Australian Government

AUSTRALIAN INSTITUTE OF MARINE SCIENCE

AIMS Science Review

An independent external review of delivery against the AIMS Research Plan (2007-11) and advice about future science directions and opportunities

Review panel

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Executive summary

The Institute has much to be proud of in the current quadrennium. The quality and broader impact of its science have both improved significantly. It has consolidated the earlier gains it made in the previous quadrennium. It has reinforced its national standing as a research institute, and this even in the face of an absolute decline registered for some other national institutes.

In some (but not all) areas the Institute is now at international benchmark and further gains are within its grasp.

We think that many of the settings — scientific, technical and organisational — are now in place for the Institute to strive uncompromisingly in the next quadrennium to reach international benchmark across most of its areas of operation.

To achieve this, we feel that the Institute needs a bolder strategy. The key elements of such a strategy would be:

- Address *Grand Challenge* questions to lead in the provision of policy-relevant science for managing Anthropocene changes in tropical marine ecosystems.
- Develop a world-class capability in synthesis, modelling, analysis and prediction to add value to the good process work being undertaken.
- Provide leadership internationally for tropical marine ecosystems broadly — but particularly in the Coral Triangle, the global biodiversity hotspot for coral reefs that lies just north of the GBR and is the focus of considerable international conservation efforts.

We recognise that this requires a more programmatic approach, with KRAs more tightly organised against fewer, larger questions to capture the synergies of diverse skills. In order to capture creative ideas from staff that may lead to future breakthroughs, we suggest that this should be offset by a significant component of scientific flexibility and incentives by adopting the *Google model* (20% of time for exploration of non-managed research) for all research staff.

Such a strategy will build on the Institute's key comparative advantages:

- A capacity for integrated field and laboratory work.
- First class technical resources, such as the new ATOS facility, the research fleet, and historical and ongoing databases.
- An ability to plan and commit to long-term research programs.

We believe that such a strategy will help the Institute move up a level in the international arena as the world's most important research centre on tropical marine ecosystems.

Recommendations

The Panel strongly believes that the Institute should seek to lead the world in understanding tropical marine ecosystems. To that end, we make recommendations under the following heads:

- Provide visionary science leadership and high-value policy-relevant science outputs that lead to substantive research and policy outcomes
- Continue and strengthen the steps taken since the last review and to publicise the scientific knowledge gained and its significance
- Remove obstacles to achieving excellence

Provide visionary science leadership and high value policy-relevant science

- Develop *Grand Challenge* questions to lead in the provision of policy-relevant science for managing Anthropocene changes in the tropics (e.g. climate change, acidification, water quality, and issues yet to be recognised).
- Develop a world-class capability in synthesis, modelling, analysis and prediction by hiring and enabling international leaders and forging meaningful partnerships with other international groups. This process should lead to the next big investment.
- Grow and empower the Team Leader role so that they are more clearly engaged in and responsible for identifying and developing science initiatives (e.g. *Grand Challenges*) for the institution as a whole. This should encourage ambition and lead to bottom-up innovation from the best researchers.
- Provide leadership not only in Australia, but also for tropical marine ecosystems broadly – particularly in the Coral Triangle.
- Use the Institute's field capability – a significant comparative advantage – to conduct large-scale, long-term field experiments to identify and evaluate interventions to address threats to marine ecosystem health.
- Implement a science advisory panel to advise the CEO and Council about emerging questions and the quality of science effort, balance and relevance.
- Make better use of opportunities to *sell* the Institute to policy makers and the public.

Continue and strengthen the steps taken since last review

- Maintain and expand the Institute's capacity in molecular approaches, microbiology, symbiosis and related disciplines including a crucially needed bioinformatics capability.

- Continue to grow the number of doctoral students and postdoctoral fellows (e.g. invest money in student top-ups for salary, training and travel) drawing on a more diverse array of partners (not just JCU).

- Use the next two years to plan efforts in experimental ecology that take immediate advantage of ATOS upon completion in ways that build the Institute's science and collaborations.

- Continue to focus aquaculture and natural products activities in ways that exploit the Institute's science excellence and scale (e.g. enhance synergies between microbiology and aquaculture diseases).

- Build interactions and collaborations via Institute-sponsored NCEAS-style think tanks[1].

- Explore additional mechanisms for interaction with a broader group of universities (e.g. expand science visitor program) based around world-class facilities and field capabilities to fill gaps and highlight emerging opportunities.

- Continue Data Centre efforts to streamline forms and reporting (much work still needed).

Remove obstacles to achieving excellence

- Develop a more effective strategy for the recruitment of emerging world leaders in tropical marine science.

- Reduce the load of routine administrative tasks on Team Leaders (to no more than 25% of time), e.g. by assigning dedicated time of specific personal assistants and streamlining reporting requirements.

- Empower the Team Leaders, prioritise roles and consider incentives to ensure that substantial time is dedicated to science leadership

[1] The National Center for Ecological Analysis and Synthesis (NCEAS), located in downtown Santa Barbara, is a research centre of the University of California, Santa Barbara. NCEAS supports cross-disciplinary research that uses existing data to address major fundamental issues in ecology and allied fields, and to encourage the application of science to management and policy. NCEAS is a unique institution with an explicit mission to foster synthesis and analysis, turn information into understanding and, through effective collaboration, alter how science is conducted.

(identification, development and promotion of good ideas) and synthesis of results across the Institute in preference to administrative details. This opportunity to help shape the future of the Institute may assist in the recruitment of leaders (earlier point).

- Provide scientific flexibility and incentives by adopting *Google model* (20% of time for exploration of non-managed research) for all research staff. Although requiring initial investment, we anticipate that this will pay for itself in the medium (and long) term by making the Institute more attractive to the best researchers, and more likely to identify emerging and tractable key research areas ahead of the competition.

- Assign enduring and important core service activities (e.g. GBROOS) to science support rather than science teams (to avoid forcing these activities into science evaluation mode), with regular Team Leader input to science support activities to maintain linkages.

- Ensure that Framework Surveys, such as the Scott Reef surveys, are clearly profitable to the Institute and do not result in its scientists spending their time in creating low-value data.

- Minimise high frequency and duplicative reporting and seek single reporting for multiple outcomes and make sure that authors of reports get substantive feedback. In order to identify reporting for elimination, solicit input from all staff scientists about what reporting requirement seem least valuable and most onerous.

- Ensure that expensive data sets become valuable data sets by providing time and expertise for synthesis and analysis.

Introduction

The AIMS science program is planned and delivered in 3-4 year tranches linked with triennial/quadrennial funding from the Australian Government.

The current plan (2007-11) is based on 12 Key Result Areas delivered by five thematic Research Teams:

- Exploring Marine Biodiversity
- Supporting Sustainable Use of Marine Biodiversity
- Measuring Water Quality & Ecosystem Health
- Responding to Climate Change
- Understanding Marine Microbes & Symbioses

The Institute invited us to act as a review panel to evaluate delivery against the AIMS Research Plan (2007-11) and to provide advice about future science directions and opportunities. We are:

- Prof Roger Bradbury, College of Asia and the Pacific, Australian National University, Canberra (chair)
- Prof Russell Hill, Institute of Marine and Environmental Technology, University of Maryland Center for Environmental Science, Baltimore MD
- Dr Nancy Knowlton, National Museum of Natural History, Smithsonian Institution, Washington DC
- Prof Hugh Possingham, The Ecology Centre, University of Queensland, Brisbane
- Dr Roger Shaw, Former CEO of the Coastal CRC, Brisbane
- Prof Sandy Tudhope, School of GeoSciences, University of Edinburgh, Edinburgh

Our review focussed on the research since 2007, but we also considered this work in the context of the previous research program. We conducted it at the Institute on 29 November – 3 December 2010.

We considered a written portfolio of evidence prepared by each of the Research Teams and the Research Directorate supplemented by presentations

in a seminar format. Each Team's portfolio reported the outcomes of all of its major projects over the last four years and the productivity of all Research Scientists contributing at least 0.25 full-time equivalent (FTE) per annum to the team's activities. We also interviewed the Team Leaders and some Team members, reviewed the key scientific papers published by the Team, and interviewed senior managers and senior staff in the Research Directorate.

The Terms of Reference

AIMS asked us to evaluate delivery against the AIMS Research Plan (2007-11) and to provide advice about future science directions and opportunities. Specifically, we were asked to consider the big picture and to:

1. Review the quality and impact of outcomes from the 12 Key Result Areas (KRAs)

2. Review the effectiveness of the five Research Teams in terms of:
    - Portfolio balance (e.g. strategic vs. demand-driven)
    - Capture and utilisation of resources
    - Project management
    - Stakeholder engagement & knowledge transfer
    - Collaborations

3. Review the performance of AIMS PhD scientists with focus on:
    - Publications
    - Impact of top three outputs during the review period
    - Research training
    - Collaborations and networks

4. Comment on the alignment of AIMS science with
    - International benchmarks
    - National Research Priorities
    - AIMS Strategic Directions

5. Identify under-performing investments (if any) in the AIMS science program

6. Comment on the performance of AIMS in exploiting its access to technology resources

7. Comment on Team strategy for the next Research Plan (2011-15) and suggest new directions (as appropriate)

In meeting the Terms of Reference (ToRs), we were asked specifically to rate the quality and impact of the science. So our review follows these steps:

- We first rated each of the individual Key Result Areas being managed by each Team.
- We then rated the overall performance of each Team, taking into account our understanding of the relative importance of the different KRAs and projects to the Team and the Institute.
- Our ratings were based on the written evidence portfolios, team presentations and interviews. In general the presentations were more informative than the written submissions in terms of providing the broader significance and context of activities.
- Next we rated the individual scientists with a significant involvement in the Team (greater than 0.25 FTE), taking into account their relative contributions to the different KRAs and projects.
- Finally we used these ratings in our discussion of the ToRs.

The Panel's view of the rankings

We were happy with the following descriptions of the different rankings for science quality proposed by the Institute. They are:

Science quality

Score	Explanation	
5	Benchmark	Sustained scientific leader – well recognised in the international research community for this.
4	Strong	Able to set and sustain new scientific/technical directions within the international research community.
3	Favourable	Able to maintain a good position in the international research community "pack"; not a scientific leader except in developing niches (not mainstream areas).

2	Tenable	Not able to set or sustain independent scientific/technical directions – a sense of being continually a follower.
1	Poor	Inferior quality of scientific/technical output compared with other research groups.

User impact

But we slightly modified the descriptions of user impact to better reflect the Institute's current circumstances. We used these descriptions:

(Users include government, industry, resource managers, community organisations and the general public)

Score	Explanation	
5	Benchmark	Research results are used as the foundation of a scientifically-based commercial, management, planning, community or policy framework and acknowledged through active researcher-stakeholder interactions
4	Strong	Research results are incorporated into activities and strategies of organisations and used in decision making or optimisation of plans and activities generally facilitated by researcher-stakeholder interaction
3	Favourable	Research results are relevant to and used by organisations facilitated by researcher-stakeholder interaction
2	Tenable	Research results are able to be used by organisations involved in management, policy, planning or commercial initiatives to maintain, and improve their activities. The results are not used but could be adopted with some researcher-stakeholder interaction.
1	Weak	Research results are not in a form relevant to, or able to be used by organisations involved in management, policy, planning or commercial initiatives.

In making these changes, we wished to reflect our perception of what is important for the broad range of clients and stakeholders of AIMS and to reflect effective modes of knowledge exchange. The emphasis on competitive positions in the original table does not necessarily fit closely with the Commonwealth government and agencies being the major funder and a significant user of results through GBRMPA.

Secondly, the criteria seemed to indicate a somewhat passive style of science uptake whereas an interactive collaborative style seems to be closer to what is happening, including the contracts with Woodside and associates for the NW shelf.

Given that one of our recommendations addresses an increased promotion of the good science of AIMS, encouragement of scientist stakeholder interaction and promoting champions for AIMS in other organisations would be helpful.

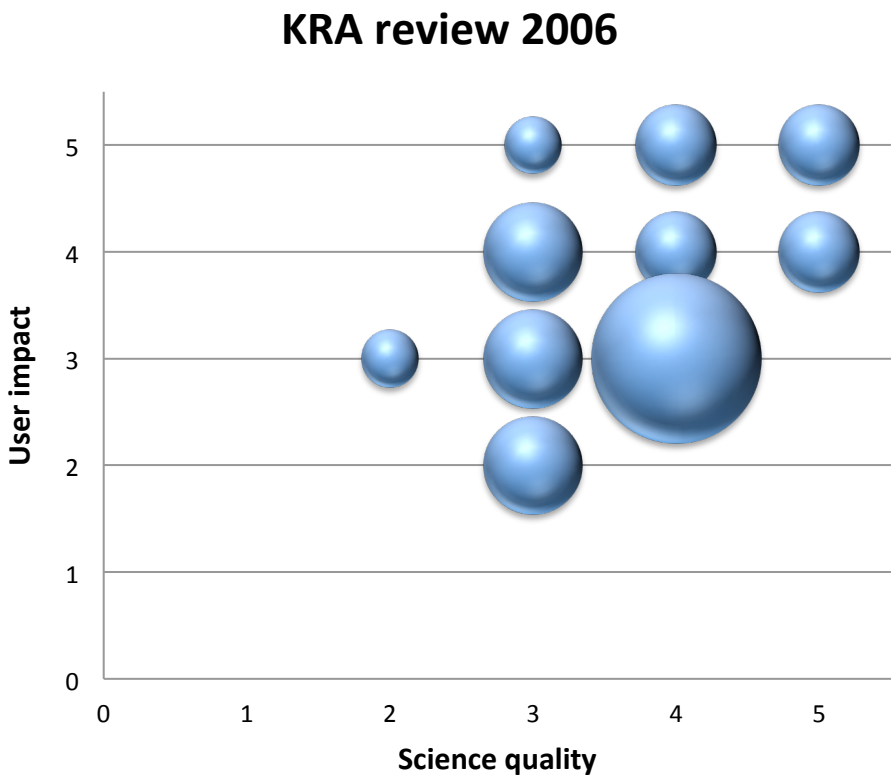
Thirdly, it is very difficult for science facts to influence policies and behaviour in relation to the coral reefs because the reefs are an 'icon' for many people, This means that science results are easily enmeshed into existing user belief systems and ideologies thus requires proactive scientist interaction with users to ensure that scientific findings are effectively used.

Overview

The Institute presents a mixture of scientific excellence and missed opportunities and it operates in a difficult and fast-changing environment. The current Research Plan has built a framework of much good science and goodwill within the Institute, but even so the challenges facing the Institute will need to be addressed in the next Research Plan.

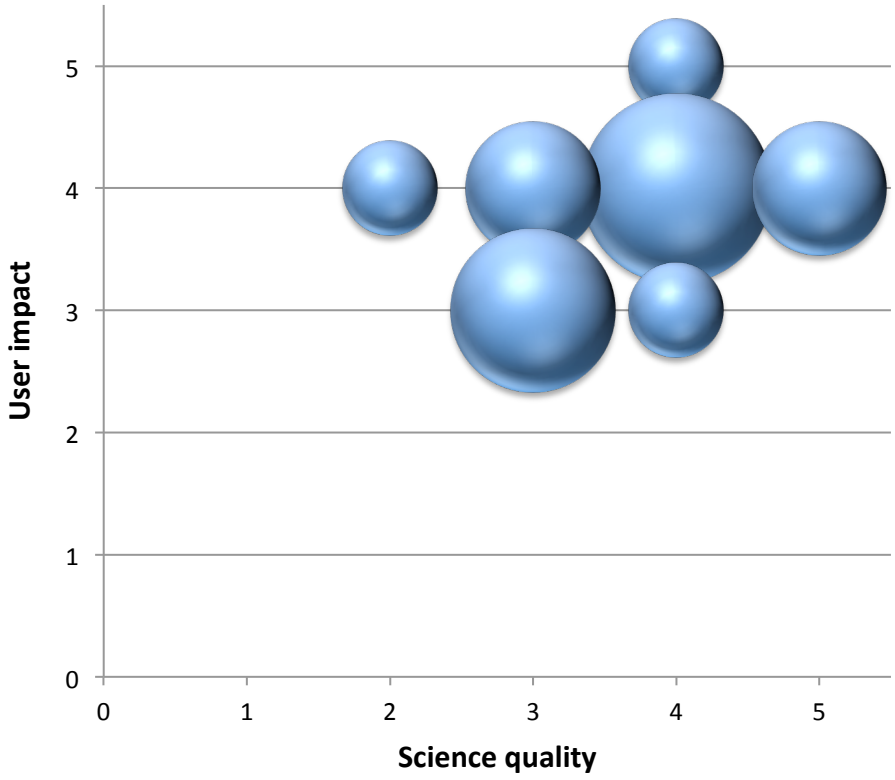
The KRAs then and now

In 2006, the evaluation of the KRAs looked like this – where the size of the circles represents the number of KRAs of a particular level of science quality and user impact.



The most frequent evaluation for the KRAs was 4/3 in terms of science/impact. But there were some very high quality KRAs and many high impact KRAs. There was also a spread of lower quality and lower impact KRAs.

In the present review, the Panel found the KRAs arrayed like this.



Even allowing for the fact that there are fewer KRAs in this review, one immediately notices that the impact has risen broadly, while the quality has remained high. The other interesting change is that the spread into lower categories has been reduced. This is particularly noticeable in impact.

A SWOT analysis

We found that the Institute's key strength – its good current scientific trajectory – will be tested by a key weakness – a poor ability to capitalise on this science through synthesis, integration and modelling.

In addition, a key opportunity for the Institute – to move to a world-class level in tropical marine research – could be threatened by more nimble competitors poaching key staff and capturing ideas or resources.

More particularly, we found the following.

Strengths

- The current trajectory of science is good. On balance, the Institute is producing high quality science and is on an improving trajectory.

- The research infrastructure at Townsville is excellent. It supports a world-class tropical marine research facility, with efficient boats, specialised equipment and specialised technical fabrication facilities.

- The Institute has created and continues to support a very valuable long-term monitoring research program with well-managed databases and an enlightened public access policy. This is an asset whose value continues to increase.

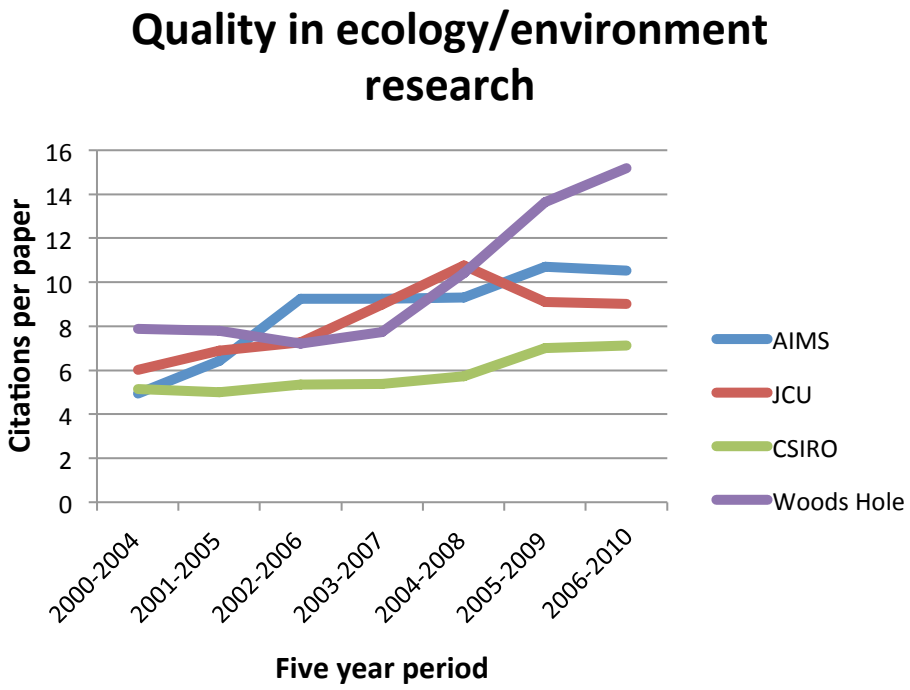
- The research program is approaching global benchmark in science publication quality with increasing citations per paper – and is superior to national competitors with regard to citations per paper (a standard quality metric) – see below (data from ISI Web of Knowledge).

- A strong and valuable tradition of scientific study of patterns and processes in tropical marine systems is being maintained.

- The Institute has been refreshed during the current Plan with a world-class postdoctoral fellowship and doctoral student program.

- There has been a productive and significant expansion of resources in other geographical areas.

- The Institute has demonstrated a strong capacity to take initiative and support promising new people and directions, such as in microbiology and symbiosis.



Weaknesses

- The valuable long term monitoring data are not well exploited by analysis and through theory-driven synthesis. These data – and other synoptic data sets - are key Institute assets and offer it a strong comparative advantage.

- More broadly, the Institute is underpowered in science synthesis, integration and modelling skills, which are useful not only in 'telling the big story' but also in evaluating results and in research planning.

- There seems to be little agility and opportunistic flexibility (e.g. to pick up exceptional postdoctoral fellows as staff who can fill a need or provide future direction).

- Research Team Leaders and project/task leaders do not have enough autonomy and scope to demonstrate initiative, and, as a consequence the role is not sought after by some of the researchers most able to provide insightful leadership.

- There is a strong perceived communication disconnect between the Research Directorate and Research Team Leaders, several of whom feel marginalised and lacking in feedback.

- Internal approval processes seem overly bureaucratic.

- Some line reporting is duplicative and receives insufficient feedback.

- The Institute has failed to create a collective conversation on new science possibilities and blue-sky science (*Grand Challenges*).

- The Institute has often failed to work proactively with stakeholders seeking knowledge exchange, not just transfer.

- There is limited flexibility to follow new ideas during a quadrennium – a weakness that grows as science cycle time shortens.

- Given the opportunities available, not as many scientists have stepped up to world benchmark as we would have expected. We think there are problems here to do with difficulties in recruitment, but also with a science culture that remains somewhat inward looking and parochial. We think these problems could be mitigated with greater attention to national and international science linkages.

- Many staff, when asked to explain their major research contributions, failed. They listed papers, prizes and other trappings of science. The inability to express in plain English exactly what has been achieved, which in almost all cases was very significant, represents lack of

experience with communicating science outcomes. This was also a problem in some of the written evidence.

Opportunities

- There is a large supply of exceptional young scientists in the national and international market who could provide new skills and approaches to the Institute, including through synthesis activities.
- The research results and database derived from the WA effort have the potential to produce high quality and impact science.
- Good use of publicity and marketing could increase the visibility of the Institute's achievements.
- Exploring various incentives to engage more visiting scientists could bring new skills and start initiatives in emerging fields where the Institute is currently not leading.
- The Institute has the opportunity to shape the future of the GBR Reef Water Quality Protection Plan.
- Additional publications are possible with increased supervision of postdoctoral fellows and students by those Institute scientists who currently are underutilizing this opportunity (perhaps with an Institute strategy to facilitate high-quality student interactions).
- Institute scientists have the capacity to identify major new fields of research if given more research flexibility.
- The ATOS facility is a significant opportunity as it will allow new classes of research and new classes of collaboration.
- A rethinking of the AIMS mission statement (inclusively with all staff) with emphasis on discovering, developing, exchanging and applying knowledge and on prioritisation, could minimise low-value time-consuming roles and activities.
- There is enormous potential for creative discussion among individuals with differing views of tropical marine ecosystem processes that could lead to creative synthesis of new understanding and directions.

Threats

- There is an enduring policy risk of not being able to capture increased appropriation funding to capitalise on geographical expansion.
- There is a critical risk of missing the next emerging science issue and being too slow in implementing initiatives.

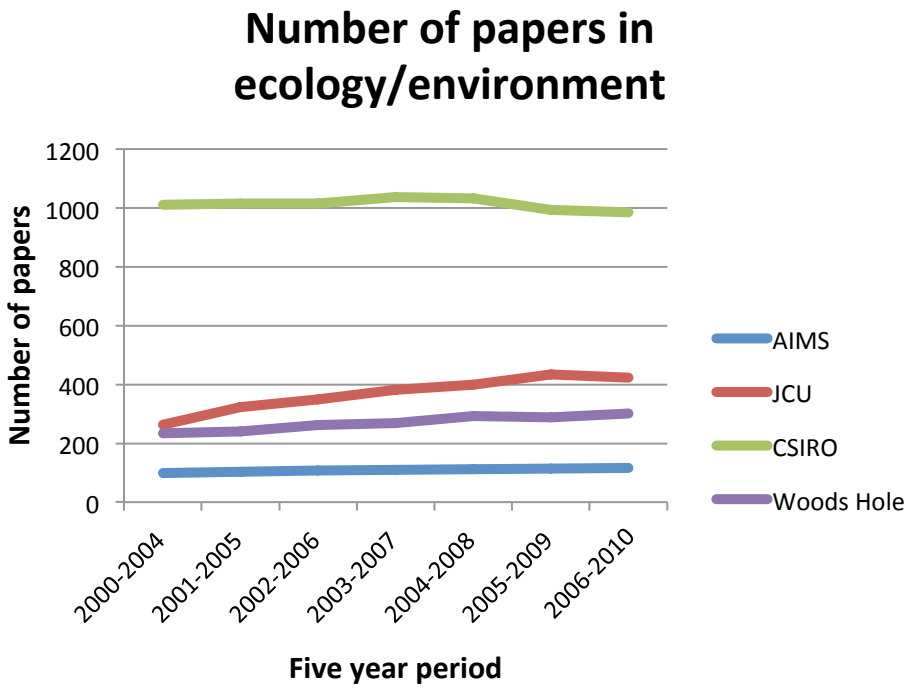
- There is an emerging tactical risk of not capitalising on the Institute's core strengths and allowing competitors to claim the field – for example, coral biology being claimed by JCU.

- There is a significant risk of failing to capitalise on the high levels of ongoing investment in long term monitoring.

- Scientific achievements could be compromised if investment in science skills suffers at the expense of investment in science infrastructure.

- The trend in the quantity of scientific papers has stagnated relative to the University sector such that AIMS is in danger of being swamped – see below. There are several possible reasons for this, but the net effect is that AIMS loses visibility relative to competing organizations.

- The Institute's skills are thinly spread and if the difficulties of quality recruitment cannot be overcome, research programs and new initiatives are at risk from the best staff leaving.



Review of Team 1
Supporting the sustainable use of marine biodiversity

Project description (provided by the Team)

Recent history

In the final year of the last Research Plan (2003-06), AIMS science was split into seven teams and elements of the current team were then spread across four teams (Biodiversity Assessment in New Areas, Status and Trends, Tropical Aquaculture, Biomolecular Resources and Innovation). In 2006-07, there was a gap year between Research Plans as the Australian Government moved from triennial to quadrennial funding. Consequently 2006-07 provided an opportunity for a year of consolidation and review in preparation for the next Research Plan and Funding Agreement. In a minimalist change, biodiversity tasks were pooled into two completion teams (Biodiversity Assessment & Trends, Biodiversity Sustainable Use) joining surveys with monitoring, and aquaculture with fisheries research. The new Research Plan (2007-11) further consolidated these teams into a single one (Assessing and Using Marine Biodiversity) to be led by Chris Battershill. The AUMB Team also acquired the Marine Bioresources Library when an external review of Biomolecular Resources and Innovation recommended AIMS exit from internal biodiscovery.

In the first year of the current Research Plan (2007-08), AIMS entered negotiations with Woodside Energy for a $30 million project of biodiversity assessment and monitoring based at Scott Reef in the Indian Ocean. The arrival of an additional 30 FTE resulted in a single biodiversity team of unmanageable size, which led to the creation of a second biodiversity team in 2008-09. These are the current teams (Exploring Marine Biodiversity, Supporting Sustainable Use of Marine Biodiversity). While similar to the two themes in 2006-07, the new Team was based in Perth, Western Australia. This regionalism has meant that two of the current KRA (1.1 biodiversity surveys, 1.2 biodiversity monitoring) are delivered through both teams albeit through separate tasks.

The mission of the SSUMB team is to facilitate sustainable use of the marine environment and marine living resources. This requires us to understand the system drivers underlying patterns of marine biodiversity in order to interpret and predict change, as this is the most frequent request from natural resource managers. We also seek to facilitate the development of sustainable new marine industries based on tropical seafood and other marine bioproducts.

Significant changes in research focus from the previous funding period are:

- Increase number of co-invested projects
- Focus on Census of Marine Life
- Focus on developing predictive tools (Reef Atlas/eAtlas/CERF)
- Securing past data/collections and making them freely available to the public on line
- (Coral ID/Coral Geographic)
- Focus on data synthesis and publication

- Focus on workup and publishing long term data series
- Hand over matured aquaculture projects to industry (Prawns/Sponges)
- Focus on development of a key new target tropical aquaculture species of significance to Australia
- Focus on developing National biodiversity repositories (libraries) for future Australian and International screening opportunity

Mission

Biodiversity has intrinsic environmental, economic and social values. Sometimes activities to realise these values conflict; usually where actions that enhance short-term economic gain lowers the capacity of the environment to sustain resource exploitation in the longer term, or compromises environmental resilience in response to other impacts. Environmental modification will simultaneously reduce social amenity value.

Today, humans have considerable power to impact the structure and function of natural ecosystems. Such impacts stem from strong economic and social drivers. In order to manage natural resources in the face of these powerful drivers, environmental managers require knowledge of human effects on ecosystems and need to be in a position to make robust predictions about the ecological responses (of species and assemblages of species) to be expected under alternative management scenarios.

While the end goals are clear, considerable gaps remain in our fundamental knowledge of tropical marine biodiversity. During the 2007-2011 quadrennium, the SSUMB Team is committed to research that will help fill these gaps (detailed under Key Result Area 1).

Although substantial knowledge gaps about tropical marine biodiversity exist, in a few cases tropical marine biodiversity is comparatively very well sampled. For example, AIMS has collected substantial long-term and spatially rich data sets from the Great Barrier Reef over the last two decades. These data sets will underpin the development of a new generation of models to advance understanding of the processes that generate and maintain biodiversity, leading to the development of decision support tools for conservation and management (detailed under Key Result Area 2).

In addition to generating knowledge about the environment that will assist natural resource managers to attain their goals of sustainable use and conservation, AIMS will continue to play a role in the development of alternative industries, principally through aquaculture (detailed under Key Result Area 3), but also through developing novel uses for Australia's marine biodiversity (detailed under Key Result Area 4).

Project review

Ratings

Quality	4	Impact	4

Introduction

As noted in the team summary of its activities, this area of research has had several structural changes since the last review. What were originally two groupings (Biodiversity Assessment and Trends, Biodiversity Sustainable Use) were then joined into one group under the leadership of Chris Battershill. Subsequently, the receipt from Woodside Energy of a 30 million dollar grant for Western Australian research (and 30 FTEs) resulted in a biodiversity group that was too large and too geographically disparate to manage easily, and the WA component was split off into a separate Team 5 (Exploring Marine Biodiversity), with very similar objectives as are covered by KRA 1.1 and 1.2 for Team 1. Thus in some aspects KRA1.1 and 1.2 are now more closely related to Team 5 than they are to KRA 1.3 and 1.4, which are concerned with aquaculture and bioresources. (Indeed, for many reporting purposes, KRA 1.1 and 1.2 are combined for the two teams as there is no separate KRA 5.1 and 5.2 – this can make it difficult to separate some aspects of their activities). Moreover, many aspects of KRA1.2, which is broadly concerned with the health of the GBR, have important linkages with research efforts by other teams, in particular Team 2 (water quality).

There is no perfect way to carve up activities in an organization the size of AIMS, and there was considerable sentiment expressed that repeated rearrangements of groups was counterproductive. However, this makes integration across teams an especially important requirement in the case of Team 1.

Quality and impact of KRAs

KRA 1.1 Assessments of tropical marine biodiversity

Quality	4	Impact	4

KRA 1.1 (Team 1) is led by Julian Caley (who also plays a smaller role in KRA 1.2); it is a small group with two postdoctoral fellows and four support staff. It is a strategic research effort whose primary responsibility during the last review period has been to carry out research associated with the Census of Marine Life Coral Reef Project (CReefs); AIMS was one of three research nodes in this effort. Several achievements in this project are especially noteworthy: the attraction of multi-million dollar co-investment from BHP Billiton, the formation of strong collaborative relationships with Australian museums and taxonomists (who participated in numerous expeditions with AIMS to Heron Is, Lizard Is, and Ningaloo reefs), and the development of standardized biodiversity sampling methods that are being adopted worldwide. This five-

year project is just finishing and many of the discoveries are still being prepared for publication. Already, however, CReefs publications have documented both the enormous diversity of coral reefs, and the large mismatch between diversity and research effort.

KRA 1.2 Accurate and timely information issues and threats to coral reefs

Quality 4 Impact 4

KRA 1.2 (Team 1) is demand driven and has two primary responsibilities. The monitoring of the long-term changes in the GBR is led by Hugh Sweatman, who supervises a team of seven non-PhD scientists. The ecological analysis and synthesis effort is led by Glenn De'ath with the participation of four PhD staff, four non-PhD staff and two postdocs.

These activities are central to the marine management needs of Australia and the data sets acquired through the activities of this group are invaluable for many reasons. The restructuring to focus on the effects of rezoning is especially commendable and has already resulted in very influential papers documenting the role of no-take areas in creating reef resilience (Current Biology, PNAS). It is particularly encouraging to see these results of analysis and synthesis emerge from the long term monitoring data sets, and this kind of effort should be continually encouraged and supported so that the benefits from the enormous effort expended in collecting these data are realized.

This KRA also makes important contributions to electronic data distribution via Coral ID, Coral Geographic, the Reef Atlas, and the Australian Oceanographic Data Network.

KRA 1.3 Sustainable tropical aquaculture

Quality 4 Impact 5

The project on crustacean aquaculture aims to close the life cycle for the ornate rock lobster identified as a species for potential high-value aquaculture in tropical Australia. Targeting of this species builds on lessons learnt by previous efforts of this group to raise the larvae of the prawn *Penaeus monodon* that ultimately were successful scientifically but did not stimulate a local aquaculture industry for prawns because this was uneconomic due to competition from southeast Asian countries with much lower labour costs. The stringent water quality and microbial management requirements for the ornate rock lobster and, in particular, the complexity of the life cycle and the specific dietary requirements of the phyllosomas mean that rock lobster aquaculture will likely remain a relatively high-technology and knowledge business where the expertise being developed at AIMS will provide a great competitive advantage. The Review Panel were initially sceptical of the role that AIMS could play in stimulating the Australian aquaculture industry but were impressed by the quality of the work of this group. The experiments in which hatchery reared naïve phyllosomas were transported on AIMS research vessels and challenged with live zooplankton collected from mid-water tows to

establish dietary preferences were most impressive. The Panel became convinced that careful selection of target species and the strong expertise of this group led by Mike Hall could give AIMS a strong niche role in stimulating high-value aquaculture in tropical Australia. Links with the UMMS team are good and provide an important component of microbial management that is essential for successful aquaculture.

The second project in this KRA is sponge aquaculture led by Libby Evans-Illidge. The scientific basis for successful aquaculture of several sponge species has now been established and the project has been successful in transferring this knowledge base to indigenous people and other partners for commercial sponge farming. The high impact rating for this KRA is based primarily on the achievements in sponge aquaculture since the rock lobster work has not reached the stage of transition to the aquaculture industry at which time its impact is also potentially very high.

KRA 1.4 Sustainable supply of bioresources

Quality 3 Impact 4

Prior to 2007, AIMS had an active marine biodiscovery effort that build up a major resource in terms of extracts from marine invertebrates and microbes. This KRA aims at protection and effective use of this important resource that was established at considerable expense. Protection of this existing asset was seen as a high priority by the Panel. The strategy of populating the Queensland Compound Library with AIMS samples is a good one and should ensure maximum "screening exposure" of these samples, increasing the likelihood of important biomedical discoveries from this resource. It is important for AIMS to maintain some involvement in this area if only for protection of its existing assets. This KRA could expand if the team is successful in securing external funding for additional targeted biodiscovery efforts, and this is certainly possible given the resurgence in interest in marine drug discovery. Until this happens, AIMS is fortunate to have the expertise of Libby Evans-Illidge who has worked relentlessly to obtain legal clarity for access to bioresources throughout Australia as well as curating the collection and dealing with the Queensland Compound Library.

Review of team effectiveness

Portfolio balance

The team overall is reasonably well balanced between strategic and demand-driven activities, and it is important that it continue to preserve that balance. For example, for KRAs 1.1 and 1.2, both supplying relevant information for management of Australian reefs and providing basic understanding of biodiversity and the factors which influence it, are important for AIMS to maintain.

Capture of resources

KRA 1.1 and 1.2 have in different ways been very successful in supporting their activities (though KRA 1.1, apart from the WA effort, will have to work hard in the future in this regard following the termination of the Census of Marine Life).

Project management

This is a difficult team to manage as a team because of the disparate nature of activities being pursued. Moreover, Chris Battershill's priorities, as evidenced by his decision to leave AIMS, are more in the area of research than administration. Thus as a team, this is not as effectively managed as some other teams (e.g. water quality). The extent to which this affects the performance of the individual KRAs or the ability of this team to interact effectively with other teams (an important need) is difficult to judge.

Stakeholder engagement and knowledge transfer

KRA 1.1 has built important bridges between AIMS and the museums of Australia, and KRA 1.2 maintains a close working relationship with management authorities, including providing access to crucial long-term datasets (especially LTMP surveys). In addition, several web-based projects are designed for broad knowledge transfer (e-Atlas, Ningaloo Atlas, Coral ID, Coral Geographic). Some thought needs to be given as to how this is going to be maintained and grow in the future, as static web products have no future (for example, how is Coral ID going to be updated as systematic knowledge about corals grows?).

Collaborations

KRAs 1.1 and 1.2 are broadly collaborative. For example, KRA 1.1 is part of the global Census of Marine Life (with explicit links to NOAA, the Scripps Institution of Oceanography and the Smithsonian Institution) and members of KRA 1.2 publish with collaborators from JCU and elsewhere and jointly supervise a good number of students.

Future research directions for next Research Plan (2011-15)

With respect to the assessment and monitoring of biodiversity, it is essential that AIMS work to fully integrate the activities of this team with the WA team, via common methodologies and integrated analysis, even if for administrative reasons the activities remain split into distinct teams. Moreover, developing global initiatives (e.g. the proposed Biodiversity Observation Network) will allow data from the GBR and WA to be part of a global assessment and synthesis effort. As has been noted, strengthening synthetic and modelling capability is an important goal for the Institute broadly, and this team will benefit from strengthening capabilities in this area. There are already considerable opportunities for partnerships along these lines, as indicated in the summary statement from a recent workshop on Australia/US collaboration in science.

KRA 1.1. Because funding for the Census of Marine Life by the Sloan Foundation came to its planned end in 2010, this team has the challenge of planning how to move forward and acquire the resources needed to build on its past accomplishments. Many of the activities that were started during this review period have considerable potential if carried forward, so every effort should be made not to "drop the ball" in this area of research, not only because of its importance, but also because it is a relatively empty niche in where AIMS can corner the market in terms of Australian efforts linked to international initiatives.

KRA 1.2. Because of the demand-driven nature of this KRA, major changes in the kind of activities undertaken is not expected – the value of the long term data sets lies in the continuity of approach. However, one area, which does need clear planning, is the future of the various electronic databases that are not part of the monitoring effort (this was also noted in the previous review). Coral ID, for example, will not be very useful in 20 years if there is no mechanism to update it as new taxonomic discoveries are made. Similarly, the AIMS geographic databases need to be kept up to speed as enhancements in global efforts develop.

KRA 1.3. A strong foundation has been laid for aquaculture of the tropical rock lobster and efforts should be made in transitioning this research to stimulate the nascent rock lobster aquaculture industry. The group identified that a gap in their expertise is in eukaryote molecular biology and addition of this skill to the team by a new appointment or visiting scientist supplemented by appropriate postdoctoral appointments could open up research in larval metamorphosis and in the development of microbial resistance. Good interactions already exist with the UMMS team and these could be expanded. A particular challenge facing this group is the need to obtain external funding for their work and efforts to engage industry have been unsuccessful. Given this groups track-record of practical, scientifically-important contributions to aquaculture, it should be possible to secure funding from industry, but this requires redoubled efforts by team members as well as flexible and nimble approaches and realistic expectations from AIMS management. This team also needs to look towards their next target species in sustainable tropical aquaculture.

KRA1.4. Work should continue to focus on maximizing the return to AIMS of the considerable investment made in the bioresources library, and the group needs to be responsive to any significant leads that emerge from the on-going screening through the Queensland Compound Library. Work on the chondropsins should be continued. High quality samples collected during other AIMS on-going biodiversity research should be used to add to the AIMS Bioresources Library.

Previous review of team (June 2006)

The most relevant comments from the previous review of biodiversity assessment and monitoring, and the response to these comments, are as

follows:

- 1) …the Team's impact is not as high as it should be … trying to do too many things in too many places with too few resources.

Biodiversity activities have been focused and resources substantially increased.

- 2) …see the 'paddock' – the Institute's natural territory of the inshore and shelf waters of northern tropical Australia – as an entity, much as it now sees the Great Barrier Reef as an entity, so that it sees the science issues and opportunities at the right scale.

With the existence of KRA 1.1 and 1.2 now established in both the GBR and northwestern Australia, the potential for this to occur has been established, although it remains the case that the research in these two geographic regions could be better integrated.

The comment of the previous review that the "potential movement of Tropical Aquaculture to Research Team 4 (Microbes and Symbiosis) would strengthen partnerships within the excellent microbial ecology section" was not acted on and is not repeated here. The Review Panel considered the necessary interactions with UMMS to be effective under the current structure and is reluctant to recommend structural changes except where absolutely essential.

Review of Team 2 Measuring water quality and ecosystem health

Project description (provided by the Team)

Recent history

The previous Team ("Water Quality in the Great Barrier Reef WHA") was reviewed in June 2006 under the Government's Research Quality Framework. The financial year 2006/07 was the last year of the previous funding cycle. A number of changes were made to the team structure in 2006/07 following the 2006 review (however, not all explicitly recommended by the review panel), some of which affected the Team structure of the current MWQEH Team.

- The RTL changed from Lindsay Trott to Britta Schaffelke in July 2006, with Lindsay Trott as deputy RTL to ensure continuity;
- David McKinnon and his ACIAR-funded project *Planning tools for environmentally sustainable tropical finfish cage culture* in Indonesia and tropical Australia (ACIAR) were moved into the Water Quality in the Great Barrier Reef WHA Team. David has since resided in the MWQEH Team as a key research scientist;
- Andrew Negri was moved into the Water Quality Team and has been a key member of the MWQEH Team.
- A number of senior science staff were allocated to a newly formed "Synthesis and Integration Team" in 2006/07. Four senior research scientists who were previously associated with the *Water Quality in the Great Barrier Reef WHA* Team (Bandaranayke, Brunskill, Klumpp, Wolanski) left the institute (voluntary redundancy or retirement) before the new Research Plan.

The current quadrennium research plan for the newly formed *Measuring Water Quality and Ecosystem Health* team was developed in 2007 and commenced in 2007/08. The contingent of Research Scientists has changed compared to the previous funding triennium with the departure of several senior members (see above) and the transfer of three RS into the MWQEH Team (D. McKinnon, A. Negri and K. Burns, who was moved into MWQEH from the Synthesis and Integration Team). The staff configuration of the Team has since been largely stable.

Key research and monitoring activities of the *Water Quality in the Great Barrier Reef WHA* team have continued in the current MWQEH Team under KRA 2.1 *Human impacts on tropical water quality and ecosystem health.* In addition, a new research area has been added with KRA 2.2 *Tropical marine ecosystem processes and land-sea interactions*, with an emphasis on biological oceanography and bio-geochemical processes.

The geographic area of the MWQEH Team's activities is still predominantly the GBR but has broadened into the Northern Territory, Western Australia and South-East Asia. The Team's activities in the NT have intensified from late 2008 with the appointment of Prof David Parry as Scientist-in-Charge of AIMS Darwin Office, which is part of the Arafura Timor Research Facility (ATRF). David brought into the Team a wealth of achievement in marine and coastal environmental chemistry, with particular emphasis on aquatic pollution and a well-established

stakeholder network in northern Australia. Research at AIMS Darwin has concentrated on the impacts of coastal industrial development, especially in Darwin Harbour, which is to be developed as a hub for Liquified Natural Gas processing, and the Gulf of Carpentaria, predominantly associated with KRA 2.1. Currently, four MWQEH staff permanently reside in Darwin. Research activities of Team members as part of the Scott Reef Research Project, which are closely related with East coast research under KRA 2.2, have for administrative reasons been included in the Exploring Marine Biodiversity Team and are reported as part of that Team.

Mission

The health of coral reefs and other tropical marine ecosystems depends on the quality of the water in which they live. Sedimentation and turbidity regimes, nutrient availability, the amount and type of organic matter, presence of contaminants, salinity, temperature and alkalinity can all strongly influence the productivity, resilience and function of these ecosystems. The primary causes of observed declines in coastal water quality and ecosystem health are increasing human populations, intensifying land use and development in coastal regions and river catchments.

The mission of the MWQEH Team is to support coastal and marine planning and conservation through delivery of robust information about:

- status and trends of water quality and coral reef health;
- fate and effects of sediment, nutrient and pollutant inputs from various sources; and
- ecosystem processes underlying these effects.

The Team's research aligns strongly with the National Research Priorities. The outcomes from our research and monitoring are in particular relevant to National Research Priority Area A *An Environmentally Sustainable Australia*, especially National Research Priority Goals A2 *Transforming existing industries*, A5 *Sustainable use of Australia's biodiversity* and A7 *Responding to climate change and variability*, as well as the Goal C4 *Smart information use*.

As a response to the Review of the National Innovation System in 2008, the report *A Marine Nation: National Framework for Marine Research and Innovation* by the Oceans Policy Science Advisory Group (OPSAG) identifies the need for a national approach to marine research and innovation. Of the identified five main challenges facing Australia over the coming decades, the research by the MWQEH Team addresses four:

- *Opportunities for increased economic and energy security from marine and subsea resources*: addressed by MWQEH research to support and inform impact assessments of coastal development and seacage aquaculture
- *Conservation of marine biodiversity and ecosystem services*: addressed by MWQEH research into environmental pressures on marine biota, especially in coastal environments
- *Management and protection of the marine coastal environment*: addressed by MWQEH research and monitoring of status and trends of inshore water quality and coral reef health in the GBR and by impact studies of coastal development;
- *Climate change*: addressed by MWQEH research into cumulative environmental pressures on marine biota posed by the interaction of water quality and climate change related pressures (this is an emerging area of Team research)

The MWQEH Team is an *established international leader* in three research areas, (i) the effects of anthropogenic disturbance, especially land run-off and pollution on coral reef organisms (Fabricius, Negri, Uthicke and co-workers), (ii) mangrove ecology and biochemical cycles (Alongi) and (iii) tropical zooplankton ecology (McKinnon). The Team has an *average position* in

the fields of organic geochemistry (Burns), impacts of coastal development incl. tropical aquaculture (various) and biological oceanography (Furnas and McKinnon). *Emerging research* areas for the team are impacts of coastal development and pollution chemistry, which are expected to be future areas for international recognition.

Project review

Ratings

Quality	4	Impact	3

Introduction

The Measuring Water Quality and Ecosystem Health (MWQEH) team has been largely stable during this current quadrennium after some adjustments in the early period. While mostly concentrated on the east coast, the appointment of David Parry in Darwin in 2008 has expanded activities in the north and an involvement in Scott Reef has resulted in a presence in the west also.

Quality and impact of KRAs

KRA 2.1 Human impacts on tropical water quality and ecosystem health

Quality	4	Impact	4

There are 3 projects within this KRA. Around 50% of the KRA team effort goes into project; 2.1.1 - Water quality and ecosystem health monitoring of the GBR supported by the Commonwealth Government Reef Rescue funding. Data has now been collected for 6 years and together with associated AIMS databases has become a high-value resource. A significant component of this KRA has been the sharing of knowledge with stakeholders estimated at 30% of the effort. The tight timeframes for the current GBR Water Quality Protection Plan joint government initiative has meant that communication is an important ongoing task.

The existence of gradients in water quality parameters from near shore reefs towards the outer reef offers a major opportunity to evaluate impacts of multiple stresses on the GBR. This work has commenced with an experiment evaluating dissolved inorganic N, suspended particulate matter and temperature stress on coral. New parameters being considered for monitoring include biofilms on sediments and hard substrata; gene expression and physiological measures of coral; coral recruitment, benthic cover composition and bioerosion.

One important outcome of this KRA has been the adoption of water quality dose response relationships into the Water Quality Guidelines for the GBR by GBRMPA in 2009.

KRA 2.2 Tropical marine ecosystem processes and marine interactions

Quality	3	Impact	3

There are 2 projects within this KRA comprising about one third of the team FTE. The nutrient budgets for the Timor-Leste coastal zone have been completed with an interactive worksheet. A comparative study of nutrient budgets in the northern and southern (Pompey Reef complex) areas of the GBR, where upwelling occurs, has been submitted for publication. The importance of pelagic microbial processes for nutrient recycling and biogeochemical processes for carbon are being evaluated.

The book by Dan Alongi, *Energetics of Mangrove Forests*, and associated publications are a significant contribution to a phase of work now largely completed.

Review of team effectiveness

Portfolio balance

Generally the balance appears to be slightly too demand driven, although it is acknowledged this is a difficult balance. Some resources are required for conceptual synthesis, thinking about the data being collected and developing emerging ideas.

KRA 2.1 The team is currently demand driven for most of the tasks that have significant outcomes for the Reef Plan. The opportunity to conduct small experiments on the interaction of various stresses has been a useful adjunct to the main activity. Big picture strategic synthesis of data is best conducted in parallel to the monitoring activities wherever possible. If this synthesis cannot be funded as a necessary component of any external funding for monitoring, it will probably need to be funded from appropriation.

KRA 2.2 With the completion of the Alongi mangrove book, this KRA seems to be a collection of activities without a strategic focus. The foodwebs and nutrient budgets activity is an important aspect that could be enhanced with some strategic thinking and focus.

Capture of resources

External funding is well captured and used and contributes substantially to the utility of the AIMS databases. It positions AIMS as the significant provider in the Reef Plan initiative and offers the potential for AIMS to be an important driver of any proposed future science-based activities.

With around 2/3 of the team FTE either co-invested or fully externally funded, there is currently a good level external funding.

Comments on the team SWOT analysis

It is agreed that the team **strengths** are a critical mass in experimental benthic ecology and stakeholder engagement. Also a major strength is the very good assets in long-term monitoring databases that are well maintained and updated.

The **weaknesses** of the team, identified as being somewhat insular and having insufficient time for blue-sky thinking and research, are agreed. Also the acknowledged gap in synthesis and modelling is agreed.

For the **opportunities**, the lack of competitors in the land runoff marine interface and the ongoing need for information on the impact of changed exports of sediments, nutrients and pesticides on reef and reef lagoon health by government and NRM bodies are agreed and important opportunities. There is a major opportunity emerging to use the databases and the ATOS facility to develop a capability to predict possible responses to management, climate and pollutant changes and also to create possible restoration initiatives in the future.

As for **threats,** an expanded focus on climate change may be best served by joint projects with the Responding to Climate Change team to optimise effort and skills. A lack of conceptual and modelling skills in the team and the strong biophysical modelling skills of CSIRO will mean that groups with capability in ecosystem prediction and decision making, which have a high profile with policy and planning agencies, may overtake AIMS. This is a real threat. Developing integrated ecosystem process understanding and modelling skills relevant to decision making would help alleviate this threat (and provide additional opportunities).

Project management

The Team Leader, Britta Schaffelke, received very strong support from team members and management on the execution of her role. Projects appeared to be delivering on their milestones, particularly for external stakeholders.

Stakeholder engagement and knowledge transfer

Both KRAs (and the educational aspects of the project in KRA 2.2 for Timor-Leste) are delivering well. The Team Leader is involved with stakeholders which is to the advantage of the team. Anticipation of future major policy issues and influencing them through proactive stakeholder engagements and knowledge exchange as a two-way process would be beneficial to the team.

Collaborations

There is scope for further collaboration with external groups with mutual interests and to develop new initiatives for AIMS. It is suggested that involvement of other people in marine ecosystem health approaches would be beneficial. Dr Rebecca Lester from Flinders University, South Australia is actively involved in assessing the Coorong ecosystem and impacts of freshwater flows and has considered several modelling approaches of relevance to AIMS. A closer strategic collaboration with the Centre of Excellence at JCU on coral reef ecosystem concepts, including assistance in data interpretation and synthesis from the Institute's databases with PhD students and post doctoral fellows, may offer opportunities to capture core skills for the future.

Overfishing, water quality and reef health are related, and there appears to be a shortage of skills related to understanding herbivory and other fisheries research at AIMS. A targeted international visiting scientist scheme, where invited scientists come to co-develop and/or enhance a nominated new initiative at AIMS, is needed. This also allows the networks of the visiting scientists to be considered for future collaboration on core gaps.

Future research directions for next Research Plan (2011-15)

The directions provided by the team were reviewed. There needs to be some overarching concepts to give direction and focus beyond the existing KRA frameworks. We fully support the direction of assessing cumulative impacts of multiple pressures (KRA 2.2) within a broader focus.

A conceptual, semi-quantitative understanding of the interactions between water quality, ecosystem health, resilience, grazing, fisheries, climate, episodic catastrophic events, phase shifts, hysteresis and lag times in the light of multiple stressors having synergistic and sometimes compensating effects is a real challenge but of major future benefit. Furthering this understanding will be required for a predictive capability to allow decision making on the most effective options to maintain or restore reef and coastal lagoon areas if the current Reef Plan strategies do not work as expected.

To enable understanding and synthesis of data on ecosystem processes, some in-house modelling expertise is required. A skilled person will facilitate negotiation of effective partnerships with other groups with modelling expertise and manage refinement of models over time. This will become a priority requirement once the current hydrodynamic model development is largely completed.

Use of the databases for creative discovery of relationships and justification or falsification of hypotheses from the data analysis, together with the experimental opportunity from transects documenting change in water quality parameters and reef health, as well as the ATOS facility, offers an exceptionally powerful capability not available to any other agency.

Proactive input into decision tools and policy development by stakeholders, even more than the current major achievements in stakeholder communication, will ensure the ongoing relevance of AIMS into the future and an ability to foreshadow future research needs.

Some thoughts for the team to discuss in developing the research plan are:

- the role of water quality as a main emphasis compared to being a component of a multi factor analysis of ecosystem response

- clarification of the meaning of the concepts of resilience, ecosystem, health, hysteresis etc. and their relevance to the future research plan

- specifically identifying a few essential gaps in capability in the research plan and targeting strategies to overcome each one over the first 3 years of the plan may assist in achieving the desired outcomes in a timely manner.

Previous review of water quality team (June 2006)

The results of the previous review of this team in 2006 were considered. While there have been some significant changes since the last review, the following table lists the emerging science needs/opportunities and recommendations from the 2006 team review in the left column, some comments based on this current review in the centre column and links to recommendations of the current review in the right hand column. There are common issues from both reviews that will deserve some careful thought in positioning AIMS for the next few years.

Summary of emerging science and recommendations from June 2006 review	**Progress and comments in this current 2010 review**	**Relevant recommendations from this 2010 review**
Emerging science needs/opportunities		
No major science shifts/needs/opportunities were identified.	A move towards a broader and synthesised conceptual focus is needed.	Develop a world-class capability in synthesis, modelling, analysis and prediction by hiring and enabling international leaders and forging meaningful partnerships with other international groups. This process should lead to the next big investment.

Summary of emerging science and recommendations from June 2006 review	**Progress and comments in this current 2010 review**	**Relevant recommendations from this 2010 review**
The WQ team program should be expanded geographically to include areas outside GBRWHA; this also is in the interests of the AIMS contribution to the National Oceans policy and the National Framework For Integrated Coastal Zone Management.	This has happened but with sub-critical mass in Darwin and WA which is expected to improve. Close integration with coastal zone management is adequate and of lower priority than getting good synthesis and modelling skills in AIMS.	Develop a world-class capability in synthesis, modelling, analysis and prediction by hiring and enabling international leaders and forging meaningful partnerships with other international groups. This process should lead to the next big investment.
The program must be expanded geographically and conceptually to encompass the consideration of material sources (especially land-based) if it is to be fully effective in satisfying both scientific and client requirements.	See above. Land based aspects are well covered. An expansion of conceptual understanding is needed but towards multiple stresses and to identify relative contributions to ecosystem response.	Develop *grand challenge* questions to lead in the provision of policy-relevant science for managing Anthropocene changes in the tropics (e.g. climate change, acidification, water quality and issues yet to be recognised).
We visualise major commercialisation opportunities for both monitoring tools and ecosystem status measurement tools.	Commercialisation is doubtful but the major national interest of the infrastructure of AIMS and the databases are very valuable, although unlikely to generate significant income.	

Summary of emerging science and recommendations from June 2006 review	Progress and comments in this current 2010 review	Relevant recommendations from this 2010 review
Recommendations		
Our ranking of 3+ for the Team reflects principally the lack of international impact and lack of "Team" synergy. Both the Team and AIMS need to look carefully at these areas of deficiency.	Team synergy is considerably improved. Increased international science impact would be desirable.	Explore additional mechanisms for interaction with a broader group of universities (e.g. expand science visitor program) based around world-class facilities and field capabilities to fill gaps and highlight emerging opportunities.
The Furnas (2003) book is of major relevance to AIMS and consideration should be given to a downloadable PDF version to assist in greater uptake and recognition of the work.	This is taken as a need to publicise the good science of AIMS in contexts relevant to a wide group of stakeholders.	Make better use of opportunities to *sell* the Institute to policy makers and the public.
Attention should be given to more extensive data mining of existing WQ databases in association with the AIMS Long Term database.	Strongly agree. This is becoming critical to establish AIMS in a leading position for the future.	Build interactions and collaborations via Institute-sponsored NCEAS-style think tanks. Ensure expensive data sets become valuable data sets by providing time and expertise for synthesised analysis.

Summary of emerging science and recommendations from June 2006 review	Progress and comments in this current 2010 review	Relevant recommendations from this 2010 review
Ideally, the long-term chlorophyll database should be continued indefinitely because of its international comparability. It must be continued at least until displaced by more direct proxies of ecosystem health (c.f. Fabricius).		
Careful prioritisation of potential ecosystem health proxies should be considered in the interests of cost effectiveness (c.f. Fabricius; Codi King).		
More consideration should be given to nearshore ecosystem health indicators in the interests of economy and to take advantage of potentially greater levels of land-based perturbation.	This is expected to be a growth area and opportunity in the future. Economics is not a driver but a good understanding of multiple processes operating is important.	Use the next two years to plan efforts in experimental ecology that take immediate advantage of ATOS upon completion in ways that build the Institute's science and collaborations.
AIMS should give careful consideration to the promotion and promulgation of currently under-applied tools and conceptual advances from the work of Alongi and Wolanski.	While there have been staff changes, the intent is still that a major gap in synthesis and conceptual thinking remains a significant limitation that needs to be addressed as a priority.	Develop a world-class capability in synthesis, modelling, analysis and prediction by hiring and enabling international leaders and forging meaningful partnerships with other international groups. This process should lead to the next big investment.

Summary of emerging science and recommendations from June 2006 review	Progress and comments in this current 2010 review	Relevant recommendations from this 2010 review
There should be more meetings at the Team level to establish better collaboration and information exchange both in the interests of science and management.	Probably in hand. More science meetings across teams and discussion of 'science collages of understanding' is required to find the creative synergies between the discipline foci.	
Consider whether the present administrative Team Leader approach should be complemented with an "intellectual" leader capable of dealing with all aspects of the big picture.	The current review team considered this at some length. Change to another format that still ends up with similar issues is not warranted. However, reducing administrative demands on all Team Leaders has been recommended.	
Team member and service personnel mentoring, management training, progression, and succession need Institutional attention.		
Clarification seems to be required concerning the future for the Fabricius sub-team research.	The translation of the conceptual understanding of Fabricius et al. into semi-quantitative models is very important.	Develop a world-class capability in synthesis, modelling, analysis and prediction by hiring and enabling international leaders and forging meaningful partnerships with other international groups. This process should lead to the next big investment.

Summary of emerging science and recommendations from June 2006 review	Progress and comments in this current 2010 review	Relevant recommendations from this 2010 review
Visiting scientists should be encouraged to participate in WQ research.	An important need and specifically to be even more focussed in order to target new initiatives that AIMS needs to progress.	Continue to grow the number of doctoral students and postdoctoral fellows (e.g. invest money in student top-ups for salary, training and travel) drawing on a more diverse array of partners (not just JCU).

Review of Team 3 Responding to climate change

Project description (provided by the Team)

Recent history

Prior to the current research plan, several team members were part of the Environmental Change and Impacts (EC & I) Research Team. The Responding to Climate Change (RCC) research team was formed for the current research plan when several EC & I team members moved into the newly formed Understanding Marine Microbes and Symbioses (UMMS) Research Team. The newly formed Great Barrier Reef Ocean Observing System (GBROOS), although primarily an observational and developmental rather than a research activity, was incorporated into the RCC team as it logically augmented ongoing physical environmental monitoring systems managed by team members (e.g. remote sensing, automatic weather stations, temperature loggers, ocean monitoring moorings).

Mission

RCC Team Mission Statement: Informing management strategies to deal effectively and proactively with the consequences of rapid climate change in Australia's tropical marine environments and their associated ecosystems

Australia's tropical marine ecosystems are already responding to regional consequences of global climate change caused by enhanced greenhouse gas emissions. Even with national and international commitment to stringent mitigation strategies that stabilize and reverse atmospheric greenhouse gas concentrations by the middle of this century and keep average global warming below ~2oC by 2100, tropical marine climates are and will continue to experience ongoing, rapid and significant changes that will result in organism and ecosystem responses. A key issue for tropical marine ecosystems is that it is not simply a change to a new climate regime to which the ecosystems have to adapt but that, for the foreseeable future, climate will be continuously changing and it maybe 100s-1000s of years before a new, stable climate regime is reached (assuming international success at greenhouse gas mitigation). Changes of the physical environment include: continued warming of ocean temperatures (with mass coral bleaching responses already observed), gradual acidification of the ocean (likely to reduce the ability of various marine calcifying organisms to form their skeletons and shells), tropical cyclones of increased intensity (causing local physical destruction), more extreme rainfall events (with increased amounts of freshwater extending further away from the coast), gradual sea-level rise (affecting coastal erosion, storm surges and the area available for shallow-water marine organisms) and changes in ocean circulation and upwelling patterns (presently ill-defined but fundamental to many ecological processes).

Informed management strategies, against this backdrop of rapid environmental change, require clear identification of the magnitude and spatial and temporal dimensions of physical and biological changes and responses. This Team provides this information through placing current changes and responses in an historical context (KRA 3.1), mapping the evolving spatial risks and resilience using both physical and biological data, downscaling large-scale climate scenarios to space scales relevant to coral reef processes and providing a theoretical framework for assessing the impacts of various future changes and management actions (KRA 3.2), assessing the ecological responses of coral reefs, especially to thermal stress (KRA 3.3) and

using advanced physical environmental monitoring systems to understand how the physical environment and changes in that environment operate across a range of spatial scales affecting tropical marine ecosystems (KRA 3.4).

The Team's current research builds on AIMS' historical capabilities in the area of extracting climatic and environmental information from long-lived massive corals, understanding the nature and significance of changes in the tropical marine environment through long-term monitoring programs (e.g. Automatic Weather Stations, remote sensing, ocean moorings, temperature loggers), modelling of ocean circulation patterns in the complex environments of coral reefs, and linking the physical and biological responses through, for example, determining thresholds for coral bleaching and subsequent coral mortality. Innovative activities in the present research plan include development of explicit tools that link risk mapping (e.g. thermal stress, water quality) with potential management actions; downscaling regional climate scenarios to reef-scale ocean circulation patterns; determining the potential for coral adaptation to changing environmental conditions; and using new ocean observational tools to enhance current understanding of tropical marine environments.

Activities of the RCC Team relate directly to the National Research Priority Goal: An Environmentally Sustainable Australia and, specifically, Responding to Climate Change and Variability and Supporting Sustainable Use of Marine Biodiversity, and National Research Priority Goal: Frontier Technologies for Building and Transforming Australian Industries and specifically Frontier Technologies and Smart Information Use. The Team's activities also reflect priorities of the National Framework for Marine Research and Innovation, specifically Conservation of marine biodiversity and ecosystem services, Management and protection of the marine coastal environment and Climate Change.

Activities of the RCC Team are internationally competitive in the areas of tropical ocean observing systems, risk and resilience mapping, understanding coral growth responses to changing environmental conditions, understanding how Australia's tropical marine climate is already changing, and the how corals' responses to thermal stress may evolve with continued environmental change.

Project review

Ratings

Quality	4	Impact	4

Introduction

The Responding to Climate Change research team is in a state of transition, with three posts currently advertised (including Team Leader), and with the forthcoming ATOS facility likely to play a significant role in shaping future directions and foci. Three of the KRAs (3.1, 3.2 and 3.3) are relatively small, each relying on between 1 and 1.55 FTE Research Scientists to deliver. The other KRA (3.4; Ocean Observing Systems) is a much larger endeavour, but has no Research Scientists embedded with more than 0.2 FTE.

Quality and Impact of KRAs

KRA3.1 Marine Climate History for Northern Australia.

Quality	4	Impact	4

This KRA is currently delivered almost exclusively by a single Research Scientist, Janice Lough, and is focussed on the collection and analysis of cores from annually-banded massive corals for reconstruction of past climate variability and change. This continues to be a productive endeavour, with high quality scientific publications and ongoing collection of coral cores to provide much expanded geographical coverage in the west and northwest. During the last review of the Climate Change and Impacts group, the review team recognised that AIMS was at a critical decision point: if they wanted to achieve true international leadership in marine climate reconstruction to inform our understanding of current and future climate change, then they would have to invest significantly in new geochemical facilities to allow climate reconstruction to be achieved in-house. AIMS has not gone down this route during the past four years (although we note the potential of new facilities in Darwin to contribute some capability). As a consequence, this KRA continues to rely on strong collaborations with external researchers. Fortunately, Janice Lough is an outstanding collaborator, so this works reasonably well, albeit with AIMS receiving relatively modest returns (in terms of scientific reputation) from its major long-term investment in the collection and growth-rate analysis of coral cores.

This work has high potential impact in terms of contributing to improved estimates of the probabilities of future climates and hence influencing policy and business decision-making at regional to national scales. Although there is a clear willingness to move this science to deliver impacts and there is some success, the full potential of this translation is yet to be realised. In this context, closer collaboration with national and international climate modelling groups

involved in climate prediction and potentially with major stakeholders such as the insurance industry would be beneficial.

KRA3.2 Resilience and Risk Mapping in Space and Time

Quality 3 Impact 3

This KRA has two components, "Tools to support resilience-based management" which is delivered by one person (Scott Wooldridge) and "Downscaling regional climate scenarios" (55% of Richard Brinkman and 10% of Craig Steinberg). The former project utilises Bayesian belief network approaches, and published findings include potential synergistic impacts of heating, elevated CO_2 and nutrients on coral symbiosis and bleaching. Funding for this research has been jointly through AIMS appropriation, and MTSRF (50% each). Although this work has merit, the overall contribution of AIMS research under this project to aiding decision-making for management of the GBR is modest with relatively few high profile publications or other outputs. This is largely a function of the small amount of FTE, and the lack of integration with other modelling endeavours. The "Downscaling regional climate scenarios" project consists of applying dynamic downscaling techniques to physical climate change scenarios in both Ningaloo reef and the GBR (especially Capricorn-Bunker group). The objective is to achieve realistic sub-km/reef scale resolution to aid assessment of potential impacts. The GBR study is a MTSRF funded project, while the Ningaloo project is a WAMSI and AIMS funded project. CSIRO is a key partner in this work. In 2009 a new collaborative project, *Hydrodynamics at the whole of GBR scale*, was initiated with CSIRO, RRRC and GBRMPA. This has resulted in the development of a 1km resolution baroclinic hydrodynamic model for the whole GBR, and is seen as a precursor for developing a whole GBR water quality model that could ultimately include ecosystem response. This development of realistic hydrodynamic models certainly has the potential to support innovative science related to variability and change on the Great Barrier Reef, and, ultimately, to be used to support management strategies for the GBR and adjacent landuse. However, up to this point, the research has focussed on technique and product development rather than on scientific or management applications.

KRA3.3 Ecological Responses to Climate Change

Quality 4 Impact 3

This KRA focuses on investigation of coral bleaching thresholds, how these change in space and time and with species, and assessment of the potential for corals to acclimate to warmer conditions by shuffling symbiont types. This builds on work done in the previous quadrennium, and is led by Ray Berkelmans. The approach is both observational (observing changes through time) and experimental (in the field and in the laboratory). The quality of the research is high, and the findings are being published in high impact journals. However, we note that it is unfortunate to have this work occurring in a completely separate Research Team to that of Madeleine van Oppen and colleagues. This was not the case in the previous quadrennium, and in our view the change has resulted in some loss of critical mass for this particular KRA.

Finally, the KRA reported on a potential way to predict bleaching on the basis of cold upwelling pulses at Magnetic Island. This is an interesting observation, but would benefit from a stronger theoretical understanding of the processes involved and their drivers before predictions can be made with confidence.

KRA3.4 Ocean Observing Systems to Monitor the Physical Environment

Quality 3 Impact 4

This KRA is by far the largest in terms of total staff resources, and is initially focussed on developing and maintaining a Great Barrier Reef Ocean Observing System (GBROOS) as a part of Australia's Integrated Marine Observing System (IMOS). It is delivered in a partnership with the four operators of island research stations: Heron (UQ), Lizard (Australian Museum), Orpheus (JCU) and One Tree (USyd), plus the Queensland Cyber-Infrastructure Foundation (UQ) and the ARC Research Network for Intelligent Sensors, Sensor Networks and Information Processing (U. Melbourne). GBROOS collects measurements from ship-borne sensors, moored instruments, coastal ocean surface radar, upgraded remote sensing facilities covering SST and ocean colour, and a network of sensors utilising wireless technology at the four island stations. The initial focus has been on the Coral Sea region, but AIMS is planning to deploy and maintain new oceanographic moorings in the North and West, with the final investment in the west potentially growing to be greater than in the east (with funding from the Western Australian Government). Without doubt, GBROOS is an impressive technological and logistic achievement, with the wireless sensor networks a particularly novel element. AIMS appears to have delivered all of this with professionalism and should be proud of its role, with Scott Bainbridge and his team deserving great credit. However, although IMOS comes with considerable new money to support the development and maintenance of the ocean observing systems, it is clear that at present this KRA is driven by technology and not by the science that it may enable. A large proportion of the physical oceanography capability of AIMS is tied to this work, leaving little time to support other Teams and KRAs or to pursue fundamental research on coastal, shelf and reef oceanography. The ongoing commitment to GBROOS and the geographic extension of IMOS to the west represents a threat and an opportunity to AIMS. AIMS should seek to capitalise on the investment by ensuring that they help lead in the science that can be enabled through this impressive network (requiring new research scientist appointments in physical oceanography), and they should also identify decision points for continued investment in maintaining the system. In this context it is worrying to note that recent attempts to hire a senior Physical Oceanographer have failed.

Effectiveness of Team

Portfolio balance

KRAs 3.2, 3.3 and 3.4 are identified as demand driven, while KRA 3.1 is identified as being a mixture of strategic and demand driven. KRA 3.4 (Ocean Observing System) is too much focussed on creating options rather than developing options for scientific research.

Capture of resources

The largest external investment for the RCC Team is understandably for the ocean observing system (KRA 3.4). Capture of resources for the other KRAs looks to be modest.

Comments on the team's SWOT analysis

The Team's particular strengths in ocean observing systems (from in water measurements, to data management and delivery), and in the AIMS coral core archive are correctly highlighted. The weaknesses are also well identified to be the heavy focus on delivery of operational oceanography (the ocean observing system) at the expense of research-driven oceanography, and we agree that the separation of some of the key ecologists and biologists from the researchers in this team who focus on physical processes and measurements is unfortunate. Developing optimal groupings within a multi-disciplinary organisation such as AIMS is always challenging, but AIMS should seriously consider how best to remove potential barriers to joint research between physical and biological scientists in order to capitalise on its natural advantage of having a spectrum of excellent researchers in the same buildings. We also agree that AIMS could benefit from additional resourcing of students and postdocs, including in this area of this team. The team identified a number of opportunities including expanding the geographical range of the ocean observing system, utilisation of the ecological and oceanographic and climate data to better understand the drivers and mechanisms of variability and change in the physical and biological environments, and new infrastructure that would allow the Team to be co-located and to conduct experiments using the new ocean simulator. The infrastructure is planned, but the other opportunities will require considerable investment to realise. The team realise this, and under *threats* they acknowledge that there is a significant risk of not attaining the correct balance between data generation, and data analysis and interpretation. The lack of opportunity for innovative science under the current structure and funding model was also noted.

Project management

Janice Lough is acting as Team Leader while the post is readvertised. This could be a critical appointment. The Team, and the Institute would benefit from a leader who is enthusiastic about the role, and who will work with senior management to evolve the team structures and composition as new staff and facilities (e.g., ATOS) come online. This will be important to ensure that AIMS is optimally positioned to grasp the high ground in key interdisciplinary research into the nature and impacts of environmental change. We were very

impressed with Scott Bainbridge's management of the ocean observing system, but felt that more scientific leadership for the Team would help steer this endeavour.

Stakeholder engagement and knowledge transfer

Knowledge transfer is particularly strong in areas of making data widely available (e.g., from GBROOS and coral core data), although engagement with stakeholders appears to be focussed on relatively traditional knowledge transfer activity.

Collaborations

AIMS' contribution to the Australian ocean observing system is delivered through collaborations with CSIRO and others. These appear to work well, although naturally CSIRO is also regarded as a competitor in some areas including the dynamic downscaling work. If AIMS does not succeed in appointing at least one more research scientist physical oceanographer, then AIMS will need to rely on collaborations to deliver research science from all the ocean data being collected. Janice Lough has an excellent list of international collaborators, and researchers in the other KRAs have a reasonable mixture of national and international collaborations. As was noted in the previous quadrennium, the lack of analytical facilities for coral geochemistry will limit the likely scientific impact of the AIMS coral core collection (where collaborators will be required), although the appointment of Jens Zinke as a new WA-AIMS post doc may help to alleviate this.

Future research directions for next Research Plan (2011-15):

The Team's assessment of future directions was heavily influenced by the planned addition of 7 research positions (the Team Leader, 3 research scientists and 3 post docs). In essence, the aspiration appears to be to utilise the additional human resources to be able to deliver more of the science in the areas in which the team is already engaged. There was little evidence for the various KRA leaders having jointly discussed their plans before writing their sections, resulting in something that looks rather like the status quo, and which lacks bold suggestions on how best to maximise the potential synergies across disciplines. For example, although the planned increase in the RCC cohort will include coral and fish 'climate change' research scientists, there was no mention of a broader strategy of ensuring optimal engagement from existing biological researchers interested in the impacts of climate change (e.g., Katharina Fabricius and Madeleine van Oppen to name just two). Therefore, given the planned new recruits and facilities, we recommend that AIMS considers how best to ensure that the structure, composition and funding of the Teams does not inadvertently create barriers to innovative collaboration.

In this regard, we note that at present KRAs 3.1, 3.2 and 3.3 are very close to or are below critical mass in terms of allocated FTEs despite their relevance to AIMS' overall mission. The new recruits will certainly help address this issue.

However, we recommend that the activities in KRA3.2 become more clearly integrated with other synthesis and statistical work in the Institute (e.g., in the SSUMB and and MWQEH Teams), and that research into the important topic of Ecological Responses to Climate Change is more clearly integrated across the Institute (rather than the current 'isolation' of Ray Berkelmans under this heading).

Another recommendation is that AIMS must strive to capitalise more on the mass of new data and potential that results from the ocean observing system, recognising the tension between long term commitment to routine maintenance and expansion vs. giving researchers time to turn data into knowledge.

Review of Team 4 Understanding marine microbes and symbioses

Project description (provided by the Team)

Recent history

The UMMS team was established in 2007 as a response to the 2006 external review, which recommended a consolidation of a range of research areas using molecular and chemistry based technologies to answer key questions in coral reef ecology, and a disbanding of previous biodiscovery-focused research. The formation of the UMMS team resulted in staff being redeployed from existing teams (including the Biomolecular Resource and Innovation team and the Responding to Climate Change team – which operated under a different name at the time) and, with the transition into the 2007-2011 quadrennium, the chemistry staff base was reduced considerably (one principal research scientist and one experimental scientist left AIMS and were replaced by one technical officer).

The establishment of the UMMS team was primarily driven by an opportunity seen by AIMS scientists and management to develop research into the microbiology and symbioses of key reef organisms, in particular corals and sponges. Although there were and are a number of strong research groups in Australia involved in marine microbiology, genetics and symbiosis research, often these efforts are fragmented across departments and universities and therefore lack focus. The field of marine microbiology has experienced a revolution in the last decade, largely driven by an increased realisation of the enormous diversity of microbes in the world's oceans and the vital role they play in sustaining the planet. In addition, next generation DNA sequencing technologies now provide a means to study these organisms and their function in detail. At the time of planning for the current AIMS quadrennium, large investments were being made into this research overseas, but Australia was not a key player. AIMS therefore identified the field of marine microbiology and symbioses as an area where investment could result in significant scientific impact. This research is supported by the existing capabilities in genetics, chemistry, biochemistry and ecology.

The overarching goal of the team is to improve knowledge of tropical reef ecosystems in order to inform coral reef management, based on an understanding of the critical biological mechanisms mediating the ecological dynamics of microbes and symbioses in a changing climate. The research is divided into two Key Result Areas (KRAs).

- The objective of the first KRA is: *Better understanding of the biochemical and genetic mechanisms underpinning symbioses in coral reef characterising species, invoked to promote resilience and adaptation in a changing ecosystem.* This KRA links with the Responding to Climate Change team.

- The second KRA explores the role of microorganisms in reef health. Its objective is: *Enhanced reef management based on understanding trends and mechanisms in microbial community ecology and pathogen virulence against a backdrop of environmental change.* The project links with the Measuring Water Quality & Ecosystem Health and Responding to Climate Change teams.

The research team has shown consistent growth since its commencement, both through external and appropriation funding (AIMS Futures project - see appendix 1) for postdoctoral

scientists. Linda Blackall was recruited to AIMS in early 2008 to lead the team. While the research scientists and postdoctoral fellows are central to the team's scientific output, the UMMS team has a significant investment in engaging and training students. This has resulted in a significant output in terms of publications and growing scientific recognition, and has allowed the team to achieve the critical mass and a stimulating environment required to position the UMMS team at the frontier of this research field.

Mission

The overarching goal of the Team is to provide an understanding of the critical biological mechanisms mediating the ecological dynamics of microbes and symbioses of tropical reef ecosystems and their responses to a changing climate. To do so, it uses and develops cutting-edge technologies and tools. This will permit informed management of reef systems, in particular the GBR.

The research outcomes from the team therefore support a number of the National Priorities. In particular the research is focused on achieving 'An Environmentally Sustainable Australia' and 'Frontier Technologies'. The Table below highlights where the team's research addresses these National Research Priorities.

National Priority	***An Environmentally Sustainable Australia***				***Frontier Technologies for Building and Transforming Australian Industries***			***Safeguarding Australia***	
Priority Goal	A1- Water a critical resource	A2 - Transforming existing industries	A5 - Sustainable use of Australia's biodiversity	A7 - Responding to climate change and variability	C1 – Breakthrough Science	C2 - Frontier technologies	C4 –Smart information use	D1 - Critical infrastructure	D2 Understanding our region and the World
Relevance		Very	Highly	Highly	Very	Very	Very		Relevant

Key

Highly Relevant – intended outcomes and planned activity directly focused on priority goals.

Very Relevant – intended outcomes and activity closely related to priority goals, but also focused in related areas.

Relevant – intended outcomes and planned activity related and likely to contribute to priority goals.

Project review

Ratings

Quality 5 Impact 4

Introduction

The Understanding Marine Microbes and Symbiosis (UMMS) team was created in 2007 in response to the 2006 external review that recommended that marine biomedicinal discovery research be discontinued at AIMS and that molecular and chemistry expertise be consolidated. AIMS saw the opportunity to become a leader in the study of microbiology and symbioses of reef organisms. The UMMS team has grown through appropriation and external funding and has made excellent research progress in a short time. The UMMS team works mainly in the GBR region but has some field studies in WA, on coral spawning in the Ningaloo Park area and a Woodside-funded study on effects of sedimentation on sponge health.

Quality and impact of KRAs

KRA 4.1 Understand and predict the responses of reef symbioses to environmental change

Quality 5 Impact 4

The 6 projects within this KRA comprise a good balance of demand-driven and strategic research. The projects are focused primarily on interactions between corals and their zooxanthellae symbionts, with in addition one large inter-team project examining biochemical and chemical mechanisms (including signalling) underlying symbioses in corals and sponges and a developing interest in diversity and roles of viruses in the coral-algal symbioses. This KRA is ably led by Madeleine van Oppen, who is also the Director of the Centre for Marine Microbiology and Genetics.

Research in this KRA has addressed AIMS strategic directions in understanding tropical marine ecosystems and processes and the responses of those systems to global change. This research has shown that corals can form symbioses with a range of zooxanthellae types, and that trade-offs between growth rate and thermal tolerance due to symbiont shuffling are present in some environments but not others. Understanding of this level of complexity is important in predicting and potentially attempting to manage the impact of climate change on corals.

KRA 4.2 Understand the role of microbes in the functioning of healthy and stressed reefs

Quality 5 Impact 4

Of the 4 tasks in this KRA, two are focused on coral disease, both on understanding the impacts of this disease and development of diagnostic tools for early detection. This is a good fit with the AIMS mission and builds on the past leadership of AIMS in coral research that now needs to be re-established. The UMMS team have been effective in building a strong reputation in this area in a short time due to the strong leadership of Dave Bourne for this KRA. AIMS has invested heavily in the two remaining tasks in this KRA, understanding how bacterial symbionts and pathogens are affected by environmental stress and interkingdom signalling. It is too early to see the full scientific impact of this investment, but it is expected that the payoff will be considerable given that these areas are emerging as areas of great scientific interest world-wide, and that the investment has already helped team members build and integrate excellent biomolecular and molecular biology (small molecule, nano-SIMS, microarray, next generation sequencing) techniques to address important questions. High-impact papers (including Webster et al 2010, Bourne et al 2008) have already resulted. The strength of the research team working in this KRA, the unique opportunities provided by AIMS' location and field access, and the excellent facilities (including the imminent availability of ATOS) make it likely that the AIMS investment in this KRA will result in outstanding scientific outcomes and many high-impact publications during the next quadrennium.

Review of team effectiveness

Portfolio balance

The portfolio balance in the UMMS team is good. Both KRAs have a good mix of strategic and demand-driven projects and projects are well balanced between creating options, developing options and knowledge transfer.

Capture of resources

The UMMS team was initially supported strongly by AIMS appropriation funding as is appropriate for a new research team. There is a good trend of a growing amount of external funding from competitive sources, and the team needs to continue this trend, aiming for a 50:50 balance between appropriation and external funding over the next review period. Effective use of the ATOS should be helpful in attracting external, competitive funds for projects possible only with the use of this unique facility.

Comments on the team SWOT analysis

The team **strengths** have been well identified except that a notable strength of this team that was omitted is their excellent application of cutting-edge molecular approaches (next generation sequencing, microarrays) in their studies of symbionts and pathogens. A particular strength of this team that could have been emphasized is their extensive use of postdocs and graduate students as indispensible members of their team, adding considerable energy and intellectual vigour.

The **weaknesses** of the team include several that need careful management. The low maintenance budget for the Biomolecular Analysis Facility is a concern, and this important and very expensive resource needs to be appropriately maintained, especially now that the chemists are showing that their focus on small molecules is starting to be productively applied to areas such as cell-cell communication. The remote location is not seen as a major issue because of the ability of this team (and AIMS in general) to attract world-leading collaborators as visitors. The problem of extended periods of absence is addressed under Project Management, below.

Opportunities are well summarized. In sum, the combination of the strong foundation already build by the UMMS team and the opportunity provided by ATOS mean that this team is poised to become a real powerhouse in research on marine microbes and symbiosis in the coral reef environment, provided the team is able to capitalize on external funding opportunities for further growth.

The team has listed all the key **threats**, none of which is seen as existential except possibly for loss of key staff. A large part of the success of this team has been driven by three young scientists, Madeleine van Oppen, David Bourne and Nicole Webster, and it is imperative that they are retained or, if any of them are lost to opportunities that will undoubtedly be offered to them, that they are rapidly replaced by scientists of equal calibre. It seems unlikely that there would be a major change in the appropriation funding base for the UMMS team given its success, but the team needs to be careful of complacency and take the current funding as a window of opportunity in which to increase external funding.

Project management

The review panel was informed that current Team Leader, Linda Blackall, was unlikely to continue serving in this role and had not been fully engaged in this position for a while. Fortunately, the leaders of the two KRAs, Bourne and van Oppen, serve as excellent interim leaders for the team. However, to fully realise their scientific potential, they would be far better off working under the guidance of a fully committed senior Team Leader, and high priority should be given to filling this position with an outstanding molecular microbial ecologist.

One issue listed under *Weaknesses* and raised by several team members is the need for enhanced skills in bioinformatics and statistical analyses. This need was recognised by the review panel, and one possibility to address this need is to hire a senior bioinformaticist.

Stakeholder engagement and knowledge transfer

Both KRAs seem to be well engaged with their stakeholders. Van Oppen and Bourne are recognised for their efforts to maintain good communication with end-user/stakeholder committees and working groups. A fully engaged Team Leader would further enhance stakeholder engagement.

Collaborations

The team has a very impressive list of external (national and international) and internal collaborators. They have made effective use of these collaborations to lever their capabilities.

Future research directions for next Research Plan (2011-15)

The future research directions provided by the team were reviewed, and the reaction of the review panel can best be summarized as "steady as she goes". The team plans to move beyond their foundational diversity studies of microbial associates of corals and sponges to unravel functional roles of these associates and their relation to health and resilience of the invertebrates. This is a logical progression. Now is not the time for any major changes in research direction for this team. They have used the previous review period to identify important research questions in symbiosis and marine microbiology and the largest pay-off from this effort will be during the next four years, provided appropriation funding remains steady and core team members are retained and maintain their research focus.

One new research area that has been proposed is that of marine viruses and coral reefs. This would be done together with an outstanding scientist and good collaborator, Curtis Suttle. However, this area should be approached with some caution because there are already several strong groups (notably, the world-leading group of Forest Rohwer) that have effectively used metagenomic approaches to study viral diversity in the coral reef environment. The team should carefully consider *What is the key question in marine viral effects that can be better addressed by UMMS+Suttle than by anyone else?* The team must be careful that this potentially very interesting research direction does not detract from efforts on their existing projects.

Review of Team 5 Exploring marine biodiversity

Project description (provided by the Team)

Recent history

Team 5 is a new group, formed in May 2008 from a division of the Assessing and Using Marine Biodiversity Team. The team was formed largely in recognition of the substantial growth in the Perth office following the establishment of the Scott Reef Research Project (see appendix 1) and in recognition of the potential for further work in support of oil and gas development in NW Australia. Interim leaders were appointed to the Team for the first 18 months (principally Simon Woodley) until the present leader was recruited in September 2009. The Team Leader is also the Office in Charge of the Perth Office and has been recruited into the Science Management career stream rather than the Research stream. This recognized the need for full time management of Team research as well as management of the office, and of AIMS' institutional presence in the region and the state.

Mission

The key mission of the Exploring Marine Biodiversity Team is to improve our understanding of the distribution, abundance and dynamics of marine living resources in tropical Australia. Activities include: a) assessments of new and poorly surveyed areas, experimental research to understand the drivers and consequences of change in different systems and key groups; b) the development of innovative techniques and tools to carry out research in remote, deep and inaccessible areas; and c) the provision of support to managers and policy makers charged with resource planning and management of resources in NW Australia.

The main objectives of the Team are to:

- Provide quantitative information on the status and trends of benthic biodiversity in tropical marine habitats including some exploited species and responses of species to management actions, with particular emphasis on tropical marine ecosystems of WA
- Characterize and map marine habitat types (especially deep and inaccessible reef communities) and improve understanding of associations between biodiversity and these habitats
- Expand taxonomic knowledge of the species associated with coral reefs
- Improve our understanding of the impacts of dredging on benthic primary producers and their habitats, particularly through work on threshold tolerances of key organisms and the design of cost-effective impact monitoring programs
- Improve understanding of population dynamics and connectivity to assist management of coral reefs and tropical reef fish populations in WA
- Improve understanding of the ecology, demography, population status, distribution and emerging and current threats to sharks and rays in northern Australia

- • Improve understanding of near and off-shore tropical marine ecosystems of the Kimberley coast

These research goals and activities support National Research Priorities primarily within Priority A – An Environmentally Sustainable Australia especially A5 – "Sustainable use of Australia' s biodiversity" and A7 – "Responding to climate change and variability". They also provide significant inputs to Priority C4 – "Smart information use" and A2 – "Transforming existing industries".

A good example of Team research supporting multiple National Research Priorities is the seabed surveys for performance assessment of Ningaloo Reef Marine Park zoning carried out in 2008-09 by AIMS and Geoscience Australia. This research supports all four priorities listed above. Over 1,000km2 of the deeper sections of the Ningaloo Marine Park was surveyed with the results being used to predict patterns of marine biodiversity and develop tools for managing Australia's marine biodiversity. An AIMS-led workshop confirmed an unexpectedly high diversity sponges in the deeper sections of the Ningaloo Reef Marine Park (200 different species including new distributional records and some possible new species). The map of habitats and biodiversity values predicted by the survey will be used to assess whether the current marine protected areas within the Ningaloo Marine Park meet the conservation objectives of the Marine Park Plan, which were developed without information from deep water habitats. The ultimate goal of this research is to enable managers to refine the Ningaloo Reef Marine Park Management Plan to optimise the balance between human use and conservation of the Park's resources, while preserving maximum resilience in the system to face the challenges of climate change.

The Team research objectives also fall within several areas of current global research interest, including the resilience of social-economic systems, the ecology and dynamics of mesophotic reefs, and the impacts of climate change on key functional groups.

Project review

Ratings

Quality	3	Impact	3

Introduction

This KRA is largely built around the WA arm of AIMS. As such it cuts across, to a certain extent, several kinds of research. It is also unusual in that it has had enormous financial support from large industry contracts.

The group is new, only two and a half years old, and has only recently brought in a new regional leader – Dr Jamie Oliver. In some sense, any evaluation is potentially premature. That said, any advice is clearly timely. Hence our comments below are more broadly targeted than for the other teams.

Quality and impact of KRAs

KRA 5.1 Assessments of tropical marine biodiversity (KRA 1.1 component)

Quality	2	Impact	4

KRA 5.2 Accurate and timely information issues and threats to coral reefs (KRA 1.2 component)

Quality	3	Impact	3

As the group comes off the back of huge endeavours in the field, much funded by external sources, now is the time to provide the key researchers with the freedom to capitalise on this data. We note that productivity has recently accelerated from around ten papers per year to over 20. The impact and quality of this recent research is not easy to assess, however the productivity is now high and core funding will be required to maintain the momentum.

Some very exciting discoveries have been made – for example, biannual spawning of corals (Gilmour et al. 2009), a deeper understanding of connectivity and resilience issues in isolated coral reefs (Smith et al. 2008; Underwood et al. 2007, 2009 – with KRA 4) and fundamental life-history research (Depczynski, et al. 2007; Heyward and Negri, 2010; several Meekan papers). This was not brought out well in the review documentation, and we lament the inability of some researchers to vividly convey the excitement of what they have achieved in their individual statements. More time must be spent writing succinct plain English paragraphs on why these discoveries are important.

The team identify that one of their weaknesses is a relatively low proportion of publications in high profile journals. While the Impact Factor of a journal is not everything, and truly outstanding work will be recognised wherever it is

published, we agree that much of this group's work could be targeted in higher impact journals if it were marketed appropriately – bringing in high level synthesis and analysis skills may be useful.

As we have noted across all of AIMS, there is a need for more synthesis and analysis skills, and this is particularly true for this group. Evidence for this comes from the very successful partnerships with analysis and synthesis researchers, like Mellin (AIMS postdoc – Mellin et al. 2010) and Bradshaw (University of Adelaide) that have led to papers in higher impact journals. The key here is to think of quantitative skills as high-level skills, not service positions. The long-term data sets, large spatial-scale data sets, and work in a truly remote area present great opportunities for collaboration.

The team has a broad mix of talents and interests. This is both a potential strength and weakness. Given its size and the potential for isolation we recommend building on the strengths that exist. Hence, any changes in staff should be aligned to work closely with existing staff or add skills in analysis and synthesis that will aid existing staff to capitalise on their data.

The co-location at WAMSI with CSIRO and UWA has enormous potential and can only be positive. The AIMS researchers at WAMSI, if they are willing to embrace collaborators as opportunities rather than threats, will prosper under the new arrangements. In many ways, the WAMSI arrangements give AIMS in Perth an enormous advantage over AIMS in Townsville. For a small organisation like AIMS, partnerships are everything. This was an exceptionally clever strategic move by AIMS decision-makers. A key advantage is access to PhD students from UWA.

The impact of the research for industry has been substantial. Of course, given the massive developments in the area, the chance for more impact is high. The key will be to balance a desire to attract new sources of funds with the need to capitalise on the data already acquired. This will require strong management.

While industry impact is substantial and partnerships with industry are exceptional, led largely by Dr Heyward, the group also has potential to engage more closely with the roll-out of marine reserves. Data collected by this group is central to both state and federal marine conservation planning yet there is little discussion of this impact in the documentation.

As noted in the analysis of Team 1, it is important for Team 1 and 5 to coordinate activities in a way that data collected under their joint KRAs can be directly compared.

Review of team effectiveness

Portfolio balance

This team is currently both demand-driven and strategic, but the balance in terms of funding is demand-driven. For example, much effort is devoted to

information needed to understand the ecological impacts of oil and gas development and other commercial activities and to provide the scientific basis for marine parks and other management tasks. In the future, additional effort should be made to develop an intellectually coherent vision for strategic research that integrates understanding of Western Australia reefs with the GBR and reefs elsewhere.

Capture of resources

The existence of this team is due to the extraordinary capture of resources for research in Western Australia, so in this regard performance is excellent, although funding for more strategic research would be desirable.

Project management

Current leadership is very new (scarcely over one year at the time of the review), and therefore difficult to judge, but seems to be very effective (this is a full-time administrative position because it also involves managing a remote office).

Stakeholder engagement and knowledge transfer

The efforts of the Team to work with extraction and tourism industries are substantial and appear to be successful. For example, the documentation of spawning times saved 3-4 days of dredge shutdown time worth several million dollars. In total 39 reports for clients have been produced. In addition there are several electronic databases that are available for wide use (e.g. the Ningaloo Atlas Web Portal). Scott Reef data are still mostly "available on request" according to the documents provided, and this would be a good area to develop knowledge transfer further.

Collaborations

Development of collaborations with Western Australian entitites (academic, government and industry) is on a good trajectory. Several scientists on this team are involved with prominent global initiatives (CReefs, GEF Targeted Research, WORMS), in addition to numerous collaborations with national and international scientists.

It is notable, however, that most masters, PhD and post-doctoral supervision occurs with just one scientist (Mark Meekam), and only one "high-profile" international visitor was listed. This is an area that could be improved, and it is encouraging that Ross Jones has advertised for two PhD students via the AIMS@JCU collaboration.

As noted elsewhere, close collaboration with Team 1 will be essential for high-value science products of interest to the global coral reef community. Discussions occur regularly, according to the Team Leader, but the products of these discussions are not yet clear given the newness of the Team.

Future research directions for next Research Plan (2011-15)

In addition to delivering on commitments associated with external funding sources, this Team needs to think strategically so that the whole is greater than the sum of its parts. What are the key general questions to which understanding biodiversity and ecosystem function in Western Australia can contribute? How can research efforts be synergized with those on the GBR to provide Australia-wide insights (a goal noted in the earlier review)? What kinds of research would influence the global community of reef scientists? There is a lot of potential here, with expertise in corals, sponges, fishes, biostatistics, spatial modelling, and oceanography (though the team also notes areas where expertise is lacking). Inevitably, given the newness of the effort and the far smaller knowledge base in this region, some of the research is in effect "catch-up" – mapping, species distributions, etc. – necessary for effectively tackling bigger picture questions. Five clear themes have been identified for the future (effects of dredging, submerged reefs, shelf-edge reefs, megafauna, knowledge management) but *Grand Challenge*-style thinking about broader themes that would generate greater synergies among the scientists of this and other teams would be beneficial.