AIMS

Australia's Tropical Marine Research Agency

Submission to the Productivity Commission study into public support for science and innovation in Australia

4 August 2006

Executive Summary

Australia's marine resources have significant conservation and commercial value[1] and marine research is in the national interest.

The Australian Institute of Marine Science (AIMS) is a leader in marine research and is largely, publicly funded. It is one of the most innovative and progressive research laboratories in the world with unparalleled capability in the field of tropical marine science and technology.

The core focus of AIMS is to generate and disseminate the knowledge to support the sustainable use and protection of the marine environment through innovative, world class scientific and technological research. AIMS is recognised worldwide for its expertise and the quality of its research into complex large-scale problems in tropical marine environments. It has unique capacity to investigate molecular to whole-of-system questions to help provide solutions for the conservation and sustainable use of Australia's marine estate. This is largely research in the national interest, often referred to as public good research.

AIMS provides independent advice based on the best available science to help ensure that Australia's marine resources are well managed, used sustainably and available for future generations. Government funding provides essential support for this research since, in general private industry does not conduct marine research for public benefit. Support for marine research is even more critical since property rights in the marine environment are not owned in the same way as terrestrial resources.

Specifically, AIMS' research plays an important role in supporting:

- the conservation and management of the Great Barrier Reef;
- Great Barrier Reef World Heritage Area catchment management;
- management of the Northern and Western Australian tropical marine environment;
- management of the international tropical marine environment; and
- environmentally sustainable development for tourism, oil and gas, aquaculture, mining and other industries.

A recent independent study of AIMS' research activity and impacts from that research[2] noted the tremendously high regard in which AIMS' scientific research is held by its industry, government and other stakeholders. It found that the fundamental impacts of AIMS research

[1] The common assessment of the value of marine industries is $52 billion per year, or about 8% of GDP.

[2] *Marine Imprint: the crucial impact of 33 years of AIMS research in the public interest*. Insight Economics, August 2006. The final impact assessment report will be available in mid August and AIMS would be pleased to provide a copy of this report to the Productivity Commission study team if it is of interest to the Commission

were its contribution to the preservation of Australia's iconic tropical marine ecosystems, significantly (to date) the Great Barrier Reef World Heritage Area (GBRWHA). These iconic ecosystems are not just important for the economic value generated by marine industries, but also from its "non market" environmental, cultural and social significance.

While the true value of AIMS' research cannot be fully captured in purely economic terms, analysis showed that "public good focused research such as that conducted by AIMS has the potential to generate dramatic regional economic benefits and, at the national level, economic benefits for Australia well in excess of its costs".

These findings demonstrate the value of marine research to the nation and the importance of continued public funding to support this effort. Diversion of public funding away from mission-driven marine research in the national interest towards short term commercially focused research impacts these longer term high value objectives.

Introduction

The Australian Institute of Marine Science (AIMS) is pleased to provide this submission to the Productivity Commission study team investigating *Public Support for Science and Innovation in Australia*. AIMS understands that the key issues of interest to the Productivity Commission in this study are:

- the economic, social and environmental impacts of public support for innovation;
- impediments to the effective functioning of Australia's innovation system; and
- evaluation of decision making principles and program design for public support for science and innovation.

AIMS' submission has been structured to assist the Productivity Commission in its investigation of each of these issues. To this end, the AIMS submission:

(I) provides a brief summary of the role of AIMS in the Australian innovation system;

(II) sets out the key findings, in terms of the identified impacts generated by AIMS, from the current impact evaluation that AIMS has commissioned to explore the impacts of AIMS over its 34 years of operation[3];

(III) presents the findings from an attempt to quantify the economic value of just some of the impacts generated by AIMS;

(IV) outlines the key implications of the findings of the impact evaluation study for the future operations of AIMS; and

(V) provides suggestions for how environmental research that is in the national interest should be funded and evaluated in Australia.

[3] *Marine Imprint: the crucial impact of 33 years of AIMS research in the public interest*. Insight Economics, August 2006. The final impact assessment report will be available in mid August and AIMS would be pleased to provide a copy of this report to the Productivity Commission study team if it is of interest to the Commission.

I. The role of AIMS in the innovation system

The Australian Institute of Marine Science is one of the most innovative and progressive research laboratories in the world with unparalleled capability in the field of tropical marine science and technology. The core focus of AIMS is to generate and disseminate the knowledge to support the sustainable use and protection of the marine environment through innovative, world class scientific and technological research. AIMS is recognised worldwide for its expertise and the quality of its research into complex large-scale problems in tropical marine environments[4]. It has unique capacity to investigate molecular to whole-of-system questions to help provide solutions for the conservation and sustainable use of Australia marine estate. The Institute has three sites, Perth, Darwin, and its headquarters are at Cape Cleveland near Townsville at the geographical centre of the Great Barrier Reef. While core research is conducted throughout Australia's ocean territory, AIMS research effort is concentrated on northern Australia from the Great Barrier Reef to Ningaloo Reef in the west, its expertise is enlisted throughout tropical waters worldwide.

Inputs into AIMS

Since its establishment in 1972, AIMS has received funding from the Australian public and private sectors as well as from the public and private sectors overseas. When its revenue is adjusted earnings into constant 2005-06 dollar terms (using the long term ABS inflation index), over its 34 years of operation AIMS inputs have been:

- $658 million in annual appropriation funding from the Commonwealth Government;
- $32 million in other revenue from the Australian public sector;
- $33 million in revenue jointly from the Australian public and private sectors;
- $19 million in revenue exclusively from Australian private sector sources;
- $21 million from overseas funding sources; and
- $26 million from other sources such as interest, publication sales and revenue from related entities.

In total, AIMS revenue to date from all sources totals $789 million in 2005-06 dollar terms. In 2005-06, AIMS' total revenue was $31.4 million, comprising:

[4] AIMS is ranked in the top 1% of institutions in the field of *Environment & Ecology* based on its total citations in that field ISI Essential Science 2006.

- $23.1 million in appropriation funding from the Commonwealth Government;
- $0.3 million in other revenue from the Australian public sector;
- $4.8 million in revenue jointly from the Australian public and private sectors;
- $0.8 million in revenue exclusively from Australian private sector sources;
- $1.3 million from overseas funding sources; and
- $1.1 million from other sources such as interest, publication sales and revenue from related entities.

Over AIMS' lifetime, the proportion of earnings (in 2005-06 dollars) generated from sources other than its annual appropriation funding, "external earnings", has increased considerably. Over the period 1972-73 to 1983-84 external earnings contributed on average 1.2 percent of AIMS revenue, from 1984-85 (when the first significant increase occurred) to 1993-94 external earning contributed on average 14.5 percent of AIMS revenue and the for the 1994-95 to 2005-06 period external earnings has contributed on average 21.7% of AIMS revenues.

Another shift in the sources of AIMS inputs has been generated by the Institute's expansion into western and northern Australia. In addition to its own smaller offices in Perth and Darwin, AIMS has in recent years been actively seeking joint ventures and collaboration with other research providers to enhance research capability to meet the research needs of these regions. In 2005, the Premier of WA announced that the state government will spend $21m over 4 years on the WA Marine Science Institution (WAMSI). AIMS is a key partner in this group, which was established with Curtin, Edith Cowan & Murdoch Universities, UWA, CSIRO, Bureau of Meteorology, and the state government agencies in the fisheries, environment, industry and resources, and heritage portfolios. WAMSI is expected to be one of the platforms for increasing investment by AIMS in WA.

In 2004, AIMS formally affiliated with James Cook University (JCU) in a joint venture, AIMS@JCU. This formalised the collaborative research relationship between the two organisations, through investment in infrastructure and research staff. AIMS and JCU received additional funding of $3.9m in the 2003-04 Federal Budget to support this collaboration. This funding was utilised for actions such as the commissioning of a fibre-optic communication link between the two facilities to enable virtual in-lab collaboration, for example through the transfer of field data in real time.

In June 2005, AIMS also increased its capacity in the north with the opening of the Arafura Timor Research Facility (ATRF), a joint venture between AIMS and the Australian National

University (ANU) to provide a well equipped specialist marine science research precinct for marine and social scientists to conduct world-class research in the Arafura and Timor seas. The ATRF has facilitated close collaboration and cooperation with other Territory research bodies, in particular Charles Darwin University, and to facilitate the effective and efficient use of all local marine research resources to benefit the Territory, Australia and our regional neighbours. The ATRF was the result of a successful bid by AIMS and ANU for an Australian Government Major National Research Facility (MNRF) grant of $3.25m.

Overview of AIMS activities

AIMS has the capacity and expertise to explore and examine the marine environment from ship-based regional studies to state-of-the-art laboratory analysis. The core of AIMS' activities is the development and dissemination of fundamental marine science knowledge. The Institute's scientific research has included the gathering of marine data, analysis and synthesis of this data to develop predictive understanding of the functions of marine ecosystems, and assessment of impacts from land activities on the marine environment – *rainforest to reefs*.

Following its establishment through the Australian Institute of Marine Science Act 1972, AIMS began its research programs in 1974-75. These initially comprised three program areas:

- Coral reefs and reef-building organisms – this program was intended to provide a taxonomic basis for future studies of the ecology, morphology and geology of the GBR. Projects organised over 8,000 specimens of the hard corals which dominate the reef into systematic groupings, and these were published as monographs. Additional studies concerned the physiography of the reef area, and of mechanisms and environmental factors in coral calcification in the reefs.
- Tropical marine webs – this program initially undertook a surface survey and documentation of the aquatic and atmospheric environment of the mangroves of Hinchinbrook Island, including systematic collections of herbarium material, and statistical analysis of the ecological character of this eco-system. Other projects included research into the behaviour, distribution and density patterns of planktonic animals, the basic feedstock of marine ecosystems, and the impacts of water currents and biological factors (including environmental stress, competition and predation) on population size.
- Marine pollution – this program was established with the goal of collecting and analysing preliminary baseline data relating to trace metals in representative organisms in the GBR area. This led to studies into the importance of river run-off in the

distribution of pesticides in reef organisms. By 1979-80, AIMS had increased its focus on human impacts on catchment and reef ecology, emphasising that these impacts on tropical coastal ecosystems must be understood to be efficiently managed.

In recent years, AIMS has continued and enhanced this program of research, building understanding of tropical marine ecosystems with particular expertise on coral reefs, continental shelf and coasts, land-sea interactions, climate change impacts, and marine microbes. The goal is to help facilitate good stewardship of Australia's marine resources. The Institute's research has evolved and broadened and effort now falls into six areas of focus:

- Biodiversity assessment and trends with a particular focus on coral reefs, coasts and continental shelf ecosystems;
- Environmental change and impacts including climate change and climate variability;
- Water quality and ecosystem health to understand the link between the land and the sea;
- Biodiversity sustainable use to ensure wealth generation from Australia's marine estate;
- Microbiology and biodiscovery. Microbes constitute the vast majority of marine biomass and are the primary engines of Earth's biosphere.
- Knowledge integration and synthesis and prediction.

AIMS' work includes the dissemination of scientific knowledge; long-term monitoring of the Great Barrier Reef World Heritage Region and the reefs of northern and north-western Australia; monitoring the impact of land/water management; continued research on the implications of climate change (coral bleaching and ocean acidification); collaboration with the tourism, oil and gas, fisheries and aquaculture industries; and most recently, significant strategic alliances with overseas researchers and pharmaceutical firms to exploit the potential for developing therapeutic substances found in marine organisms. Strong links with users of its research has enabled AIMS to effectively transfer new knowledge to users of marine research.

Based on independent interviews conducted with both key external marine management stakeholders such as the Great Barrier Reef Marine Park Authority (GBRMPA) and the Australian Government Department of Environment and Heritage and major industry stakeholders such as the Association of Marine Park Tourism Operators (AMPTO), Woodside Energy, BHP Billiton Petroleum Pty Ltd (BHPBP) and Alcan, it is clear that the quality and relevance of AIMS' research into tropical marine ecosystems is held in very high regard[5].

[5] *Marine Imprint: the crucial impact of 33 years of AIMS research in the public interest*. Insight Economics, August 2006. The final impact assessment report will be available in mid August and AIMS would be pleased to provide a copy of this report to the Productivity Commission study team if it is of interest to the Commission.

In another measure of quality, AIMS and its researchers have featured highly in an ISI Essential Science report that analysed contribution to the field of coral reef ecology over the past 10 years. The analysis was based on more than 3,400 papers, more than 5,000 authors, and more than 1,600 institutions. AIMS was the second ranked institution in terms of citations, and two AIMS staff were in the top twenty cited researchers. AIMS staff were also authors on three of the four most highly cited papers during this period[6]. AIMS is ranked in the top 1% of institutions in the field of *Environment & Ecology* based on its total citations in that field[7].

AIMS' long-term monitoring of coral health has meant that researchers have become expert in the extraction of climatic records from corals, using these as a measure of the extent and pace of past environmental change. Researchers have found that Australian coral reefs have 'bleached' when exposed to water that is hotter than the historical average, suggesting that coral may be an indicator of climate changes, with the possibility that these weather data may be used to predict how reefs might respond to climate change in the future. The climate change project group at AIMS also studies the impacts of sea level change and increased carbon dioxide on reefs and tropical mangrove systems.

In 2003-04, AIMS research in WA, Palau and Micronesia added to understanding of coral bleaching, providing more detailed knowledge of how hydrodynamics control variability in the heat stress associated with coral bleaching. AIMS' collection of satellite temperature data on coral reef health has also resulted in the Sea Surface Temperature Atlas for the GBR, launched July 2002. These products are now used to support the national ocean modelling work of CSIRO, the Bureau of Meteorology, and the Australian Navy, as well as forming the basis of a prototype application developed by the GBRMPA to monitor temperatures associated with coral bleaching on the GBR.

While AIMS research programs have evolved and broadened over its years of operation, is core focus has remained firmly on building up the basis understanding of tropical marine ecosystems. AIMS' research plays an important role in supporting:

- the conservation and management of the Great Barrier Reef;
- longer term Great Barrier Reef World Heritage Area (GBRWHA) catchment management;
- management of the Northern and Western Australian tropical marine environment;
- management of the international tropical marine environment; and
- in supporting environmentally sustainable development for tourism, oil and gas, aquaculture, mining and other industries..

6 www.esi-topics.com/coralreef/inst/c1a.html
7 www.in-cites.com/institutions/Australian_Ins_Mar_Sci.html

II. The impacts of AIMS

The fundamental impacts of AIMS – namely its contribution to the preservation and sustainable use of iconic tropical marine ecosystems – which in turn provide the primary rationale for its existence are not able to be described in economic terms. The reason why tropical marine ecosystems such as the GBRWHA are so important to Australia is not simply a function of the economic value associated with industries in the area such as tourism or fisheries. The iconic status of such an ecosystem comes from its "non market" environmental, cultural and social significance.

Designating an ecological area 'heritage' highlights the long time scales which must be considered. In designating an area a 'heritage' place, we as a society are acknowledging that it is going to be of importance to generations in the future, and that we have a duty to preserve and pass down such a place to future generations. The GBRWHA is part of Queenslanders' heritage, as it is part of Australia's; indeed, it is regarded as part of world heritage. As UNESCO describes the sites included on its list of valuable world heritage places,

> *"Heritage is our legacy from the past, what we live with today, and what we pass on to future generations. Our cultural and natural heritage are both irreplaceable sources of life and inspiration. Places as unique and diverse as the wilds of East Africa's Serengeti, the Pyramids of Egypt, the Great Barrier Reef in Australia and the Baroque cathedrals of Latin America make up our world's heritage."*

When considering the measurable economic impacts of AIMS and its research, it must be remembered that these impacts represent just a secondary dimension of the true "value" of AIMS' research.

Notwithstanding the fundamentally public good oriented nature of much of AIMS' research, AIMS' does generate directly economic impacts through a number of channels. The key channels through which AIMS generates economic impacts are:

1. expenditure effects generated by AIMS
2. benefits from better informed GBRWHA management policy;
3. contribution to the reef tourism sector;
4. contribution to the development of the Western Australian offshore gas industry
5. contribution to fisheries and aquaculture industry development;
6. contribution to mining sector performance;
7. biomolecular research sector development; and
8. the direct commercialisation of AIMS technology.

1. Expenditure effects generated by AIMS

A clear measurable economic impact of AIMS is associated with the expenditure by AIMS, primarily within Northern Queensland, of Australian Government funding.

A second measurable impact of AIMS is associated with the private sector expenditure that it has attracted into (primarily) Northern Queensland and Western Australia that otherwise would not have occurred.

A third measurable impact of AIMS is associated with the fact that it has attracted international expenditure into (primarily) Northern Queensland that otherwise would not have occurred.

There is of course an opportunity cost to Australia associated with the first and second of these outcomes. The Australian Government funding expended primarily within Northern Queensland could have been left in the hands of Australian taxpayers while the private sector expenditure could have been elsewhere directed within the Australian economy. Fortunately, when assessing the net economic impact of AIMS (see details in section below) the Centre of Policy Studies MMRF Monash Computable General Equilibrium (CoPS MMRF) Model of the Australian economy allows the net effect of such impacts on the Northern Queensland, Queensland and Australian economies to be accurately assessed.

2. Benefits from better informed GBRWHA management policy

The major mechanism for AIMS delivering an end impact for the Australian community is through the application of AIMS generated knowledge/intellectual property to improve the management of Australia's most iconic marine environment – the GBRWHA.

Since commencing operations in the early 1970s AIMS has undertaken research to build understanding of tropical marine ecosystems with a view to providing the information necessary to underpin good stewardship of marine resources.

The scientific understanding of marine ecosystems generated by AIMS is crucial to the development of environmental management practices and policies. AIMS research has played a significant role in shaping management policies in the GBRWHA. For example, the GBRMPA used AIMS data on water quality in rivers and coastal seas to recommend new standards for the acceptable levels of sediments and nutrients carried by terrestrial run-off entering the GBRWHA. Fifteen years of AIMS data up to 2001-02 formed the basis of the GBRMPA's 2001 *GBR Catchment Water Quality Action Plan*, which recommended specific water quality targets for individual river systems flowing to the GBR. This comprehensive body of river runoff research also stimulated the development of the joint Australian Government - .Queensland Government *Reef Water Quality Protection Plan* (2003).

> *"GBRMPA uses research results to determine appropriate zoning regimes, and to formulate management plans for the various regions and resources of the Park."*
> Chief Scientist, 2001, *Review of Marine Research in Tropical Australia*, pg. 95

AIMS knowledge base of the distributions of plants and animals, habitats and ecosystems in the GBRWHA was also used by the GBRMPA as a framework for its Representative Areas Program (RAP). These data were stored in large public geographical information systems which were important resources guiding the selection of candidate sites for a network of marine protected areas to conserve the diversity of the World Heritage Area. The RAP initiative used AIMS' scientific data as well as analyses and decision support tools developed at the Institute. The GBRMP Zoning Plan 2003 provided increased protection through representative areas of the major habitats. The new plan provided zoning for 28 new coastal sections added to the marine park between 2000-02, development of a single Zoning Plan for the entire park, and a coordinate based zoning system intended to assist public understanding and compliance. In March 2004, new zoning of the GBRMP was passed through parliament. The AIMS GBR long term monitoring program is currently being used to help assess the performance of the Plan.

One of the key factors in the translation of scientific understanding of an ecosystem into the development of good ecological management policies is the effective communication of scientific research to non-scientific stakeholders and users. AIMS long-term monitoring data is delivered in 'near' real time to GBRMPA and reported by the Authority as an indicator of performance. In another initiative to enhance communication of research outputs, the Reef Futures Knowledge Management System has now been established through collaboration between AIMS, JCU, and the CRC Reef. Its intent is to provide ready access to highly technical research in easily usable forms, using a range of media including text search engines and interactive mapping technologies to allow broader understanding of these complex issues.

Although it is not possible to put a precise dollar value on the contribution made by AIMS to GBRWHA management, it is possible to provide some information in relation to the potential scale of economic value associated with AIMS' work in this area by looking at its impact on the Tourism Industry.

3. Contribution to the reef tourism sector

Results of a study into the link between GBR quality and recreational demand suggest that 35 per cent of tourist who visit the GBRWHA would not do so if the quality of the GBR significantly declined[8]. The recent introduction of a new zoning plan and a comprehensive water

[8] Kragt, M.E., Roebeling, P.C., Ruijs, A., (2006), *Effects of GBR degradation on recreational demand: A contingent behaviour approach*, Fondazione Eni Enrico Mattei

quality control plan for the GBRWHA are specifically targeted at preventing such environmental degradation of the GBR occurring.

> *"The implementation of a Reef Water Quality Protection Plan will reduce the amount of nutrients and sediments from land-based sources that are impacting the inner reefs and seagrass areas. This will improve the sustainability of tourism business in these areas. The Great Barrier Reef Marine Park Authority, in consultation with all industries, has proposed a new zoning plan that aims to provide greater protection of the biodiversity of the Reef while maintaining its range of activities and uses. This Representative Areas Program seeks to protect the reef environment and preserve the commercial value of the reef underpinning the long term sustainability of the reef tourism industry."*
>
> Australian Government Tourism White Paper,
> *A Medium to Long Term Strategy for Tourism*, pgs 42-43

If these plans act to prevent environmental damage that otherwise would have become apparent from say 2010 onwards, the flow on effect to tourism revenues would be significant. Between 2010 and 2020, tourism revenue in the GBR catchment area is estimated to total more than $60 billion (and as an industry tourism is second only to mining in terms of total value of production in the region)[9]. Hence, even a 10 per cent decline in tourism due to environmental degradation (let alone a 35 per cent decline) would lead to a loss of more than $6 billion in revenue for the tourism sector in Northern Queensland. Given the essential role of scientific information in the formulation of effective resource management policy and practice, and the central role of AIMS in generating this scientific information, it is clear that the work of AIMS generates very real economic benefits.

4. Contribution to the development of the Western Australian offshore gas industry

Since 1994 AIMS has been collecting data on the marine ecosystem off the coast of Western Australia. In particular AIMS has focused on building up understanding of the Ningaloo Reef, Exmouth Gulf region and remote coral reefs of North West Australia and the Timor Sea. Research at Scott Reef (off North West Australia) was initially co-funded by Woodside, who wanted to understand natural variation of marine conditions, particularly in their development lease areas around the reef. At the conclusion of the initial five year funding agreement in 1999, Woodside Energy and AIMS negotiated a series of additional agreements to continue and expand AIMS' scientific work in Western Australia. While AIMS was interested in conducting this work from a scientific interest perspective to improve our understanding of the Timor and Arafura Seas, Woodside Energy saw this work as a valuable source of information that they

[9] Based on industry projections in Productivity Commission, (2003), *Industries in the GBR Catchment and Water Quality*

required to properly meet lease retention requirements and to plan for the future development of gas fields in their lease areas. Hence a mutually beneficial co-funding arrangement for this scientific research has now continued for over 11 years.

AIMS also has a relationship with BHP Billiton Petroleum Pty Ltd (BHPBP) focused on marine research 30 to 50 km off the Western Australian coast in areas surrounding two large prospective BHP gas field development projects. AIMS' specialised expertise environmental research and capability in mapping and assessment of deeper water habitats provides critical information on environmental risk required for BHPBP's Environmental Impact Statements for the two prospective developments, each of which would entail an investment by BHPBP of around $1 billion. As part of the agreement that AIMS has with BHPBP, AIMS is able to conduct strategic research as part of the expeditions they are undertaking for BHPBP. In this way, the relationship is not a simple fee-for-service arrangement, but rather a mutually beneficial partnership whereby BHPBP gains improved understanding of the marine ecosystems in which it would operate, information that it needs to progress its projects, while AIMS is able to leverage off the BHPBP-funded projects to conduct a range of public good / national interest scientific research.

Both Woodside Energy and BHPBP see a number of benefits resulting from their relationship with AIMS. Most directly, independent scientific advice and high quality scientific data collection conducted by AIMS provides a necessary input to the completion of environmental impact statements relating to a number of proposed major gas field developments off the Western Australian coast. Woodside attests that without the long-term data sets that AIMS has developed, prospects for securing regulatory approval for their proposed gas field developments would be diminished. Also, because AIMS conducts this work on a co-funding basis, reflecting the fact that AIMS has an interest in conducting this work from a broader national scientific interest perspective, Woodside Energy has also benefited from some direct cost savings in accessing the scientific data they require.

Beyond such direct benefits however, the relationship with AIMS is seen to provide a number of less quantifiable benefits for Woodside Energy and BHPBP. These include:

- Reputational benefits – by funding the work of a highly credible independent, public scientific agency such as AIMS, the companies boost their corporate reputation. In addition to funding the data gathering work relevant to their lease areas, BHPBP is now entering into a funding agreement with AIMS to undertake public good research as part of their community support programme. Woodside has also contributed funding to

AIMS' public good research into better understanding of the Whale Shark population in the region.

- Credibility with regulators – AIMS is rightly seen as a highly credible and unbiased source of scientific information and the companies see this as boosting the credibility of their environmental impact statement submissions to regulatory agencies.
- Shaping of future work programs – AIMS plays an important independent role in guiding the companies as to what environmental analysis they need to undertake and, just as importantly, what analysis they do not need to undertake. This helps the companies avoid undertaking unnecessary costly data collection projects.
- Shaping of development plans – AIMS, through its sea floor mapping work for Woodside, identified potential viable sites to consider in the planning phase for gas platform location in shallower water that will be far more cost effective than alternative deep water locations. While the company may have independently located such options, without AIMS' work this would have taken longer and involved the company undertaking its own costly mapping exercise.

Overall, while it is not possible to put a precise dollar value of the contribution of AIMS work in Western Australia, it is clear that through building better regional understanding of the marine environment they are increasing the prospects for the environmentally acceptable development of major gas fields occurring. Given the multi-billion dollar nature of these potential developments, even if AIMS only boosted chances for development by a small percentage such an impact would translate to many millions of dollars in expected additional investment in the region and subsequent revenue generation from gas sales.

5. Contribution to fisheries and aquaculture industry development

A significant body of AIMS research conducted in conjunction with relevant industry stakeholders has led to improved management of fisheries and/or aquaculture production. AIMS' 1998 national review of Australian fisheries habitat synthesised knowledge on the subject, and was used by the Fisheries Research and Development Corporation to guide its Ecosystem Protection Program. In 1998-99, AIMS research showed that mangrove-lined creeks efficiently capture excess nutrients in prawn farm effluent, quickly converting it into potential fish food.

AIMS role in prawn aquaculture industry development

Prawn aquaculture became tagged as a potentially sustainable use of land which was associated with fewer risks of ecological damage than traditional agriculture. AIMS research intended to improve prawn farming included the isolation of genes regulating fertility to improve the control of reproduction. In 2002-03 AIMS scientists demonstrated the potential to select for black tiger prawn (*Penaeus monodon*) stock with an enhanced ability to survive and reproduce in captivity. Animals spawned at AIMS could grow to reproductive size in less than 12 months, which could make the farming of high-value prawn species more profitable and sustainable. Other research outputs from AIMS include the development of improved egg-washing processes and tools to identify stress/viral infection relationships. These outputs have been transferred to industry through AIMS' collaboration with the Australian Prawn Farmers Association (APFA).

Another species identified as potentially profitable and sustainable has been the tropical rock lobster (*Panulirus ornatus*). Currently, there are significant limits to profitable farming of this species, and AIMS research has been working on domestication. In 2002-03, AIMS instituted a new collaborative project, receiving funding and other inputs from commercial partners, to domesticate the rock lobster. By 2004-05, the technologies for inducing out of season breeding of rock lobster larvae had been transferred to the industrial partner The MG Kailis Group. This enabled the work on domesticating the species to continue year round, thanks to a reliable supply of larvae which allowed The MG Kailis Group achieve a world first in aquaculture by producing hatchery-reared juvenile Tropical Rock Lobsters (*Panulirus ornatus*) in July 2006.

AIMS role in sponge aquaculture industry development

Sometimes research can lead to unexpected outcomes. AIMS' researchers have used sponges as natural laboratories to enhance production of the bioactive chemicals produced by the sponge. While the focus of this research effort was boosting the amounts of these chemicals for their potential as new drugs and other products - a possibly lucrative but completely novel and therefore high risk new market – research trials demonstrated the potential for applying the low technology aquaculture methods used in this research to grow bath sponges.

Sponges can be simply grown from cuttings, with minimal overheads and infrastructure, and after straightforward processing, the product is non-perishable and light, and hence cheap to transport. In combination, these features make sponge culture a potentially ideal enterprise for

remote, coastal Indigenous communities. Sponge aquaculture presented an opportunity for culturally appropriate enterprise within Indigenous communities which could provide employment, and a significant opportunity for socio-economic recovery and independence.

In early 2001, a collaboration between AIMS, the Department of State Development and Innovation, and the Palm Island based labour and training provider Coolgaree CDEP, was formed to explore the potential for this new opportunity for uptake within the indigenous community at Palm Island.

AIMS research commenced with a sponge survey, which identified two ideal and abundant local species. Since then, a comprehensive research program has addressed a range of issues including development of culture methods for commercially viable growth and survival and an understanding of factors that promote sponge growth and survival, as well as knowledge about the wild populations, their dynamics and the potential impacts of sponge farming, to ensure that a new sponge industry can be sustainably managed. The results of this research and detailed market analysis have been compiled into a major report and provided to agencies responsible for regulation of this potential new industry, in support of Coolgaree's application for relevant permits.

A critical feature of this project has been engagement with and hands-on involvement of indigenous stakeholders from the outset. Central to this approach is the partnership with Coolgaree CDEP as the community based proponent for the work. Coolgaree personnel have been involved in all aspects of the research, including participating on research cruises and deployment of experiments. Extensive briefings have also been held on several occasions with the Palm Island Council, the Manbarra Traditional Owners, and the Indigenous Coordinating Centre (and its predecessors, ATSIC, ATSIS etc). Native Title issues were resolved through the negotiation, over an 18 month period, of an Indigenous Land Use Agreement, which was facilitated by and is now registered with the National Native Title Tribunal. This agreement is between Coolgaree and the Manbarra Traditional Owners. It lays out the conditions under which sponge farming may proceed in Manbarra sea country, including the resolution that a not-for-profit trust will operate the enterprise, with any profits available for community development projects. An extensive site clearance was conducted, and this formed the basis for site selection for the research. Two separate public displays in the Palm Island mall as well as fun and colourful sponge activity days at both schools on Palm Island, have ensured wide understanding and awareness of the project in the community.

Currently, the Palm Island project is poised at the interface between experiment and enterprise. Market assessment and business planning indicates that it will be economically viable and will

employ over 30 people from Palm Island, although fund-raising to amass the required capital has only just begun. Most recently, 5 full time traineeship positions have been funded, to be recruited from the Palm Island community. These trainees will initially be an integral part of the research team, and will have the responsibility of deploying Coolgaree's first demonstration farm. Besides on-the-job skills development and technology transfer, these trainees will be formally trained as commercial divers. They will be skilled and well positioned to become the first employees of Australia's first sponge farm. The Palm Island experience is now being transferred to two Torres Strait communities in collaboration with the Torres Strait Regional Authority.

AIMS role in aquaculture in the Asian region

AIMS aquaculture expertise has also been applied in the Asian region, with cost-effective aquaculture techniques introduced in Vietnam in 2000-01 expected to generate improved living standards in coastal communities in the Mekong Delta. The 5-year joint project between AIMS, the Vietnam Ministry of Fisheries, the Australian Centre for Agricultural Research, the Network of Aquaculture Centres in the Asia Pacific, and the University of Tasmania resulted in survival of black tiger prawns increasing from 5% to 40%, resulting in higher harvests and farm income.

6. Contribution to mining sector performance

AIMS role in the Alcan Gove Alumina Development

In much the same way that AIMS' is contributing to the offshore gas industry in Western Australia, AIMS is now playing an important role within the mining sector through the provision of advice and knowledge of marine environments and how they are changing. Integration of this knowledge provides an understanding of marine ecosystems that reduces environmental risk and assists in the sustainable use of marine resources.

Over the past year AIMS has been working with Alcan, a major industry partner, on a range of projects relating to their $2 billion expansion of the Alcan Gove alumina refinery. The expansion of the Alcan Gove alumina refinery presents major economic, social and environmental benefits for Nhulunbuy, the Northern Territory and Australia. The project is located approximately 650 km east of Darwin at the western end of the Gove Peninsula in the north-east of Arnhem Land. The Gove Peninsula juts into the southern end of Melville Bay in the Northern Territory. The AIMS projects include environmental monitoring and the development of environmental remediation technologies.

The NT Office of Environment and Heritage (OEH), in granting approval for the development, concluded that:

> *"the environmental issues associated with the proposed project have been adequately identified. Appropriate environmental management of some of these issues has been resolved through the assessment process, while the remainder will be addressed through monitoring and management actions detailed in a comprehensive Environmental Management Plan (EMP), included as part of the Mining Management Plan."*
>
> Alcan Gove Alumina Refinery Expansion, *Assessment Report 42*, July 2004

In granting approval for the development, a requirement was placed on Alcan to:

- report monitoring data on a regular basis;
- undertake an annual review of monitoring data and to submit an annual report on the interpretation of the monitoring data and the company's performance against stated environmental objectives or targets; and
- in interpreting monitoring data, also analyse developing trends so that potential issues can be identified and addressed well before they reach trigger values and become environmental issues.

Provision of improved knowledge about the marine ecosystems of marine environment near this development assists Alcan (and regulators) monitor and manage environmental risks. It should also be noted that Alcan, in establishing its relationship with AIMS, has been motivated by more than its need to meet minimum mandated environmental monitoring standards. Alcan has a strong commitment to be a leader in environmental best practice. This commitment to sustainability was recognised recently with Fortune magazine ranking Alcan No.1 in the metals industry and in the top 10 companies overall in its 2004 list of the World's Most Admired Companies for Social Responsibility. Alcan was also selected two years in a row as a component of the Dow Jones Sustainability World Index, which tracks the performance of sustainability-driven organisations worldwide.

Alcan sees its partnership with AIMS as important for a number of reasons, including:

- Most obviously, it helps Alcan to meet its obligations under its development license. Alcan sees AIMS as being a high quality independent provider of scientific data that is well regarded by regulators. The credibility of AIMS science is key to regulators having confidence that Alcan is meeting its environmental obligations.
- The partnership with AIMS also helps Alcan to boost its reputation within the community. As part of its partnership with AIMS, it is intended that AIMS will make regular presentation of its reports to both regulators and the wider community.
- AIMS' work is expected to help Alcan identify the most cost effective approaches to environmental management at the Gove development.

The expansion of the Alcan Gove alumina refinery presents major economic, social and environmental benefits for Nhulunbuy, the Northern Territory and Australia. The economic benefits associated with the development have been quantified as including[10]:

- Increased exports from about $560 million to $980 million per annum.
- Additional Gross State Product (GSP) to the Northern Territory economy of $90 million per annum during construction and $200 million per annum during the operational phase.
- Direct employment for an average of 750 people, with approximately 1,700 people during peak construction and up to 120 when fully operational.
- Approximately $60 million per annum in additional government payments through taxes.
- Ongoing royalty payments to traditional landowners of around $9 million per annum.

In addition to these direct economic impacts, the development will deliver social and environmental benefits such as:

- It will secure the long term future of Nhulunbuy as a regional service centre, providing improved power supply, infrastructure and service to the local community and create new opportunities for local Indigenous enterprises.
- The waste water inventory reduction project being undertaken as part of the development will reduce the amount of stored water in the residue disposal area and enable safe runoff to the marine environment.
- The conversion of power supply from fuel oil to gas will deliver air quality and greenhouse gas improvements.

While it is not possible to assign a particular share of "credit" for the economic benefits and other impacts associated with the Gove development to AIMS, or to place a certain economic value on the fact that AIMS will contribute to environmental best practice at the development, this does not mean that AIMS has not made a real and valuable contribution to both these outcomes. As is the case in relation to the offshore gas industry in Western Australia, due to the large size of the economic impacts associated with the development, even a very small share of such impacts would dwarf the level of public funding that has gone into supporting AIMS' capability to enter into such partnerships with industry.

[10] www.alcangove.com.au

AIMS role in improving efficiency of QNI ship scheduling

On a much smaller scale than its role in the Alcan Gove Alumina development, AIMS has also made a contribution to the mining sector through its recent work with Queensland Nickel (QNI) to improve the efficiency of its ship scheduling into and out of the Port of Townsville.

The QNI Yabulu Refinery is located 25 kilometres north of Townsville. QNI is part of BHP Billiton Pty Ltd's international nickel business, involved in the exploration, mining, processing and marketing of high-quality nickel and cobalt. QNI's Yabulu Refinery is a lateritic nickel and cobalt processing plant. It processes ore from third party mines in New Caledonia, Indonesia and the Philippines, and produces high-purity nickel and cobalt products that are used in the manufacture of stainless steel, specialty steels, alloys and chemicals. The nickel production capacity is currently 32 000 tonnes per annum, and the cobalt production capacity is approximately 1900 tonnes per annum. However, two new extension projects being undertaken will by 2008 more than double the production output at the Yabulu Refinery, from the current 32 000 tonnes per annum of nickel, to nearly 76 000 tonnes and over 3500 tonnes of cobalt.

QNI engaged AIMS to undertake a project to link AIMS' tide data forecasting capability to the QNI ship scheduling system. This project allows QNI to improve the accuracy of its ship scheduling which allows them to better schedule stevedoring services and to provide better information to clients on delivery times.

7. Biomolecular research impacts

In 2004-05, AIMS reorganised its effort in biotechnology, recognising a change in industry priorities from agrichemical biodiscovery to a focus on anti-tumour agents and microbes.

Current estimates[11] identify that over a third of the world's marine-based anti-cancer drug leads come from, or have affinity with, species in Australasia, in spite of the low level of exploration and development effort in the region. Research at AIMS is ideally positioned to develop expertise and infrastructure leading to the identification of usable compounds. Its collection of marine samples has been stored in a database which captures details such as abundance and location, symbiotic microbiology and natural products chemistry. This knowledge is the basis for access to these potential social and economic benefits arising from biodiversity in Australasian water ecosystems. The harvest of wild populations is unlikely to provide an ecologically sustainable source of bioactive compounds for development. The culture of micro-organisms and molecular biological approaches may be an alternative to chemical synthesis.

[11] Newman DJ and Cragg GM (2004) Marine natural products in clinical or advanced preclinical trials. *J Natural Products* **67**:1216-1238.

While the delivery of final impacts from AIMS biomolecular research are still to come, an example of the ways marine science may potentially lead to drug discovery, and of the ways a biomolecular approach may aid understanding of marine ecology, was the AIMS discovery in 1999-2000 of a substance isolated from a common marine sponge, *Rhopaloeides odorabile*, that was shown to be capable of killing human leukaemia cells. Studies of the bacterium's symbiotic relationship with the sponge led researchers to conclude that the active compound appears to be a product of this symbiosis. AIMS scientists have continued to develop techniques which increase understanding of active chemicals in marine organisms, including means of converting these into usable drug forms. In collaboration with scientists from the University of Aberdeen and the University of London's School of Pharmacy, AIMS researchers have replicated a cancer-fighting DNA from a sea squirt. This has been placed into an easily cultured bacterium, so that the therapeutic benefits of this agent can be utilised without the environmental consequences of harvesting large amounts of the original marine specimen.

AIMS biotechnology innovations also have the potential to improve food quality and optimise farm production management processes. The active chemicals found in marine organisms potentially have other applications than human pharmaceuticals. In 2002-03, research yielded 30 new lead compounds exhibiting specific C4 plant herbicidal activity. C4 class plants include most of the world's worst weed species but are harmless to major food crops which are C3 class plants. AIMS now have IP arrangements with Nufarm agricultural producers for commercialisation of the compounds0.

AIMS role in shaping the biodiscovery legislative environment

At the 1992 Earth Summit in Rio de Janeiro, world leaders agreed on a comprehensive strategy for "sustainable development" - meeting our needs while ensuring that we leave a healthy and viable world for future generations. One of the key agreements adopted at Rio was the Convention on Biological Diversity (CBD). The CBD was negotiated under the auspices of the United Nations Environment Programme (UNEP) and came into force in December 1993. This pact among the vast majority of the world's governments, including Australia, sets out commitments for maintaining the world's ecological underpinnings as we go about the business of economic development. The CBD establishes three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources. It is much more than an environmental treaty - it is a hybrid that also addresses environmental, trade, development and intellectual property rights issues. Perhaps not surprisingly, practical implementation of the third objective has proven a

struggle, and due to the resulting ambiguities and commercial uncertainties, the CBD had a significant global negative impact on the viability of biodiscovery, including at AIMS.

In the post-CBD era, AIMS experienced great difficulty obtaining collection permits from some jurisdictions, the rights to existing collections were cast into legal doubt, and significant projects were stalled. In response to the lack of process and legislative basis for benefit sharing and the ambiguity on beneficiaries and benefits themselves, AIMS consulted widely and developed a Policy and Procedure for Access and Benefit Sharing (ABS) for Biodiscovery. The breakthrough was to procedurally separate the process of seeking a collection permit (based purely on environmental grounds, and for which there was already plenty of process and law), from that of negotiating benefit sharing, as well as acknowledge a wide range of non-monetary benefits of biodiscovery, including documentation of biodiversity to support better conservation and management, capacity building, and the ability to attract industry investment. AIMS put its new benefit sharing policy into practice for the first time in 2000, when it executed Australia's first benefit sharing agreement, with the State of Queensland.

AIMS' practical approach and unique perspective, as both a user and provider of biodiversity, has been widely acknowledged and consulted in a range of national and international forums. These include regular invitations to speak at international conferences, and appointment of AIMS staff to expert committees such as the CBD's panel of experts on access and benefit sharing, the Australian Government delegation to CBD negotiating meetings, the national inquiry into access to genetic resources in Commonwealth areas, the Commonwealth interdepartmental committee for access and benefit sharing and the PMSEIC biodiscovery working group. The biodiscovery potential of Australia's mega biodiversity is now recognised at the highest levels, as are the key impediments including anything that increases the cost, risk, and timeframe, such as lengthy, ambiguous process. In 2002, all governments entered into an inter-governmental agreement to develop a nationally consistent approach to access and benefit sharing. A new emerging legislative framework to deliver this includes the Biodiscovery Act (Qld) 2004, and the Environment Protection and Biodiversity Conservation Regulation Amendment 2005 (which both incorporate a procedural separation of access and benefit sharing), and other jurisdictions have indicated their intention to draft new laws. As a Commonwealth Government statutory authority, AIMS will continue to play an important role in the provision of independent advice, based on practical experience from the biodiscovery coalface.

8. Direct commercialisation of AIMS technology

AIMS has in recent years pursued the commercialisation of technology it has created where the opportunity has arisen.

The Kord® hand held computing device and software is a technology developed at AIMS that has subsequently been directly commercialised by its spin-off company WetPC P/L. The underwater computer was first developed to assist data collection by providing a capacity for researchers to record observations while still underwater. WetPC P/L has produced a related product, the SeaSlate®. This unit is allows divers to search and map underwater landscapes, and in 2005 prototypes were produced for the Royal Australian Navy. This mapping capability could be adapted to many purposes, for example use by salvage divers, divers supporting offshore oil well operations, or marine archaeologists.

AIMS signed exclusive commercialisation rights to WetPC in 1998. The Kord® IT was sublicensed by WetPC P/L to a West Australian company, Nautronix, in 2000. WetPC P/L clients have included the Royal Australian Navy, the Australian Army, Australian Special Forces, DSTO, and the Royal Netherlands Army.

Another example of the direct commercialisation of AIMS research has been the creation of fast, sensitive and cost-effective biosensor tools, which combine natural chemistry and computer chip detector systems. Cleveland Biosensors P/L, a spin-off company of AIMS and JCU, has built on the platform technology of AIMS and JCU to develop a test kit with the potential to detect paralytic shellfish toxins in seafood and water. This is expected to be used by shellfish farmers and restaurants in order to check the safety of seafood products. The company is currently developing other applications of the platform technology including the detection of algal toxins in drinking water for national and overseas markets.

The direct commercialisation of AIMS technology has not been, and is unlikely to be in the future, a major channel for the delivery of economic impacts from AIMS when compared to the scale of impacts that AIMS can generate within major industry sectors such as tourism, mining and offshore gas development.

While the direct commercialisation of the research produced by an organisation such as AIMS will always be a small component of the benefits that the organisation generates. This does not imply that opportunities for commercialisation should be ignored, but given the relatively low economic impacts available in this area when compared to the significant economic impacts that are associated with better marine environment management (for instance), the pursuit of commercialisation opportunities should not be allowed to displace activity away from AIMS'

core focus on conducting national interest (public good) research that informs marine environment management.

III. Quantification of the economic impact of AIMS

AIMS commissioned Insight Economics to conduct an assessment of the impact of its research[12]. Two economic modelling scenarios were applied to conduct the assessment.

Scenario One

The first scenario is designed to capture only the expenditure effects associated with AIMS to date. The modelling scenario presents what Northern Queensland, Queensland and Australian economic performance would have been if AIMS had not been created and then received the inputs that it has received since its inception. The time horizon for this first scenario ends at 2005.

The dominant input into the "without AIMS" case for scenario one was to reallocate Australian Government funding for AIMS out of the public R&D sector in primarily Northern Queensland, but also to a small extent Western Australia and Darwin, to income tax reductions. The assumption is therefore that if AIMS had not received government funding, this money would have instead been returned to taxpayers as income tax reductions.

The other, much smaller, expenditure change inputs into the "without AIMS" modelling scenario were:

- To remove the international investment that has gone into AIMS from the Northern Queensland public R&D sector. This is because without the presence of AIMS such funding would have been unlikely to have been directed to that sector.
- To remove the Australian business expenditure that has gone into AIMS from, as appropriate, the Northern Queensland and WA public research sectors. This funding is returned to the private sector and reallocated to other activity as per its overall expenditure pattern.
- To marginally increase costs in the gas/mining sectors to reflect the expenditure that these sectors would have incurred, in the absence of their relationships with AIMS, employing private environmental consultancy firms to conduct environmental data collection.

Scenario Two

The second economic impact scenario extends the time horizon for AIMS impacts out to 2020 and has a different purpose to the basic expenditure effect tracking conducted through scenario

[12] *Marine Imprint: the crucial impact of 33 years of AIMS research in the public interest*. Insight Economics, August 2006. The final impact assessment report will be available in mid August and AIMS would be pleased to provide a copy of this report to the Productivity Commission study team if it is of interest to the Commission

one. In addition to capturing expenditure effects it represents an attempt to capture a small set of the potential "investment" effects associated with AIMS.

In the second "without AIMS" modelling scenario all inputs for the period up to 2005 are the same as those included in the first "without AIMS" modelling scenario. For each of these inputs, for the period 2006 to 2020 the level of inputs observed for 2005 were assumed to continue at the same level in constant 2005 dollar terms out to 2020. While this may or may not prove to accurately project such expenditure patterns out to 2020, in the absence to any evidence to the contrary it was the only reasonable approach to adopt in estimating necessarily uncertain future events.

Two new "investment" effects from AIMS have been included in the modelling over the 2006 to 2020 period. These are changes in output in the Northern Queensland tourism sector and changes in output in the Northern Queensland commercial fisheries industry that are forecast to be potential outcomes associated with AIMS' role in informing key recent GBRWHA management policies. In the "without AIMS" case it is assumed that gross output in these two sectors would have differed in the ways presented from the "business as usual" forecasts for the future output of these industries.

This of course introduces several levels of uncertainty into the modelling scenario. Firstly, the business as usual projections for the two industry sectors in Northern Queensland, which we have taken from projections set out the Productivity Commission's 2003 study *Industries in the GBR Catchment and Water Quality*, are, as was cautioned by the Productivity Commission, not certain to be accurate base case performance projections. Secondly, the impacts that we assume AIMS to have on shifting future output in these industries away from the business as usual projected output for the industries are also uncertain. Both the projected performance of the industry with or without AIMS is contingent on a range of unpredictable economic and environmental event factors. For instance, a catastrophic natural event could severely affect either industry or a major economic downturn or upturn could also dramatically alter the prospects for either industry.

Notwithstanding the inherent uncertainty associated with forecasting the future with or without AIMS outcomes, an attempt has been made to reasonably project, based on current knowledge, the potential future change in output in these industries that would result from AIMS not continuing to operate in the future.

The forecast changes in future performance in the Northern Queensland tourism sector attributed to the removal of AIMS' activities since its inception are derived as follows:

- The tourism industry's output in the GBR catchment is projected under a business as usual case to increase over the 2001 to 2020 period from a base level of $4,228 million per annum in 2001 to $4,878 million per annum in 2010 and to $6,367 million per annum in 2020[13]. These projections are based on an assumption that the GBR does not suffer significant environmental quality decline.
- Results of a study into the link between GBR quality and recreational demand suggest that 35 per cent of tourists who visit the GBRWHA would not do so if the quality of the GBR significantly declined[14]. The recent introduction of a new zoning plan and a comprehensive water quality action plan for the GBRWHA are specifically targeted at preventing such environmental degradation of the GBR occurring.
- In the absence of such best practice environmental management policies, we assume that from 2010 GBR quality may in fact have started to suffer significant environmental quality decline and that from 2010 to 2020 tourism output in the GBR catchment region would therefore suffer a steady decline when compared to the "no significant environmental decline" projections. It is assumed that in the absence of best practice management policies tourism output in 2010 would be 3% lower than the base case projection, in 2011 it would be 6% lower, in 2012 it would be 9% lower and so on until by 2020 tourism output in the region is 33% lower than the level forecast in the "no significant environmental degradation" base case.
- This still leaves the issue of how much of this "avoided tourism output decline" can be attributed to AIMS. While there is no objectively "right" answer to this issue, what is clear is that scientific information has played a necessary role in the formation of management policy. The other necessary contributor to the formation of best practice management policy has of course been the management policy makers themselves. In the modelling scenario it was assumed that half of the attribution for the policy changes should go to the underpinning scientific information and half should go to management policy makers. This admittedly arbitrary apportionment of responsibility for management policy outcomes is an attempt to reflect the fact that while scientific information is not fully responsible for management policy outcomes it is still a very important input to those outcomes.

[13] Based on industry projections in Productivity Commission, (2003), *Industries in the GBR Catchment and Water Quality*

[14] Kragt, M.E., Roebeling, P.C., Ruijs, A., (2006), *Effects of GBR degradation on recreational demand: A contingent behaviour approach*, Fondazione Eni Enrico Mattei

- AIMS is not the only scientific organisation to have contributed to the formation of management policy. James Cook University and the CRC Reef (of which AIMS and James Cook University are core members) in particular have also played a role in providing scientific research to underpin management policy and practice. The CSIRO, Universities of Sydney and Queensland and the Queensland Department of Primary Industries also have involvement in research into the GBR. However, in terms of staff numbers, provision of infrastructure (AIMS has the two research vessels operating on the GBR) and the duration of involvement with GBR research, AIMS clearly represents at least half of the scientific endeavour into the study of the GBR ecosystem. Therefore, in the modelling AIMS was assigned half of attribution for the impact of scientific information onto tourism output.

Under these assumptions, AIMS is assigned a conservative 25 percent of the "credit" for avoiding the potential decline in tourism output in the region between 2010 and 2020 that may have occurred in the absence of well informed and effective marine ecosystem management policies being adopted.

The forecast changes in future performance in the Northern Queensland commercial fisheries industry attributed to the removal of AIMS' activities since its inception are derived as follows.

- The commercial fishing industry's output in the GBR catchment is projected to decline over the 2001 to 2020 period from a base level of $117 million per annum in 2001 to $111 million per annum in 2010 and to $93 million per annum in 2020.
- We assume that this decline is primarily driven by changes to marine zoning policy which have restricted some fisheries activities and hence reduce output.
- As in the case with the tourism industry outputs, we have assumed that half of the attribution for the policy changes goes to the underpinning scientific information and that AIMS accounts for around half of that underpinning scientific information.

Under these assumptions, AIMS is assigned 25 percent of the "responsibility" for the forecast decline in fisheries output in the region between 2006 and 2020.

Findings from the economic modelling

Scenario One findings

The modelling outcomes for scenario one simply account for the various expenditure effects associated with the measured inputs to date into AIMS. Scenario one does not account for any of the flow on economic impacts of the research outputs of AIMS and as such the results of this

scenario do not measure of the actual overall impacts of AIMS on the regional, state or national economy. Rather, they establish a base line for the "costs" of investing in AIMS for the Australian economy as well as the "benefits" accruing to the Northern Queensland and Queensland economies that would result if AIMS' research delivered no economic impacts other than the simply expenditure effects associated with its activities.

Bearing the limited objectives of the scenario one modelling in mind, what the CoPS MMRF Model shows is that if AIMS had not existed and resources had been otherwise allocated as described above, in terms of Gross Value Added (in 2005 dollars):

- The Far North region (Division 34) would have had Gross Value Added cumulatively $781 million *lower* than has been the case with AIMS. In 2005 Gross Value Added would have been $20 million *lower* than was the case with AIMS.
- Queensland would have had Gross Value Added cumulatively $1,127 million *lower* than has been the case with AIMS. In 2005 Gross Value Added would have been $34 million *lower* than was the case with AIMS.
- Australia would have had Gross Value Added cumulatively $322 million *higher* than has been the case with AIMS. In 2005 Gross Value Added would have been $14 million *higher* than was the case with AIMS.

In terms of Real Private Consumption (in 2005 dollars):

- Queensland would have had Real Private Consumption cumulatively $699 million *lower* than has been the case with AIMS. In 2005 Real Private Consumption would have been $24 million *lower* than was the case with AIMS.
- Australia would have had Real Private Consumption cumulatively $408 million *higher* than has been the case with AIMS. In 2005 Real Private Consumption would have been $11 million *higher* than was the case with AIMS.

In terms of Real Government Consumption (in 2005 dollars):

- Queensland would have had Real Government Consumption cumulatively $923 million *lower* than has been the case with AIMS. In 2005 Real Government Consumption would have been $22 million *lower* than was the case with AIMS.
- Australia would have had Real Government Consumption cumulatively $904 million *lower* than has been the case with AIMS. In 2005 Real Government Consumption would have been $22 million *lower* than was the case with AIMS.

What these results indicate is that when only the expenditure effects associated with AIMS are taken into account, the net result is that on an Australia wide basis the economy has suffered very slightly due to the resourcing of AIMS while the Queensland economy has gained. At the Regional level, the Far North region has gained significantly from AIMS.

Overall, what the scenario one modelling shows is that when just accounting for expenditure effects, the net economic impact of provision of taxpayer funding for AIMS is negligible. The Australian economy's output is reduced by around 0.001% in 2005 due to AIMS while Australian taxpayers in 2005 have real private consumption around $1 dollar a year each lower due to the provision of funding for AIMS[15].

Scenario Two findings

Scenario two sets out one possible scenario for the economic impact of AIMS out to 2020. It assumes that in addition to simply expenditure effects, AIMS also has impacts on the future gross output of the tourism and commercial fisheries industries in Northern Queensland through the role AIMS has played in key recent GBRWHA management policy changes.

The modelling should not be viewed as a definitive accounting for the full future impacts of AIMS, but rather as a means of illustrating the type of economic impacts that national interest focused research into marine ecosystems may generate at a regional, state and national level.

The CoPS MMRF Model shows is that if AIMS had not existed and resources had been otherwise allocated as described above, and tourism and fisheries output altered as described above, in terms of Gross Value Added (in 2005 dollars):

- The Far North region (Division 34) would have Gross Value Added cumulatively $2,788 million *lower* out to 2020 than would be the case with AIMS. In 2005 Gross Value Added would be $309 million *lower* than would be the case with AIMS. This represents a fall in regional Gross Value Add in 2020 of 2.68% when compared to what would be expected with AIMS.
- Queensland would have Gross Value Added cumulatively $3,094 million *lower* out to 2020 than would be the case with AIMS. In 2020 Gross Value Added would be $264 million *lower* than would be the case with AIMS. This represents a fall in Queensland

[15] Based on the $11 million annual decrease in private real consumption in 2005 shown by the CoPS modeling to be the net result of the presence of AIMS and a figure of 10.9 million taxpayers in 2005/06 that is based on Department of the Parliamentary Library 2004 data as interpreted in Macdonald and Kippen, 2005, Working Paper in Demography No. 95, *Reform of income tax in Australia: A long-term Agenda*.

Gross Value Added in 2020 of 0.21% when compared to what would be expected with AIMS.

- Australia has Gross Value Added cumulatively $387 million *higher* out to 2020 than would be the case with AIMS. In 2020, however, Gross Value Added would be $1 million *lower* than would be the case with AIMS. This represents a fall in Australian Gross Value Added in 2020 of 0.003% when compared to what would be expected with AIMS.

In terms of Real Private Consumption (in 2005 dollars):

- Queensland would have Real Private Consumption cumulatively $1,764 million *lower* out to 2020 than would be the case with AIMS. In 2020 Real Private Consumption would be $144 million *lower* than would be the case with AIMS. This represents a fall in Queensland Real Private Consumption in 2020 of 0.20% when compared to what would be expected with AIMS.
- Australia would have Real Private Consumption cumulatively $140 million *higher* out to 2020 than would be the case with AIMS. However, in 2020, Real Private Consumption would be $53 million *lower* than would be the case with AIMS. This represents a fall in Australian Real Private Consumption in 2020 of 0.015% when compared to what would be expected with AIMS.

In terms of Real Government Consumption (in 2005 dollars):

- Queensland would have Real Government Consumption cumulatively $1,126 million *lower* out to 2020 than would be the case with AIMS. In 2020 Real Government Consumption would be $7.7 million *lower* than would be the case with AIMS. This represents a fall in Queensland Real Government Consumption in 2020 of 0.11% when compared to what would be expected with AIMS.
- Australia would have Real Government Consumption cumulatively $1,096 million *lower* out to 2020 than would be the case with AIMS. In 2020 Real Government Consumption would be $6.6 million *lower* than would be the case with AIMS. This represents a fall in Australian Real Government Consumption in 2020 of 0.02% when compared to what would be expected with AIMS.

What these results indicate is that when the expenditure effects associated with AIMS and just ONE potential "investment" type effect are taken into account, the net result is that at the Australia wide level the impacts of AIMS remain relatively small. However, it should be noted

that by 2020 AIMS is generating higher Australian real private consumption of $53 million with the effects of AIMS on the tourism industry more than offsetting the simply expenditure effects associated with $26 million in taxpayer funding for AIMS (that would have seen $11 million lower real private consumption based on expenditure effects alone). Under this scenario, by 2020 AIMS is generating increased real private consumption in Australia of more than twice the level of taxpayer funding that it receives.

At the regional and state level however, the results indicate that AIMS could generate significant net economic benefits, both cumulatively and on a per annum basis. When compared to the low level of taxpayer resources directed to AIMS, the potential impacts on the regional economy in particular are very large. A 2.68% fall in the Far North region's annual gross value added would represent more than a halving of economic growth in the region.

Overall, what the scenario two modelling indicates is that even when viewing the impacts of AIMS in purely economic terms, public good focused research such as that conducted by AIMS has the potential to generate dramatic regional economic benefits and, at the national level, economic benefits for Australia well in excess of its costs.

IV. Implications of the impact assessment for the future of AIMS

Four major conclusions, that have important implications for AIMS' future activities, can be drawn from the study being conducted into the impacts of AIMS, namely:

1. It is clear that, based on assessment of expenditure effects alone, AIMS represents a very small cost to the Australian taxpayer – $1 per taxpayer per year.

2. Given the tremendously high regard in which AIMS' scientific research is held by its external industry, government and other stakeholders, the economic significance of the ecosystems that its research informs the management of, and the role AIMS' research plays in supporting environmentally sustainable marine industries (tourism, off-shore gas and on-shore mining developments and aquaculture), is highly likely to deliver strong net economic benefits for Australia for a small investment by taxpayers. Effective environmental management also mitigates against the high economic costs associated with ecological restoration[16].

3. The true value of AIMS' research can never be fully captured in purely economic terms. Investment in AIMS' research is primarily an investment in better understanding of the marine environment to enable conservation and sustainable use of Australia's marine natural heritage. Information generated though AIMS' research minimises the risk associated with decision making by managers and users of marine resources and provides a preparedness to respond to future/emerging issues. .

4. It is clear that while opportunities for the direct commercialisation of AIMS research should not be ignored, but given the relatively low economic impacts available in this area when compared to the economic impacts that are associated with better marine environment management (for instance), the pursuit of commercialisation opportunities should not be allowed to displace activity away from AIMS' core focus on conducting research that informs sustainable use and protection of the marine environment.

The implication of these findings is that public support for AIMS' provides economic, social and environmental impacts that add significant current and longer term benefits to Australia. In noting the value of AIMS research in relation to marine resources and existing areas of iconic

[16] "Ecological restoration is expensive. The United States government is slated to spend almost $8 billion restoring parts of the Florida Everglades as wetlands between 2000 and 2030. The Army Corps of Engineers had a plan to spend $14 billion to restore New Orleans' barrier islands before Hurricane Katrina arrived. On a smaller scale, South Africa, whose gross domestic product (GDP) is 4% that of the United States, is spending $450 million to restore native vegetation and increase water supply" (Woodworth (2006) The Scientist Volume 20, Issue 4). In Australia, the costs associated with restoration of the Murray-Darling reinforce these findings in the national context.

value it is important to recognise the extent of Australia's marine jurisdiction[17] and that little is known about the marine ecosystems of Northern Australia. Continued investment into basic strategic marine science and marine research capability is necessary to fully understand and benefit from Australia's Marine estate.

> *"Strengthened marine research capability and effort in tropical regions is needed to grow the knowledge base, to describe organisms and resources, to implement ecosystem approaches to improved understanding marine processes, and to support the Regional Marine Planning process of Australia's Ocean Policy[18]. In so doing, tropical marine research can continue to provide a context for developing skills that will be increasingly important to the national economy and to sustainable resource development and management, as marine industries, already one of our fastest growing sectors of the economy, continue to expand."*
>
> Chief Scientist, 2001, *Review of Marine Research in Tropical Australia*, pg. 16

The impacts from AIMS' research also show that investment in environmental research provides an informed, and essential, base needed to manage uncertainty in the marine environment – being prepared and planning for the future. Ongoing public support for marine science is an investment in Australia's future wellbeing and is particularly important given that private industry does not conduct environmental research for the public good (national benefit) - in the marine environment this is even more important since marine resources are not owned in the same way as terrestrial resources.

[17] Australia's marine territories are 2.5 times its landmass.

[18] *Australia's Ocean Policy*, Environment Australia, December 1998.

V. Suggestions for how national interest oriented research should be funded and evaluated in Australia

To be deserving of taxpayer support, any publicly funded research – irrespective of whether it is oriented to commercial or national interest outcomes – should be of high quality. Fortunately there are a number of well established and reasonably well accepted measures available for the evaluation of the quality of research being produced. Quality metrics such as publications in referred journals, publication citation rates, membership of learned academies, awards received and so on can be used to build an understanding of the academic quality of the research being produced by a research group or organisation. For an Institution such as AIMS to continue to receive funding, it is therefore necessary that AIMS should be able to convincingly demonstrate, using such generally accepted metrics, that it consistently produces high quality research. This performance expectation is entirely appropriate and is integrated into the Institute's funding process through the inclusion of performance indicator's in the AIMS' Triennium Funding Agreement. The indicators include measures of quality and AIMS reports against these indicators each year in its Annual Report. More recently, AIMS has implemented a regular program of external expert review of its research consist with the approach being adopted in the Research Quality Framework.

In relation to the need to demonstrate the impact of research, the situation is more complex. There is always a temptation to base evaluations of research impact on what can be easily measured rather than on what is important but difficult to measure. For instance, measures such as patents held, licences executed and spin-off companies formed are sometimes used as proxies for the economic "impact" of research. The use of such measures, or even the use of more sophisticated measures for commercialisation performance such as the turnover of spin-off companies or the value of licensing revenue, while perhaps appropriate for research that is highly targeted at commercial outcomes, are entirely inappropriate as measures of the economic impact of national interest oriented research.

As the current study being conducted into AIMS' impacts since its formation demonstrates, such "commercial" outcomes may represent only a very small part of the economic impacts that public good oriented research can generate. Rather than reliance on inappropriate metrics for impact evaluation, it is therefore necessary to evaluate the impact of research organisations such as AIMS by actually looking at what the organisation does, how its research outcomes are applied by end users, and what the results of such research application are. It should be stressed that not all such results will be able to be expressed in purely economic terms.

Such a detailed impact evaluation process is time consuming and costly, and hence is not something that can or should be done on an annual basis. However, it would be reasonable to expect that national interest oriented research groups or organisations undertake a detailed review of their impacts every five years or so and that the results of such a review should influence future funding outcomes.

The timelines upon which impact should be assessed, should be tied to the timelines upon which funding is awarded. The arrangement between the Institute for Molecular Bioscience (IMB) and the Queensland Government provides a best practice example of such alignment of research funding and research evaluation.

The IMB was initially awarded ten years of funding but on the proviso that the extent to which its agreed Key Performance Indicators (in relation to both research quality, organisational efficiency, and research impact) had been met must be independently assessed after five years of operation. Only once the results of this review of performance had been evaluated by the Government, was the second tranch of five year funding released. Such an arrangement strikes an appropriate balance between providing the funding certainty needed to facilitate the proper planning and undertaking of long-term research projects on the one hand and ensuring performance accountability and focus on delivery of end value to the community on the other hand.

AIMS would strongly recommend that the adoption of such a funding and evaluation model by the Commonwealth Government would be a very positive step in how long-term national interest focused research organisations such as AIMS are funded and evaluated.

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