field observations, laboratory and field process studies, and modelling.

In 2008, as has been the case for a number of years, the capability is spread (in many cases thinly) across a wide number of portfolios and thematic areas in CSIRO. Arguably, the fractionated deployment of MBOPM capability across so many projects and themes hinders CSIRO’s ability to concentrate effort on the biogeochemical components of Australian oceanic, coastal and aquatic systems. However, it is equally true that there is a strong demand for these skills across a wide range of output areas within CSIRO’s broader portfolio which would have to be met from elsewhere in CSIRO if a key strategic goal for CMAR/MBOPM is to influence CSIRO output portfolio priorities in the broad area of marine biogeochemistry. We believe this is best achieved through clear articulation of where the capability is most effectively focussed to increase the impact of output portfolios such as the WfO, CAF and WfHC Flagships, as well as CMAR’s own Climate and Atmosphere theme.

What are likely to be the major trends in science in this capability over the next 3, 6, 12 years?

Having analysed international trends and the current skill mix and science applications of the capability group, Parslow (2008) identified five major science areas where CSIRO might focus its capability in order to contribute significantly to international advances in marine biogeochemistry over the next 5 to 10 years:

a) Operational Coastal and Ocean Biogeochemical Forecasting

The international community plans to extend ocean forecasting capability from eddy-resolving regional models to inshore coastal, and from physics to biogeochemistry (e.g. in the transition from GODAE to CODAE).

b) Integrating Biomarker, Isotope and Genomic Research

MBOPM
These techniques in combination promise to deliver new insights into ecophysiological processes, both in the field and in the laboratory, and to enhanced understanding of organic matter sources and cycling. They also offer new observing tools and diagnostic indicators.

c) **Integrated biogeochemical and ecosystem models (and observations).**
The traditional boundary between biogeochemical and ecosystem models, drawn at the herbivore level, is arbitrary, and its existence is counter-productive for important applications from both sides. There is now a major international IGBP research program, IMBER, with the objective of integrating across this boundary in ocean ecosystems, and LOICZ shares this goal for coastal ecosystems. The opportunity for integration of the CMAR’s MBOPM capability with our leading edge ecosystem and earth system modelling capabilities is exciting and provides a compelling vision for science and capability development over the next 10 years.

d) **Impacts of Climate Change and Acidification on Marine Ecosystems**
The potential impacts of climate change, and acidification, on marine ecosystems are now recognized as serious and potentially catastrophic. These are hot international research topics, with great relevance to Australia’s marine systems.

e) **Enhancing Primary Production**
The science challenge is to translate knowledge of biogeochemistry in general, and phytoplankton ecophysiology in particular, into practical tools to help design and manage highly perturbed (eco)systems for organic matter production and microbial transformation. This applies across large-scale ocean fertilisation, biofuel from microalgae and intensive aquaculture production.

*How well could CMAR/CSIRO tackle these challenges with existing capability/capacity? SWOT analysis.*

Clearly each of these areas involve major (and difficult) science challenges, and as with many of our science fields, we may/will need to consider how many CSIRO wants to tackle, and importantly how we might best partner with others (nationally and internationally) to achieve the quality and depth of science required. In developing a strategic plan for the MBOPM we have considered how well CMAR is currently placed from a capability/capacity perspective to work effectively on these challenges. A summary of these considerations is provided below.

**Physics**
CMAR’s ocean and coastal physical science capability is particularly strong. Only a small proportion of CMAR’s capability in physical oceanography is mapped formally into the MBOPM capability, but it’s worth looking briefly at the broader physical capability, because it plays such an important underpinning role for biogeochemical science. At ocean basin scales, CMAR has world-leading and/or world-class strength in physical oceanographic observations. We are world leaders in Southern Ocean studies, and play a regional lead role in studies of the Indian Ocean and Indonesian Throughflow, and the Tasman and Coral Seas. We play a well-recognised role in the international ARGO program, and in the science of altimetry. We have played a long-term leading role in maintaining regional ocean observations through ships of opportunity.
We have a long history of oceanographic field studies at continental shelf scales, including the major boundary currents around Australia. Most recently, we have played a lead role in forming a national partnership to successfully bid for NCRIS funding for an Australian Integrated Marine Observing System (IMOS). A substantial fraction of that investment is going towards enhancing our observations of Australia’s continental shelves and boundary currents, and their interactions with basin scale circulation.

Our physical modelling capability at ocean basin scales is also particularly strong. The CSIRO-BoM partnership CAWCR maintains an international reputation as one of a small number of credible producers of global coupled ocean-atmosphere climate models for IPCC scenarios and for studies of climate variability. We are valued partners in the development of the MOM community ocean model. Over the last 5 years, the BlueLink program has given us world-class ranking in the development of eddy-resolving, data-assimilating ocean forecasting models. The BlueLink modelling system is in itself a critically important platform for biogeochemical studies around Australia.

Our coastal physical oceanographic capability has been through something of a dip (at least in terms of numbers) over the last decade. Nonetheless, we have through this period developed a very strong and sophisticated coastal modelling suite, which has been adopted by other partners in Australia. Our coastal physical modelling capability has been recently enhanced through improved integration between offshore and inshore, primarily as a result of BlueLink extending its operational forecasting capability inshore. This has seen the development of the relocatable, local atmosphere-ocean modelling system ROAM, and plans for a national high-resolution continental shelf model (Ribbon model). It has also seen our modellers assisting in the implementation of coastal processes into the MOM community model. The BlueLink data-assimilation scheme (BODAS) has just been implemented in our coastal circulation models.

We have maintained a small but effective effort in sediment modelling, primarily to address the role of turbidity in biogeochemical systems. BlueLink is driving an expansion in our capability in wave observations and modelling, and wave-current interactions, especially in near-shore areas, and this is likely to be extended to coastal geomorphology.

We have few dedicated observational scientists in coastal physical oceanography. Our coastal modellers have experience in making and interpreting field measurements. Moreover, the support group in CMAR provides extremely strong expertise and experience in maintenance and deployment of instruments and sensors, in mooring design, and in advanced platforms such as ARGO, across blue water and coastal scales. CMAR has a large and growing pool of oceanographic instruments, and access to others through national (IMOS) and international collaboration.

The bottom line here is that CMAR has the capability to implement state-of-the-art circulation models, supported by state-of-the-art observations, at scales ranging from ocean basin to estuaries. CMAR (with BoM) is seen in international circles as being at
the forefront of attempts to develop a seamless nested ocean forecasting capability across these scales.

**Chemistry and Biology**

CMAR has a strong observational capability in chemical oceanography at both ocean basin and coastal scales. We have an internationally recognised ability to make high precision measurements of inorganic carbon parameters, and have made an important contribution to knowledge of these fields in the oceans around Australia, especially in the Southern Ocean. This capability should play an important role in monitoring and understanding regional variation in ocean acidification and carbonate saturation. We have internationally recognised expertise in measurements of vertical fluxes of sedimenting material, and have maintained an important time series of sediment traps for the Southern Ocean. We have a long history of ultra-clean sample collection and analysis at sea, and with the recent acquisition of ICP-MS facilities, capacity to make an important contribution to knowledge of regional micronutrient distributions. We support routine hydrochemistry through the national facility, and have the ability to measure very low (nM) levels of macronutrients in oligotrophic mixed layers.

CMAR has a strong capability in organic chemistry, and specifically in the identification and measurement of biomarkers, including pigments and lipids. There is the potential to link this to our capability in natural isotope measurement, to provide a powerful tool for source discrimination and historical reconstruction, as discussed above. These techniques are used in paleo-oceanography, but have recently been applied mostly in studies of the sources, cycling and fate of organic matter and nutrients in coastal marine systems, and in estuaries, rivers and floodplains. CMAR has some capability and experience in measuring exchanges of dissolved material across the water-sediment interface, both *in situ* and in sediment cores in the laboratory. Our trace metal capability has been used to understand cycling of metals as both micronutrients and pollutants in coastal waters and sediments.

CMAR has particular expertise in phytoplankton ecology and physiology, with strong links into the international community, especially around the study of Harmful Algal Blooms. This expertise is supported by an internationally recognised algal collection, and culturing facilities. We’ve made an important contribution to measurements of primary production, especially in the open ocean, including the use of new techniques such as fast-repetition rate fluorometry. We have the leading national laboratory for measurements of phytoplankton pigments and bio-optical properties. We have expertise in phytoplankton taxonomy, and access to flow cytometers to efficiently count and sort field and laboratory samples. As noted earlier, our expertise in phytoplankton physiology and composition has been heavily directed towards aquaculture production over the last 10 years, and is now being utilised in biofuel production and, increasingly, in support of ecological studies of coastal eutrophication. Laboratory phytoplankton experiments have also been directed towards the autecology and physiology of species of environmental significance, especially toxic or harmful bloom species.

By comparison, our capability in zooplankton, bacteria and benthic primary producers is limited, being restricted to one or two scientists in each case. This is augmented by one or two additional scientists studying zooplankton along with micro-nekton as part of fisheries ecology and trophodynamics. CMAR is building core capability (field...
studies and modelling) of the role of benthic biota and processes in coastal and shelf biogeochemical cycles through the WAMSI NODE 1 project in SW WA.

CMAR is also building capability in the field of environmental genomics, and its application to biogeochemical processes. We see this as an essential future direction for both the characterization of oceanic/coastal communities and ecosystems and in the understanding of system dynamics.

Most of our capability in biological oceanography is currently deployed in the coastal domain. At both coastal and ocean scales, modern biological oceanographic field studies require a large team with a diverse mix of specialist skills and experience. We have relied heavily on collaboration with other agencies (Australian and international) in conducting major multi-disciplinary field programs and experiments, both in the open ocean (such as the Fe fertilization experiment SOREEE in the Southern Ocean), and in coastal studies. CMAR has a good record of collaboration with CLW biogeochemistry capability (field and modelling) in estuaries and in rivers.

**Biogeochemical Modelling**

CMAR has a world-class biogeochemical modelling capability. Our “blue-water” modellers have implemented ocean carbon cycles within global coupled climate models, and used these to investigate global climate feedbacks and impacts. These models are represented in international intercomparison experiments and in IPCC reports, and will be further developed through ACCESS.

The coastal modelling community is not so international in character, but our modellers are well recognized internationally, and our models compare well with the international state-of-the-art. Our coastal biogeochemical models have been at the forefront in benthic-pelagic coupling, in incorporating multiple functional groups, and in coupling to 3-D hydrodynamic models. Our coastal modelling has also had a strong applied flavour, so the group has a lot of experience in the formulation of management scenarios, and the analysis and visualisation of model output to support decision-making. The group has had strong software support, and pioneered web-based applications for model visualisation and delivery.

Biogeochemical models tend to integrate physical, chemical and biological processes, so we don’t usually distinguish “chemical” from “biological” modellers. We do lack experience in models which deal with specialized chemical processes (e.g. with speciation and equilibria for complex mixtures of trace metals).

CMAR is just beginning to develop its capability in data assimilation and model-data fusion for biogeochemistry. In doing this, we are drawing on the strong experience in data assimilation in physical models gained through BlueLink, but also on increased collaboration with CMIS.

As discussed above, CMAR’s biogeochemical modellers enjoy the benefits of a very strong underpinning physical modelling capability, but they also have the opportunity to support and interact with a world-leading ecosystem modelling capability, in the form of the Atlantis and In Vitro modelling suites. We would expect the biogeochemical and ecosystem models to become more closely integrated over time.
Taking these strengths and weaknesses into account, our evaluation of CMAR’s potential to address the five major challenges is as follows:

a) **Operational Coastal and Ocean Biogeochemical Forecasting**
World-class, if not world-leading. We can build on BlueLink 1 and 2. Collaborative opportunities exist across CSIRO in sensors and sensor networks, statistical methods, and ocean colour interpretation. Our modelling capacity adequate, but there is some question as to whether our observational and supercomputer infrastructure is sufficient.

b) **Integrating Biomarker, Isotope and Genomic Research**
World-class, if we can co-ordinate and bring critical mass to bear from our existing capacity. There is a need to select one or two high-profile high-value targets among many diverse applications, and depending on which are chosen there may be a need to recruit senior capability and build infrastructure around specific science areas.

c) **Integrated biogeochemical and ecosystem models (and observations).**
World-class, if we can coordinate and bring critical mass to bear from our existing capacity. Once again, to be world-class, we will need to select one or two high-profile high-value targets among many diverse applications.

d) **Impacts of climate change and acidification on marine ecosystems**
World-class in the physics and chemistry; gaps in observation infrastructure; strong modelling capability in the biogeochemistry and ecology, but particularly weak in historical observations. Could leap-frog into world-class position with a major investment in modern observing infrastructure.

e) **Enhancing Primary Production**
World-class, building on experimental, field and modelling strengths. We lack capacity in bacterial ecology/physiology, and are thin in zooplankton. Opportunities in large-scale culturing and production would require collaborations in engineering, processing (for biofuel).

In summary, the MBOPM “science opportunity” is great and our capability is strong in many areas. However, there are critical gaps in technology/infrastructure and in some capability areas. As we describe below, we are also significantly overstretched (i.e. lack capacity) in other, existing capability areas (see below).

The right size and right shape for this core capability over the next 10 years will largely be determined by CSIRO portfolio choices of major science foci, but we’d argue that the best strategy for portfolio leaders will be to focus on/invest meaningfully in advancing a few major science areas, rather than spreading MBOPM capability thinly/sub-optimally across a large number of projects and portfolios.

2. **Analyses of Current and Future Capability Deployment across CSIRO’s portfolios**

*Where is the Capability Area currently deployed?*
SIP3 (September 2008) staff allocations to projects show staff in the capability are distributed across 14 Themes (Figure 1). Themes 2 and 4 in WfO account for just over half of the total capability. Another 6.8 FTEs are mapped into 4 support and infrastructure Themes: CMAR Support, Marine National Facility, IMOS and Collections. Another 7 FTEs are mapped across 9 research Themes, at levels ranging from 2 down to 0.1 FTEs.

![Staff allocation by Theme](image)

**Figure 1. Staff allocation by Theme, based on preliminary project data under SIP3.**

*What is its likely future deployment over the current 3 year SIP cycle?*

Views on the future deployment of this capability have been collected through stakeholder workshops, a questionnaire and discussions with theme leaders in CMAR and the WfO, WhHC, and FF flagships. As one might expect with an annual SIP cycle, ET-initiated reviews of portfolios (in WfO a review of SAFE, MCBM and Marine Nation is currently under way) and a lack of clarity around the “home” of coastal research in CSIRO, these projections of future needs/deployment of MBOPM capability are somewhat uncertain.

**WfO**

Three of the WfO themes – Marine Nation, SAFE and Marine Conservation and Biodiversity Management – are currently being externally reviewed following questions from the CSIRO Executive Team Science Sub Committee on their points of differentiation and focus. The review is considering future directions for these Themes and their relationships with other WfO themes. Early indications from this review suggest a likely refocussing of the Theme portfolios away from individual client/sectoral interests and towards agreed major national/international science goals/challenges. Clarity around this reshaping of the portfolios will develop over the latter months of 2008, and we’d expect the Division to be heavily engaged in discussions about the science directions and capability requirements. Based on pre-review discussions, our understanding of MBOPM future deployments is as follows:
Marine Nation (currently 13 FTEs)
The Theme hopes to grow through increasing external income. However, it attaches higher priority to growth in some other areas (e.g. socioeconomics) than to biogeochemistry. It expects to maintain the current effort level in biogeochemistry, but hopes to reshape that capability to meet priority needs. The Theme sees a particularly strong need for models and observing systems which can be rapidly deployed to meet management needs, and subsequently be refined over time. This requires an improved capacity to quantify model uncertainty and error. The Theme sees a potential shortfall in modelling capacity short term, if current client engagement succeeds. [This should be addressed by CMAR’s priority recruitment plans.] The Theme would like to see better integration between biogeochemical and ecosystem models.

The Theme is currently making major strategic investments in capability development, in field process studies such as WAMS! Node 1, in sensor networks and in models. The Theme will continue some level of investment in process studies, but this will need to be sharply focused. It does not see a future in large regional ecosystem studies, unless these are focused on Theme priorities and goals.

The Theme would encourage more collaboration with CLW on coupled catchment-to-coast models and observing networks, with ICT on sensor networks and AUVs, and with CMIS on error analysis.

The Theme sees climate change as an important driver, but is unlikely to have the capacity to support a major marine climate impacts research program. The theme leader indicated that Marine Nation might take on ocean fertilisation as a research area in the future.

SAFE and MCBM (0.1 FTEs).
These themes currently use a negligible amount of CMAR’s biogeochemical capability. Both see room for an increase to small amounts – 1 to 2 FTEs each. In the case of SAFE, the need is for better integration of biogeochemistry into ecosystem models used for ecosystem-based fisheries management. In the case of MCBM, biogeochemistry is seen as providing information about processes supporting and/or threatening biodiversity. There is potential to use biogeochemistry to support productivity estimates in the pelagic domain, and rapid assessment of biodiversity in tropical environments.

Ocean Dynamics (13 FTEs)
The Theme is not expecting major growth, and expects that its appropriation and external funding envelopes, and total FTEs, will remain fairly flat. That said, the theme is conducting a due diligence project aimed at evaluating the potential for development of a new Coastal Assessment and Prediction system. If this study provides a favourable assessment, one might expect new appropriation investment in the biogeochemical modelling area in the SIP4 round.

In the absence of new SIP4 funding, the Theme expects its investment in biogeochemistry to increase slightly. It has negotiated with CMAR to absorb one additional biogeochemical modeller in SIP3. The Theme’s biogeochemistry is undergoing a shift in emphasis from studies of carbon cycle feedbacks to attribution.
of changes in marine systems due to climate and acidification. It expects that trend to continue, although there is currently considerable uncertainty around the future priorities in ACCSP, and any successor to the ACE CRC. The Theme is encountering some difficulty in developing a strategic approach to marine climate impacts within the current CSIRO climate structure.

The Theme expects BlueLink 3 to include ocean biogeochemical forecasting, and that could be augmented by coastal forecasting, depending on the outcome of the Due Diligence Study.

The Theme currently has a heavy commitment to biogeochemical observations and process studies, and a relatively small investment in modelling. It is looking to increase its investment in modelling, but also direct more of its field effort towards automated and remote observations, to support both climate attribution and ocean forecasting. The Theme sees potential infrastructure constraints in supercomputing and automated observing platforms and sensors.

WFHC

*Healthy Water Ecosystems (HWE) and Better Basin Futures (BBF) (Total 2.8 FTEs)*

WFHC is currently using 2.8 CMAR FTES, both field and modelling, to support studies of estuarine and freshwater aquatic systems. This work is expected to be consolidated into HWE, with the movement of the Tropical Rivers and Coastal Knowledge (TRACK) projects into HWE later this year.

Bill Young sees the biogeochemical capability in CLW and CMAR as a common pool, and is prepared to draw from either according to availability and skills. Future changes in the use of CMAR’s FTEs will essentially depend on shifts in sourcing between CMAR and CLW. Biogeochemical capability is used in HWE in regional case studies. He sees an ongoing need for access to the biomarker and isotope skills, and to hydrodynamic and biogeochemical modelling. Hydrodynamic modelling capacity is currently a constraint across CLW and CMAR, and CMAR is addressing this in its current priority appointments. He would like to access CMAR’s aquatic ecosystem modelling capability as well.

He has a strategic interest, shared with WfO Theme 4, in the development of coupled catchment-to-coast models. [A workshop on this is planned for early November, with participants from both Divisions and both Flagships].

**Petascale Computational and Simulation Science Platform – John Taylor (1.6 FTEs)**

This platform incorporates the old Terabyte Science Theme. It supports a strategic CMIS-CMAR project on development of Bayesian hierarchical approaches to error estimation and analysis in biogeochemical models. It is also keen to support development of scalable model codes which run on massively parallel supercomputers. Biogeochemical modelling has been chosen as a demonstration case study for its strategic goals.
Capacity has been an issue here, as CMAR has struggled to recruit a postdoc funded from this project. The Platform could potentially fund another person with suitable modelling and computational skills.

Although the total effort is small, this project has facilitated collaboration with CMIS in a key strategic area for biogeochemical modelling.

**Climate Adaptation Flagship (0.2 FTEs).**

At present, the flagship uses just 0.2 FTEs of CMAR’s capability, in the Ecosystems Theme. There appears to be some potential to grow that, but probably only to about 2 FTEs.

Like SAFE, CAF is interested primarily in coupled biogeochemical-ecosystem modelling. The first priority is in the area of climate impacts on estuarine and coastal ecosystems. There are discussions underway with SAFE about a SE Australian initiative. There are other projects under development in SE Qld / Moreton Bay. There is little prospect of CAF investing in climate impacts research for open ocean ecosystems.

CAF sees potential for more integration of the coastal storm surge / inundation / erosion modelling with biogeochemistry and ecology. (It should be possible to do this through BlueLink and ROAM.)

CAF also sees the need for better catchment to coast integration in dealing with climate impacts, and sees this as a joint task for WfHC, WfO, CAF. The GBR might provide an opportunity for an integrated project across flagships.

**Energy Transformed Flagship,**  
*Low Emissions Transport (currently 1.4 FTEs)*

CMAR is currently engaged in a project in this theme in the area of biofuel from microalgae. The Theme Leader is quite bullish on the prospects for this area, and sees it as one of the key medium- to long-range contenders for a serious contribution to biofuel. He thinks the Theme could see up to 20 FTEs invested in this area after 5 years, across biogeochemistry, engineering and processing, with 30% or more coming from CMAR biogeochemistry. He notes strong interest in coinvestment from the private sector. Co-production of fuel with other products (feedstock, industrial or pharmaceuticals) is likely to be important.

The Theme Leader sees the key challenge and requirement from CMAR’s biogeochemistry as capacity to choose appropriate microalgal species and inform the design of large-scale production systems which control the growth environment to deliver high output of predictable biochemical composition. Modelling and automated observations will have an important part to play. He sees genetic modification as potentially important, but likely following the mass production challenge.

**CMAR**  
Climate and Atmosphere (C&A) Theme (0.6 FTEs)
The C&A Theme is using 0.6 FTEs to put the marine carbon cycle into global models in ACCESS. This has the potential to grow by about 1 FTE or higher if the ocean carbon cycle assumed higher priority (e.g. if evidence of anomalies in ocean uptake appears).

The Theme will continue to focus on global coupled carbon model at coarse resolution over the next 5 years. This is limited by supercomputer capacity. The Theme will look for synergies with WfO eddy-resolving biogeochemical modelling. In the long run, ACCESS is seen as a cross-scale cross-Theme modelling platform.

The potential for more synergies across atmospheric, terrestrial and marine biogeochemistry are likely to become apparent as we study the interactions in the coupled global models.

**Food Futures**

Breed Engineering (0.4 FTEs)

A growing focus on intensive production systems in aquaculture will likely drive increased need for MBOPM capability, particularly in the areas of optimised production in prawn ponds and large-scale production of bioflocs as feedstocks. The Theme expects to start with 1 postdoc at Cleveland, potentially growing to 3 FTEs at 5 years.

**Conclusions**

There is clearly considerable uncertainty in virtually all Themes about the direction of their science, and the quantity and composition of the skills required to deliver it, on a 5 year time scale. This is perhaps to be expected: Themes operate in a dynamic external and internal funding environment, and are supposed to respond nimbly to that environment. However, in looking across the CMAR capability areas, this lack of clarity on future directions for MBOPM science seems greater than for many other areas. The challenge for capability leaders is to plan and manage capability in the long term through those fluctuations and uncertainties.

If we added up all the additional FTEs identified in Theme Leader responses, we get a net gain of about 17 FTEs. It would be very optimistic to think these would all materialise. It might be more realistic to suppose we might realise half that number, an increase of around 8 or 9 FTEs. Out of the total, the major current users are forecasting a flat or slightly increasing need. The major contributions come from ET and FF flagships, in the research area of intensive production. The other increases are spread across a number of environmental themes, mostly in the integrated biogeochemistry-ecology area.

3. **Analysis of the current and future size and shape of the Capability Area?**

Given the uncertainty about output Portfolio/Theme science future growth scenarios (reviews, dependencies for capability pull on successful completions of existing science projects, external earnings etc.) in projecting the future MBOPM capability needs we have returned to the major prospective science areas of the previous section, and asked which of these we can expect to be sustainable given Theme plans.
Operational Coastal and Ocean Biogeochemical Forecasting already attracts strong strategic support in WFO Dynamic Ocean and Marine Nation Themes, and some support from the Petascale Platform. It fits the priority need in Marine Nation for readily implemented models (at least with a flexible interpretation), and could grow substantially in Dynamic Ocean, depending on the current Due Diligence Study. But this area is likely to be supported at critical mass regardless of the outcome of the Due Diligence Study.

There is clearly a strong demand for Integrated biogeochemical and ecosystem models and observations, across the environmental Themes. It could be a challenge to co-ordinate this and deliver critical mass targeted at strategic science goals, given that this demand is spread thin, and individual Themes may have tactical requirements. Directions in ecosystem modelling, which is attracting strong demand and strategic investment in its own right, will have a strong influence on this science area, and we must ensure that key biogeochemical capability is available to engage. It is possible that there may be a decreased draw on observational capability in this area, particularly if new observational technologies fulfil early promise.

If the medium- to long-term “possibilities” around biofuels and aquaculture production become reality, CMAR would need to grow capability in the Enhancing Primary Production research area to critical mass (i.e. around 10 FTEs). While WFO themes are hesitant to commit at this stage to investment in ocean fertilization research, they are not ruling it out. If this area became a focus following the WFO Theme reviews, this research area will grow beyond critical mass.

While there is likely sufficient investment in WFO Theme 2 to support Impacts of Climate Change and Acidification on Marine Ecosystems, and potentially some additional support from CAF and/or SAFE, we think there is cause for concern about the overall level of investment in this area, given the potential extent of the problem. We’re particularly concerned that the proposed investment seems unlikely to support an adequate observation program. To put it bluntly, it appears that the economic and social value attached to our marine ecosystems is sufficiently low, at least compared with coastal infrastructure (for example), that as a nation we’re prepared to let impacts of climate change and acidification on our marine ecosystems proceed on an out-of-sight, out-of-mind basis, except perhaps in some iconic systems like the GBR. That seems to be an almost inevitable consequence of the way research priorities are being set nationally and within CSIRO. There may be opportunities to change this situation, through IMOS and successors to the ACE CRC, but it will require leadership.

Although most Themes seem prepared to support the Integrating Biomarker, Isotope and Genomic Research science area, the level of investment in each Theme is low. This will make it especially challenging to maintain the strategic focus needed to achieve world-class results. CMAR believe there is an opportunity to focus more seriously on marine environmental genomics. Based on input from international reviewers at the WFO Three Theme Review the opportunity may even be a necessity if we are to keep pace with international efforts in understanding the roles of microbes in the marine environment. Clearly this is an area where CMAR as a capability home with views on the future directions of marine science needs to work closely with Portfolio Leaders to establish the required level of support for this area of science.
Conclusions
Given recent priority hires and lack of clarity about further growth potential for this capability, MBOPM will not be targeted for growth over the next 3 years, beyond the priority appointments already committed. Growth in the out-years will depend on uptake of some of the potential science growth areas, and we plan to work closely with Output Leaders to influence investment into these science areas.

There is a need to reshape the MBOPM capability over the next 3 years, through building up some components and downsizing others.

Modelling – statistical capability
In response to strong calls from Output Portfolio Leaders, we have increased the MBOPM hydrodynamic and biogeochemical modelling capacity (including programming support) by 2 FTEs in 2008 (a hydrodynamics position is still unfilled). This is seen as sufficient for the work anticipated over the next few years. However, the potential loss of senior leadership in this area makes development and/or recruitment of potential leaders in this component of the MBOPM capability a high priority.

We recognize the need to continue to strengthen the statistics in our biogeochemical modelling. This may be possible through our relationship with CMIS, but this will require explicit conversations to avoid unmet expectations/needs. If CMIS chooses not to deploy their capability in this area, we may need to examine this as a priority recruitment area.

Environmental Genomics
The inclusion of environmental genomics capability within MBOPM is intended to provide impetus for development of critical mass in this area over the next 3 to 5 years. To fast track development of a compelling science proposition for output portfolio leaders in WfO and WfHC, we will recruit a senior leader to work with our existing research scientists.

Observational/Field capability (across physics, chemistry and biology).
Our analysis of national and CSIRO environmental Theme requirements and international trends (towards the use of automated sensor networks and platforms), suggests that we will have an increasing need for field scientists who can support a strong shift towards automated and remote field measurements.

Our current observational capability lacks the skills to support that move. The need is not necessarily for scientists to be involved in sensor development. Rather, it is for people who understand and know the systems being observed, and the nature and limitations of the sensors used to observe them. They are also quantitative scientists who are capable of analysing and interpreting the observations, and build international reputations around those interpretations. They will understand numerical models, and work hand-in-hand with modellers, but building and running numerical models is not their primary role.

We have excellent role models among our physical oceanographers, but lack those people in the chemical and biological domains. We are consequently struggling to
find people to scientifically direct and exploit aspects of IMOS, or to sit alongside and collaborate with the technologists involved in sensor and sensor network development. Similarly, we have failed to exploit ocean colour data to anywhere near the extent we might have expected 10 years ago. It’s worth noting that people with these skills are often capable of working across disciplines.

Most of the environmental Themes are looking to reduce their investment in classical process studies, and increase their investment on observing networks. We will need to make a corresponding transition in the kind of capability we provide. That may be achieved by retraining, or may require recruitment. Given the critical role SE&T plays in supporting our field observations, we probably need to look hard at the capability mix in our support as well research groups in terms of our ability to support new observing systems.

We note that CMAR currently lacks expertise in the ecophysiology of bacteria and zooplankton – capability that is associated with research domains such as intensive production and marine climate impacts which are currently potential growth areas. Our judgement is that in the next three years we will seek to partner with other agencies and universities where this capability is required, rather than recruit and extend our capability base. Subject to internal investment in these areas over this period, this decision will be reviewed at the end of the three years.

4. Key Internal (One-CSIRO) Relationships: dependencies/partnerships/brief SWOT

- Divisions –
  CLW and CMAR aquatic biogeochemists have worked together on a number of projects over the last decade, principally in estuarine and coastal systems. CLW also has a strong coastal remote sensing capability with whom CMAR biogeochemists and remote sensing researchers have collaborated. Given recent retirements in this capability area in both CLW and CMAR, the leadership of the two divisions have agreed to work together in the development and shaping of this shared capability area.

  CMIS also have relevant expertise in environmental modelling and remote sensing. CMAR has recently developed a collaborative relationship with CMIS through their XXXXX Theme.

- Flagships –
  WFO is likely to remain the most important output portfolio for this capability. The flagship is currently working with clients to evaluate the possibility of a BlueLink III collaboration, and is also undertaking a due diligence study on the prospects for a significant investment in a national coastal modelling framework.

- Platforms – current, future ideas
  - A key area for the future is the use of genomic techniques to study biogeochemical processes – especially microbiological processes – on scales and with a rapidity not hitherto achievable. Increasingly, these studies will use autonomous sensing devices, deployed on a range of moorings, autonomous robots (e.g. Argo floats, gliders) and ship-deployed platforms. The very exciting prospect is that data about biogeochemical processes will become part of the suite
of routinely monitored data available from ocean observing systems, and leading to Operational Coastal and Ocean Biogeochemical Forecasting. The development of the autonomous genomics-based sensors themselves is a matter of collaboration between the MBOPM capability and other labs around the world. But this vision is critically dependent on the development of the platforms. The Marine National Facility (Research Vessel) is fundamental; we also depend on the continued development of towed, mooring-mounted and autonomous platforms and their communication mechanisms.

5. Key External Relationships: Dependencies/partnerships and collaborations/competition/brief SWOT

- Other R&D providers (Unis and Publicly Funded Research Agencies)
  Members of the capability have a number of individual contacts and collaborations with various universities in Australia and overseas. These are mainly collaborations and partnerships; there are very few, quite local instances in which universities could be said to be our competitors. AIMS has been a collaborator and has the potential to be a competitor, but we see AIM’s development of a new Centre for Marine Microbiology and Genetics Research, and our development of microbial genomics as complementary and anticipate a valuable collaboration. We have had preliminary discussions which will be further pursued later this year. State agencies, again, may be competitors or collaborators. We have had effective collaboration, for example, with SARDI and TAFI in relation to the environmental impacts of aquaculture; we anticipate increasing interactions with Queensland DPI regarding the development of novel approaches to aquaculture production.

- Federal, state and local government clients
  State agencies have been our clients for studies of biogeochemical processes and the impacts of human activities on a range of scales (e.g. Port Phillip Bay, Gippsland Lakes, the Clarence River, the Derwent/Huon complex).
  We have worked less frequently with Federal agencies as clients, although DEWHA is always a potential client and there has been considerable discussion with GBRMPA about approaches to water quality in the GBR lagoon.
  Local government should be a major client for our work, since so many of the biogeochemical consequences of human activities in coastal systems fall under their management. Their needs, almost invariably, are not only for a biogeochemical study producing a model of hydrodynamics, nutrient flows and biological responses, but for integrated management, informed by such science. CSIRO (across several divisions but strongly in CMAR, combining our MBOPM, MSERAEM and SOPM capabilities) has relevant expertise and has articulated the vision a number of times, but it has been difficult to engage with local governments on a scale where we can best contribute. Exceptions arise when a number of local councils, often with State agencies, form some kind of consortium (e.g. Adelaide Coastal Waters; Port Phillip Bay; South-east Queensland). For CSIRO really to have impact in the coastal arena, it is necessary for Australia to find some way of extending these limited examples.

- Industry clients and stakeholders
We have industry clients for some of the above (e.g. environmental impacts of aquaculture; increasingly regarding microbial aspects of aquaculture production itself; and occasionally with other industries) but much of it is in the “public good” arena and the clients are agencies at all 3 levels of government.

- International linkages
  Members of the capability have been well connected internationally for a long time (e.g. LOICZ, IMBER) and are strong contributors to international conferences (e.g. ASLO). However, there is certainly scope and need to develop more formal involvement in these international programs. They have strong contacts and growing collaborations regarding the development of novel genomics-based sensors. BGC will become increasingly a critical part of Ocean Observing, and so it is important that these international connections are nurtured.

- Funding agencies
  Whilst some of our funding has come from R&D Corporations, much of it comes directly from either the industrial client or the relevant State of Commonwealth agency. As noted above, the area in which our MBOPM capability (coupled with others) has perhaps the most to offer is coastal environmental management, but this is unfortunately the most difficult to fund because of the plethora of responsible agencies.

6. Infrastructure needs

Supercomputing remains a vexed issue for CSIRO. While we may have agreed on an upgrade for the joint BoM-CSIRO facility, the fact remains that CSIRO and Australia are not anywhere near the forefront in terms of global supercomputing. That’s an issue, if we’re serious about world-class research. The situation is considerably worse for research groups operating at the next level down. The Petascale Platform is at least bringing a computation / simulation science perspective to the table, but it remains to be seen whether there’s a mechanism to get the investment needed.

The other major infrastructure issue is investment in observing platforms and instruments. Initiatives such as the sensor cluster may result in low-cost sensors somewhere down the track, but for the next 5 years, and perhaps the next 10, most sensors will continue to be very expensive. If we want to conduct world-class research to demonstrate sensor networks and data-assimilating models, we will need to make investments at scales comparable to those being made in world-leading studies overseas. That may require an order of magnitude increase over current investment levels. That could be affordable in principle (it’s well within the IMOS budget), but it would require a more geographically focused deployment than IMOS has achieved to date.

If we want to stay world-class in our existing science areas, there will be a need to maintain and upgrade the wide variety of existing laboratory and field equipment. There are some CAPEX gaps which are more specific to particular problems. For example, if research into intensive production proceeds, we’ll need to consider how to access mesocosm and pilot plant facilities.
As this research area moves increasingly into the Ocean Observing realm (and eventually to Operational Coastal and Ocean Biogeochemical Forecasting), large amounts of data will be generated and it is important that CMAR manages this well, and makes information widely accessible using web-based tools. Thus, this capability area has a strong interest in the current divisional review of data, visualisation and programming.
Morgan, Janet (CMAR, Hobart)

From: Gunn, John (CMAR, Hobart)
Sent: Saturday, 1 November 2008 12:26 AM
To: Moltmann, Tim (CMAR, Hobart)
Cc: Domaradzki, Anne (CMAR, Hobart)
Subject: RE: MBOPM revision

The agreement reached with Al when I phoned him last night (my time - almost midday his time) was that he would send the version he was working on and I would merge the two. As it turned out, I had no email early this morning and would have missed your deadline. So I'll send a version that could replace the one posted by Diana if/when we think that's worth it. I assume that this won't be too much work.

J

From: Moltmann, Tim (CMAR, Hobart)
Sent: Friday, 31 October 2008 5:15 PM
To: Butler, Alan (CMAR, Hobart)
Cc: Gunn, John (CMAR, Hobart)
Subject: RE: MBOPM revision

No. We're talking about the same version. My reference to "where JG is coming from" was to him as lead author of the version you sent to JV.

Hope this is clear. (It's been a day!)

Tim

Tim Moltmann
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From: Butler, Alan (CMAR, Hobart)
Sent: Friday, 31 October 2008 5:12 PM
To: Moltmann, Tim (CMAR, Hobart)
Cc: Gunn, John (CMAR, Hobart)
Subject: RE: MBOPM revision

So did you get something from JG? Mine (via JV) was my share of the job but JG was looking at other parts.

Some comments FYI below in bold.

A

From: Moltmann, Tim (CMAR, Hobart)
Sent: Friday, 31 October 2008 5:03 PM
To: Volkman, John (CMAR, Hobart); Butler, Alan (CMAR, Hobart); Parslow, John (CMAR, Hobart); Gunn, John (CMAR, Hobart)
Subject: RE: MBOPM revision

Hi all.

Here’s my attempt at taking JV’s comments on board while not losing the essence of where JG is coming from.

I’ll leave it at that for now. If there is another version over the weekend, we’ll put it on the intranet on Monday.

Thanks, Tim

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From: Moltmann, Tim (CMAR, Hobart)
Sent: Friday, 31 October 2008 3:58 PM
To: Volkman, John (CMAR, Hobart)
Cc: Butler, Alan (CMAR, Hobart); Parslow, John (CMAR, Hobart); Gunn, John (CMAR, Hobart)
Subject: FW: MBOPM revision

Thanks John (V).

Will look to take on your feedback in the interests of making this draft constructively provocative.

Have out John G in the loop as well.

Regards, Tim

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From: Volkman, John (CMAR, Hobart)
Sent: Friday, 31 October 2008 3:52 PM
To: Butler, Alan (CMAR, Hobart)
Cc: Moltmann, Tim (CMAR, Hobart); Parslow, John (CMAR, Hobart)
Subject: RE: MBOPM revision

Hi Tim

I've been through the document and made a number of small changes (in green on my version). I and others think that the document stands out from other capability documents in making a number of strong assertions about direction that have not been rigorously discussed. There are three statements that I would particularly challenge (see imbedded comments):

1. That “we” need to choose 2-3 of the 5 nominated areas. In fact there is a lot of commonality between them and many require a similar skill set. I would argue that the (internal and external) markets will
decide where the emphasis will be and we should be focussing on ensuring that we have the capability to meet the need. I've suggested some new wording in the comment. **JG says the original "we need to choose" came direct from JP.**

2. There is a bald statement that no growth is targeted for the next 3 years, but the following text points out a number of possible growth areas. I simply can't see how this need (if it eventuates) can be met solely from reshaping. **Knew that. Decided to ignore. In earlier comments, I said that of course massive growth COULD happen to any of our capabilities, and this plan ("no growth" in this case) is just our best guess at present. The document reflects the themes’ inability to be firm about their future needs for BGC.**

3. The notion that the ecosystem modelling should drive our decision making really goes against the grain. We should certainly aim for better linking and integration (and are doing so), but it is demonstrably clear that our biogeochemical modelling and measurement expertise has strong stakeholder and real client support in its own right (although widely distributed across CSIRO as currently structured). **OK true of other things as well (handfish is funded. So is carp.) but in those cases it didn't stop us from trying to be visionary. I do agree of course that ecosystem modelling shouldn't drive everything. While we're striving for a grand integrated etc., each of the components will still be a viable and important capability area in its own right.**

Best regards
John Volkman

p.s. I've copied in John Parslow who was responsible for creating much of the original text that was recycled into this document and would certainly have a view on these matters.

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From: Butler, Alan (CMAR, Hobart)
Sent: Friday, 31 October 2008 11:55 AM
To: Volkman, John (CMAR, Hobart)
Cc: Moltmann, Tim (CMAR, Hobart)
Subject: MBOPM revision

Hi John,

We (JG in South Africa and I in Hawaii) are engaged in a last-minute rush to revise the MBOPM proforma before it goes on the www for staff consultation (by COB today).

Attached is a copy with some recent tracked changes by me. If you have time to have a look that would be good, since you know the client engagement area much better than I do. If you have any comments, please get them back to Tim Moltmann.

Many thanks,

Al.

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Dr Alan Butler
Research Program Leader, Southern Marine Systems
CSIRO Marine and Atmospheric Research
PO Box 1538
HOBART

18/02/2011
Tim,
This is where I have got to, will continue to fine tune the Core capability messages, have a summary Table almost done, and Toni is recasting the Core capability histogram to a. remove the RGs (you can keep the current ones in the pack in case it is requested) b. shows total numbers of staff in each Core cap, with stacking to indicate how many of the current number are priority hires and how many are from the BoM.
Happy to discuss at any time, and feel free to edit what I have sent as you feel more or less comfortable with the approach I have taken. I have provided some notes for some of the slides, and aim to do more of this to try and keep us all on the same message. Again, feel free to add to these to meet the same objective.
You have a meeting with Johnson tomorrow. Do you want to set a time for us to chat before the presentation? I am with Petrachenko and then her offsiders to discuss the ECIFF Panel review (delivered on time on Friday to the Minister and already prompting responses of various kinds from different stakeholders) from 1.30 onwards.
Cheers
John
CMAR Capability Development Plan
history, process & draft plan

CMAR Capability Leadership Team

Why is there and need for a consultation process and what are we hoping to achieve?

CSIRO Definition of Capability Planning in the Matrix
The proactive maintenance, development, creation, alignment and termination of CSIRO scientific capabilities to allow delivery of our current and future strategic goals... it therefore underpins effective deployment of resources and workforce planning.

Over last 12 months, CMAR leadership has developed a Capability Development Plan to guide CMAR’s science capability (people, infrastructure and relationships) net to 2020.

- OTC Program and Research Leaders, P&C
- Flagship Directors, these latter streams (stream leaders)
- Environment Group Executive, Chairs of other Div. Directors.
- CMAR staff have been kept informed through Conferences and discussions within REU.

Now we want all staff to be involved in reviewing and providing input into the Draft Plan, leading to finalisation in December 2019 and implementation in 2020, ready for SIP 4.

Expectations and Desired Behaviours

Capability Team:
- Open – encourage engagement, open to input
- Honest – admit oversights or shortcomings
- Accepting – not defensive, accept new point of view
- Consultative – further improvements and changes are possible
- Decisive – while all feedback will be noted/considered, final decisions are made by a few or one (the Chief) where the accountability and responsibility resides

Staff:
- Open – willing to engage & contribute
- Honest – beyond personal interest, thinking of the greater good
- Constructive – provides communications offering alternatives, not just expressing dissatisfaction with whole process or elements
- Supportive – believe the intentions, effort, and consultation that’s been undertaken to date have been well-intentioned
- Accepting – decision-making process is open & transparent, but not democratic
Capability Development Definitions

Capability Development Strategy - CMAR (strategic):
To articulate the core strategy for Marine & Atmospheric science and thereby enable us to plan for future capability requirements (FPR) and to achieve our current and future scientific goals. (Directional and High level) it is developed in consultation with relevant output leaders and staff, with 3 year review cycles out to 2020.

Workforce Plans - CMAR (operational):
To attract and retain the right people, in the right place, at the right time, with the right skills (assessed annually at capability or RP / RO level) and develop in consultation with relevant output leaders & staff & are aligned with individual career plans – operationalise the COP strategies

December 2006

Operational Plan for Development of CSIRO Marine & Atmospheric Science Capability

[Diagram showing proposed pathways and processes]

Workforce Planning: Deployment: Development: Separation: Reemployment

Learning & Development: Capability Development Tools: OCEUS: Solutions

Right Direction, Right Shape, Right Size
CMAR Core Capabilities & Components

Right Direction?

- Marine & atmospheric science is fundamental to addressing a number of Australia’s major national challenges and opportunities.
- It is currently underpinning CSIRO’s delivery in the Climate and Oceans domains, and making significant contributions in Water, Energy, Biodiversity, Food Production & Supply, and Mineral Resources.
- Currently, approximately 75% of CMAR’s capability is deployed through Flagships — WD, CA, FFP, WHC being most important in 2006-9.
- Thus, it is up to the CMAR leadership team to work with Flagship and other colleagues in setting a long-term plan for CSIRO’s marine & atmospheric science capability.
- Delivery in these domains is vitally important, but it is equally important to have a longer-term plan for science capability beyond current delivery timelines if CSIRO is to be well-positioned to meet the emerging national challenges of tomorrow.
CMAR's Science Vision

We believe that a division should have an overarching purpose and science vision to ensure we are more than the sum of our capabilities.

Our unifying purpose:
To help Australians better understand and manage human impacts on the earth’s systems as they affect our national environment, and to better understand and manage the feedback of these impacts on the lives of all Australians. The division’s capability is therefore built around deep expertise in the domains of marine science and atmospheric science, and a strategic commitment to the science of systems and integration.

Our science vision:
To play a leading role in understanding, quantifying, and simulating the earth system at multiple scales, so as to inform Australia’s sustainable development in the context of global change.

Right Shape?

- Marine & Atmospheric science addresses big, long-term questions about the earth system (e.g., climate change projections to 2070, and the environmental, social, and economic consequences of multiple uses on a shifting environmental baseline).
- It is necessarily complex and cross-disciplinary, and draws on disciplinary strength in various types of physics, chemistry, biology, ecology, and socio-economics.
- It is increasingly quantitative and computational, and blends ever more sophisticated observational science with process understanding, predictive/wet assessment, modeling, and management strategy.
- Deciding how best to bring these disciplines together into capabilities, and how best to balance investment across capabilities, needs to be carefully planned and implemented.
- We must aim to be the right shape.

How do we determine the right shape?

- Detailed SWOT analysis (science quality, uptake, demographics, deployment history)
- Reviewing of national and international trends – we must aim to continue to be world class, if not world leading, in all of the capability areas we develop and/or maintain.
- Determining our niches in and outside CSIRO in the National Innovation systems
- Deep consultation with Flagship Directors, Theme leaders, other divisional leadership groups.
- Internal review, debate, and consultation.
Right Size?

- Marine & atmospheric science requires significant critical mass to be globally competitive and nationally leading.

- National Framework for Climate Change Science, and Marine Research, Innovation and Development are currently under development (CMAR leaders heavily involved). Designed to enhance and grow research capability in response to major national challenges and opportunities.

- CMAR currently 520 staff and 140 students, visitors & fellows, and in CMYCR = 128 Full scientists under joint leadership.

- With such a significant level of scientific endeavour now under stewardship, and such large challenges and opportunities on the horizon, it is imperative that growth/stability/strategies of effort in capability is carefully planned within financial constraints, through time.

- We must aim to be the right size.

What determines the Right Size of CMAR?

- CSIRO Core funding - flagships and divisional themes
  - in BiPP we saw decreases in funding to CMAR, due to overall CSIRO cuts following Federal Budget, and from deliberate reductions from Flagships, primarily in the oceans and water areas.

- Additional support for Marine and Climate science through new appropriation and external funds:
  - New Pacific Climate Change Science Program (footed)
  - New Australian Climate Change Science Program (proposed)
  - 2 DBIR New Policy Proposals (NPPs) for Marine Science (both with AMS).

- Clearly uncertainty still exists (and always will) – e.g. current Global Financial Crisis will have an impact on science funding.

- Our best estimates are:
  - 2008-09 actual of 0-12 FTEs
  - 2009-10 - unless NPPs are supported, expect level funding for marine science and marine potential for growth in certain aspects of climate change science.
  - CMAR must consider the impacts of the current financial downturn on the global economy and our continuing efforts to move climate and marine science ahead.

Summary of Core Capability Plans
Key Messages MSERAEM

- Working in close collaboration with SOPM and MBOPM, capability is focused on marine systems understanding and development of tools for management (ecosystem-based fisheries and multiple uses), utilising the latest information technology for computation and stakeholder delivery.
- Tools and approaches currently have widespread application in nature resource management (beyond those currently engaged)
- Thus, expanding the scope and utilisation of these approaches and tools is a key strategic goal for the capability.
- Note over-commitment of key staff and teams.
- GROW (already had 14 FTEs through Priority Lines), particularly in whole-of-systems modeling (e.g., coastal & ecological) and associated Sustainability Science areas including socio-economic capability.

Key Messages SOPM

- In close collaboration with MSERAEM and MBOPM, capability is focused on understanding the distribution and status of marine organisms, the processes that influence these populations, and the spatial and temporal characteristics of marine ecosystems.
- Tools and approaches are being utilised in high-tech, observational, and model-based approaches to understand the distribution and status of marine organisms and associated sustainability science areas including socio-economic capability.
- Significant potential for incorporation of real-time spatial dynamics within a more comprehensive Earth System Simulation capability.
- Need to maintain a critical mass of functional and observational capability, but acknowledge requirement for this to be deployable whenever required, across broad spatial ranges.
- Maintain between current skill sets and elements of future work.
- OCEANICING, emergent and also EXTESTIVE RESEARCHING, to provide scope for increased high-tech, observational, model-based, and observational capabilities.

Key Messages AGPN

- New capability, derived from elements of MBOPM and the former GEG and improved breeds (e.g., salmon, abalone, prawns), and novel feed development through microbial biomass.
- “Nutrition” and “genetics” will become increasingly linked in collaborations between CSIRO, CLC, and other DHQs.
- Regional and site-specific moves will need strong leadership.
- SLIGHT GROWTH in next 1 to 3 years, tied to Food Futures projected growth. Some scope for redeployment of other core capabilities.
Key Messages MBOPM:
- Bring all oceanic and coastal biogeochemistry together under the same core capability.
- Grow capability in hydrographic and biogeochemical modeling with a focus on better integration of biogeochemical and ecological models and linking of shelf to coastal scales.
- To enhance critical mass, need to select focus & migrate across a subset of the following science themes:
  - Operational coastal & ocean data forecasting
  - Integrating biogeochemical & ecosystem research
  - Integrated leg & ecosystem models (and observations)
  - Impacts of climate change and adaptation on marine ecosystems
  - Enhance primary production

Potentiality LIMITED GROWTH relates to Blueprint III and Oceans Climate Change priorities. RESHAPED (activity or through retaining) to allow application (and possible development) of new observational technologies; and environmental genomics.

- Load the development of a world competitive coupled ocean earth system model & infrastructure (NOES)
- Capability under-resourced to meet work plan & international commitments
- To achieve short and long term needs need increased capability in: atmospheric modelling, ocean and coupled modelling, land surface/vegetation modelling, evaluation, systems and infrastructure and integration for decadal predictions of climate change
- Term appointments an issue (BoM side)
- Too many small fractions of staff (CSIRO)
- Insufficient High Performance Super Computing

- GROW through CMAR & BoM High Priority hires and Re-deployment from other capabilities

- Demand for climate change adaptation science, including sea level, continues in peer review. Long term strategy is to develop a seamless approach to weather and climate prediction (broad, decadal and multi-decadal)
- Significant data management and delivery infrastructure to meet current demand (climate change service delivery in to moves in NCC as far as possible)
- Significant capability gap in understanding of fundamental processes of Australian climate variability due to current capability shortfalls in service delivery
- Need to increase socio-economic skills to undertake climate adaptation research
- Growing number of external partnerships and complexity of relationships in climate change
- Insufficient demand and external partnerships for seasonal skill capability in BoM or CSIRO (light balance ?)
- Experience on large numbers of junior term staff an issue (BoM - age profile of CSIRO)
- Significant capability gap (particularly in support staff) as well as capability gap
- Strong dependence on ECGM capability
- Needing renewed for detailed predictions small requires new capability (e.g. initialization)
- Insufficient computing resources
- Goal: use advanced observation systems and model-data fusion to provide timely and fit-for-purpose information and data products needed to:
  - track the changing state of the land and atmosphere
  - advance and inform climate adaptation and management policies
  - underpin and improve Earth system models
- ALOA provides the comprehensive, credible and quality capability needed to deliver CAWNP's Earth system science goals
- Key tasks required:
  - Continue to define and prioritise the 'big' science issues and to guide steps & size
  - Ensure observations are well integrated across technologies and into ACCESS
  - Adequately and sustainably resource observational technologies and systems
  - Achieve a step-change in commitment to data quality, quantity and availability
  - Maintain quality assurance processes for sensor, software and metadata staff
  - Utilise model-data fusion to improve model predictions & quantify uncertainty
  - Coordinate efforts to identify external opportunities (CSIRO, Bureau)
- ALOA also needs to address and manage the shortfall in remote sensing capability (skills and capacity) given current resource constraints
  - Along with the allied capabilities in data acquisition & data management, this is critical to CAWNP's ability to meet its research and operational objectives

- WEP comprises the bulk of Australia's meteorological expertise, needed:
  - For ACCESS (the model) and Bureau's forecasting systems
  - For fine spatial scale and short-term weather and environmental outforecasts, e.g.
    regional climate modeling, tropical cyclones, wild fire, energy, water sustainability
  - To bring expertise in forecasting systems & operational product delivery to CSIRO
  - Credible, fast and in-demand, few signals for big changes, but needs to:
    - Plan for direction and goals for an early and high impact weather service
    - Streamline deploy staff to projects aligned with CAWNP's WAIP, forecasting and
      earth system simulation goals
    - Use business opportunities to address demographic challenges:
      - Time staff (around 30% in Bureau in term contracts & < 1 years in Bureau)
      - Business planning – over half of WEP are > 10 years (senior and peer leaders)
  - Relationships are important:
    - CSFM capability (ACCESS) and SPVQCC (climate projections)
    - CSIRO Flagships (CAW, WM, IR), Bureau Programs (Water, Weather Services)
    - ACCESS strategic plan is important:
      - Shared view on capability needs and gaps - impact on WEP shape and capacity
      - Pathway for existing capability, and capability to contribute

- By enabling advances in modelling and observational technologies, COOA's goal is to observe, understand and predict processes in the oceans and surface marine environments, and to determine the ocean's role in variability and climate
  - Australian region: tropical waters to the sub-antarctic boundary of the Southern Ocean
  - Increasingly coastal in scope
  - Capacity and capability shortfall in ocean remote sensing and data assimilation; model validation; equatorial ocean dynamics, and wave modelling
  - Remote sensing critical for science and applied needs; and coordinated in concert with
    COOA and the wider CSIRO, Bureau
  - Need ongoing and shared (with output lessons) strategy for sustaining critical technology and infrastructure, especially:
    - Marine National Facility
    - High performance supercomputing
    - World-class laboratories, technical and engineering support
    - Demographic challenges: succession planning for processes/observations area and
      the need for longer-term, senior staff for sustaining prediction.
    - Changes in shape, size can be significant by current opportunities (e.g. PCCS)
Feedback pathways

- Line management (RGLs, RFLs, OTC)
- Capability Development Project Team (OTC, RFLs, P&O)
- Con Comm (includes Staff Association representatives)

Thank you

Capability Development - history

- July 2003
  - Definition of O&M Capabilities and Project Planning
  - December 2003
  - Capability Analysis, Input and Output (RFL in Feb '04 in CMAR)
- December 2004
  - Capability Statements Documented (initially by Workshop sessions)
- January 2005
  - Evaluation of O&M Benchmarks
- February/March 2006
  - O&M assessments
- April 2006
  - OA/2 for O&M Capability Review
- March 2006
  - Capability Analysis (initial session)
- July 2006
  - O&M assessments
- June/July 2006
  - Performance Standards and Target Response analysis
- August 2006
  - Capability Statement Documented
- November 2006
  - Capability (Revised Project Team) 5 Sept
- April 2007
- December 2007
  - BAO2008 project process (2006 - 2011)
Morgan, Janet (CMAR, Hobart)

From: Gunn, John (CMAR, Hobart)
Sent: Sunday, 2 November 2008 9:12 PM
To: Moltmann, Tim (CMAR, Hobart)
Cc: Domaradzki, Anne (CMAR, Hobart)
Subject: RE: Draft Slides

If you send me whatever you come up with this evening, I will insert and ensure it is consistent with the messages.

From: Moltmann, Tim (CMAR, Hobart)
Sent: Sunday, 2 November 2008 9:10 PM
To: Gunn, John (CMAR, Hobart)
Subject: RE: Draft Slides

sweet. Will hold of for half an hour and work on what you send me...

I'll put a plan in place to get Toni's updated chart inserted in the morning.

Tim

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Tim Moltmann
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From: Gunn, John (CMAR, Hobart)
Sent: Sunday, 2 November 2008 9:08 PM
To: Moltmann, Tim (CMAR, Hobart)
Cc: Domaradzki, Anne (CMAR, Hobart)
Subject: RE: Draft Slides

I will be done in 30 mins save the figure from toni which will arrive "after 10"

J

From: Moltmann, Tim (CMAR, Hobart)
Sent: Sunday, 2 November 2008 9:07 PM
To: Gunn, John (CMAR, Hobart)
Subject: RE: Draft Slides

OK, but would profess to getting a little nervous. I have a fair bit in front of me before presenting this in Cleveland tomorrow afternoon and Floreat the day after, and also need to make something visible to Mark and Rothe tonight so that they can have a squiz in the morning.

Tim

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Tim Moltmann
Deputy Chief
From: Gunn, John (CMAR, Hobart)
Sent: Sunday, 2 November 2008 9:01 PM
To: Moltmann, Tim (CMAR, Hobart)
Cc: Domaradzki, Anne (CMAR, Hobart)
Subject: RE: Draft Slides

you can work on it Tim - I am still working on it here too. You can then merge docs (as in Word under the tools menu), to review anything that I have added. This is primarily in formatting (e.g. thought it best to spell out the capability names instead of using acronyms in slide headings) and in the notes pages. And have still to pass on the table and new figure. J

From: Moltmann, Tim (CMAR, Hobart)
Sent: Sunday, 2 November 2008 8:57 PM
To: Gunn, John (CMAR, Hobart)
Subject: RE: Draft Slides

Thanks John. Looks pretty good. I'd like to make a few changes, so am assuming I now have version control.

I have a meeting at QBP from 9-11 then need to get to Cleveland for the consultation from 1-3 (all Qld time), so think I'll need to go with whatever I end up with tonight. We can tweak it over the coming days.

Tim

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From: Gunn, John (CMAR, Hobart)
Sent: Sunday, 2 November 2008 7:54 PM
To: Moltmann, Tim (CMAR, Hobart)
Cc: Domaradzki, Anne (CMAR, Hobart)
Subject: Draft Slides

Tim,
This is where I ahve got to, will continue to fine tune the Core capability messages, have a summary Table almost done, and Toni is recasting the Core capability histogram to a. remove the RGs (you can keep the current ojne in the pack in case it is requested) b. shows total numbers of staff in each Core cap, with stacking to indicate how many of the current number are priority hires and how many are from the BoM.
Happy to discuss at any time, and feel free to edit what I have sent as you feel more or less comfortable with the approach I have taken. I have provided some notes for some of the slides, and aim to do more of this to try and keep us all on the same message. Again, feel free to add to these to meet the same objective.

You have a meeting with Johnson tomorrow. Do you want to set a time for us to chat before the presentation? I am with Petrachenko and then her offsiders to discuss the ECIF Panel review (delivered on time on Friday to the Minister and already prompting responses of various kinds from different stakeholders) from 1.30 onwards.

Cheers
John