AIMS @ JCU

2009-2010 Biennial Report

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Foreword

Building on a 40 year association between the Australian Institute of Marine and James Cook University, AIMS@JCU has produced significant advances in tropical marine science research. This knowledge and expertise assists global efforts to understand and sustainably manage the most precious resource of the planet; the ocean and its ecosystems.

From a national perspective, AIMS@JCU helps to fulfil innovation priorities in building a strong base of skilled researchers and in encouraging collaboration within the research sector. The first AIMS@JCU scholarships were awarded in 2005, since then 78 young scientists have received research support from the scheme. In addition, AIMS@JCU has made significant infrastructure investments to facilitate collaboration and linkage between the partner institutions, and beyond. Combined with the substantial support of early career researchers, AIMS@JCU has delivered clear long term benefits for Australia and tropical marine research.

The success to date of AIMS@JCU and its strategic importance for future marine research, meant that both partners committed to jointly share future operational costs following the expiration of federal funding in 2011. This is the therefore the last biennial report for the work of the AIMS@JCU joint venture as it was originally formulated.

In these past two years (2009 – 2010), AIMS@JCU has moved to focus primarily on student based support, increasing the number of funding opportunities that are available. The phasing out of research theme areas has allowed any student with collaboration between AIMS and JCU to be eligible for support, thereby improving access to this scheme. This has built and will continue to build tropical marine research capacity in Australia, with increased researcher numbers and high impact scientific research outputs.

We would like to take this opportunity to thank Dr Michelle Heupel for her work as AIMS@JCU Research Director and welcome Libby Evans-Illidge as the new Research Director.

AIMS@JCU is an important collaboration for the furthering of tropical marine research, and we look forward with anticipation to its continued success into the future.

Ian Poiner, Chief Executive Officer AIMS

Sandra Harding, Vice Chancellor, JCU

"to facilitate and foster an increased capacity for world class tropical marine research, by integrating the strengths, synergies, infrastructure and expertise of the two parent institutions, so that they collectively address the national and international priorities with leading edge science outcomes that would not have been possible by either institution on its own."

Summary of Achievements

This section of the biennial report is to highlight the contributions to marine science made by AIMS@JCU since 2004. This is when AIMS and JCU formed AIMS@JCU, a joint venture between the two organizations with initial funding of $3.9m from the commonwealth government. 'Joint Venture In Review' extends from the initial input of funds through to the conclusion of this external funding in 2011.

AIMS@JCU has given infrastructure support to three major facilities: the AIMS fibre optic cable [information provided by James Smith, J.Smith@aims.gov.au], the JCU Marine and Aquaculture Research Facilities Unit (MARFU) aquashed [information and photographs provided by Ben Lawes, ben.lawes@jcu.edu.au] and the AIMS Controlled Environment Facility (CEF) [information and photographs provided by Matt Kenway, m.kenway@aims.gov.au] as well as funding infrastructure developments at the Orpheus Island Research Station (ORIS) [information and photographs provided by Haley Burgess, jcu.orpheus@jcu.edu.au].

Another significant objective of AIMS@JCU is to train the next generation of scientists in priority fields areas of research need, through provision of post-graduate research scholarships for projects co-supervised by both organisations. Since the first round of scholarships were awarded in 2005, AIMS@JCU has supported the research training of over 75 young scientists, including three post-doctoral fellows who played an important role in fostering collaborations between the two institutions, supervising students and conducting cutting edge research.

AIMS@JCU has also supported science communication initiatives in a number of ways. 45 travel awards were provided, assisting students to participate in and present their research at international conferences as far afield as the Americas, Europe, SE Asia and Tahiti. Students also presented their research at annual AIMS@JCU seminar days held in Townsville. AIMS@JCU have contributed 62 publications to date, with many more likely during the coming years as graduate research projects are written up.

Despite the conclusion of the Joint Venture funding, AIMS and JCU have agreed to continue their partnership through a new Strategic Alliance, and jointly share the operational costs of continuing to foster future collaborations and joint supervision of the next generation of marine scientists.

AIMS@JCU Controlled Environment Facility (CEF)

The AIMS@JCU Controlled Environment Facility (CEF) is a state-of-the-art facility located within the aquaculture precinct at AIMS, containing environment-controlled rooms with air conditioning, filtered ambient seawater, filtered heated or cooled seawater, and freshwater reticulation.

It was completed in February 2006 and has been used by students and researchers in the fields of reproductive biology; broodstock conditioning; larval rearing; aquaculture nutrition, disease and health; climate change; and inter-kingdom communication. Species used in this research have included aquaculture food species such as tropical rock lobsters (*Panulirus ornatus*) and the ornamental cleaner shrimp (*Lysmata amboinensis*), as well as coral larvae which are used in climate change research and inter-kingdom research.

The facility makes efficient use of energy through clever design. Air conditioning and seawater cooling access re-circulated water from a nearby chiller plant, and seawater is circulated through solar strip heaters on the roof of the building to provide heated water. Within the facility, air and seawater temperatures are continuously monitored and controlled for precise experimental conditions.

This facility is also undergoing further development to meet future needs, through installation of a recirculation system for year round operation of the broodstock facility, an air compressor and oxygen generating system for providing oxygen to larval rearing tanks, an ultrafiltration system for processing up to 200,000 litres of seawater per day and the addition of gas heaters for energy efficient heating of seawater during winter.

AIMS@JCU Aquashed

The AIMS@JCU 'Aquashed' was completed in February 2006. Located within the Marine and Aquaculture Research Facilities Unit (MARFU) at JCU, the Aquashed was originally fitted-out with equipment ready for student experiments, providing over 350m^2 of usable space. It saw the transformation of an old 'green house' with new power connection, water and waste-water collection, and provision of cool, dry work areas.

As with the CEF, the Aquashed established foundational infrastructure which is currently undergoing further development to meet future needs. It will shortly contain a range of independent and fully-recirculated systems, including:

- A new automated control system managing four separate research systems within 150,000L capacity
- A genetics research area with two 35,000L tanks for broodstock alongside another 20,000L dedicated spawning tank
- Ten 2,000L and six 2,500L temperature controlled tanks for climate change research
- Six 15,000L parabolic recirculated tanks for research into algae culture in aquaculture effluent
- Three 2,500L tanks incorporating an aquaponics system to support 4th year Aquaponics training

AIMS-JCU Fibre-Optic Link

The fibre-optic link between AIMS and JCU was designed to overcome a major impediment to effective collaboration between JCU and the relatively remote site of AIMS – that of e-connection. It first came online in May 2005, with the capacity for up to 12 separate 1Gb/s links initially used to join AIMS to JCU in two ways - a high speed Internet connection between AIMS and AARNet (Australian Academic and Research Network Pty Ltd), as well as a direct peering link between AIMS and JCU, which made the AIMS site a virtual extension of the JCU campus and vice versa. This infrastructure provided cost effective, high speed, and simplified access for researchers to the people and resources they needed to access regardless of their

location. Combined with services such as Eduroam, high performance computing & video conferencing, this infrastructure has promoted a quantum increase in scientific interaction and collaboration between AIMS and JCU, and indeed throughout the world.

In August 2007, the optic-fibre infrastructure was used to create a 4Gb/s dual fabric, fibre channel, storage area network between AIMS and JCU. This allows large quantities of AIMS data to be copied and stored in JCU systems to facilitate disaster recovery. The success of the initial project resulted in an upgrade to cover much larger datasets and implement high speed disk backups and online data archival facilities. JCU IT&R are also currently considering making similar use of the link in the reverse direction.

In future, by utilising modern technology that can increase link speeds by 40 times using the same cable, the AIMS@JCU fibre optic link will be further developed to cost effectively create increases in bandwidth by orders of magnitude. By having the vision to invest in coal-face infrastructure which was ahead of its time, AIMS@JCU created a legacy for e-connectivity which can be adapted and scaled to ensure effective state-of-the-art linkage between AIMS and JCU into the future.

Other Infrastructure Support

AIMS@JCU provides a vehicle which travels between JCU and AIMS on a daily basis. This facility is available and free for all AIMS@JCU members, making the commute more cost-effective for students and occasionally staff who wish to use the facilities at AIMS. This is likely to increase to two vehicles in the near future as AIMS@JCU supported student numbers increase.

Throughout the joint venture, additional infrastructure support was provided to augment existing facilities to make them more effective and facilitate AIMS@JCU research. For example, around $40,000 was provided to upgrade the external air conditioning unit controlling a Temperature Controlled Room at the Orpheus Island Research Station. This upgrade established the capacity of that facility to conduct experimental work with coral larvae, and facilitated international research collaborations for AIMS@JCU students.

AIMS@JCU's Science Outcomes

Through their time with AIMS@JCU, the supported young scientists became well-positioned to take their marine science skill and expertise out into the marine science world. AIMS@JCU alumni members have proven highly successful in obtaining post-doctoral research positions, including:

- examining the regional circulation of Kimbe Bay and its influence on fish larval transport, with the ARC Centre of Excellence at JCU
- assisting Pacific Island nations understand and predict coastal inundation, with CSIRO Aspendale
- examining wave properties in Australia, at JCU
- developing remote sensing algorithms for analysis of shallow waters of the GBR, at Curtin University, WA
- understanding the effects of climate change on brooding coral in Taiwan and French Polynesia, at California State University, LA
- diagnosing toxic cyanobacteria blooms, and transcriptomics of parasites, at the Veterinary Department at the University of Melbourne
- understanding the impacts of water quality on the sponge/microbial holobiont, at NAMRA, Northern Territory.

Besides providing a boost to Australia's marine science capacity by training the next generation of young scientists, AIMS@JCU supported research has produced many significant scientific outcomes in its three theme areas; more details are in the specific program sections of this report.

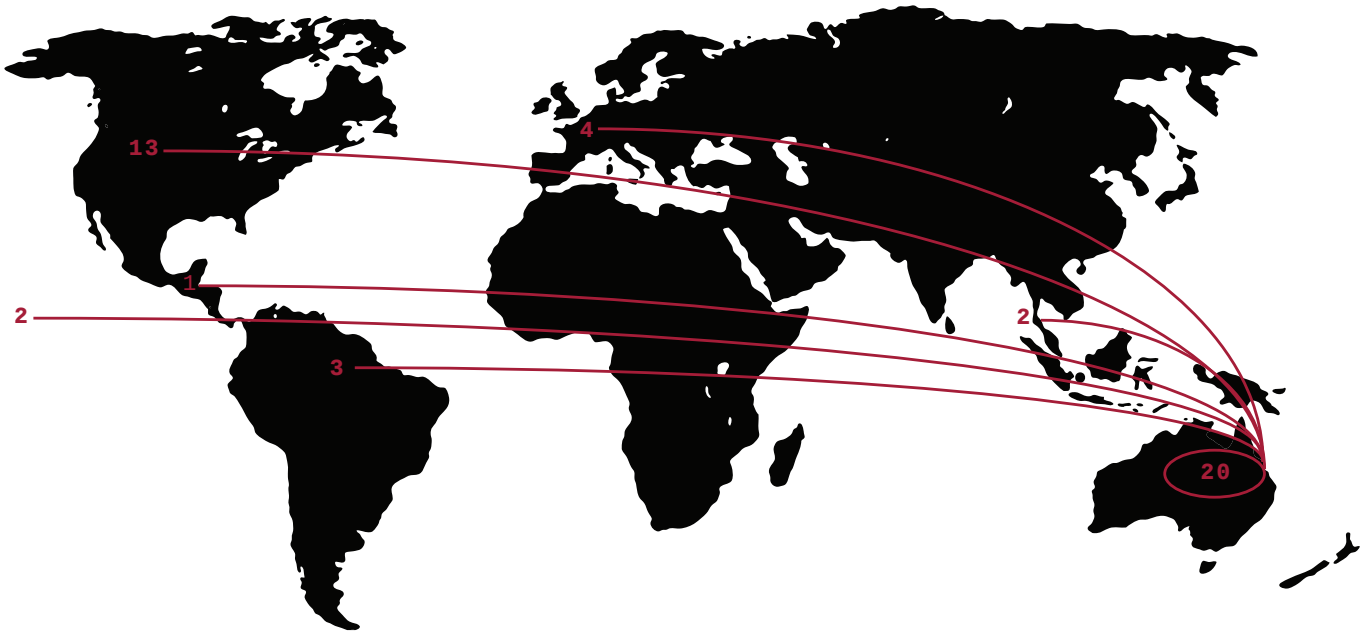
AIMS@JCU Student Support up to 2010

To date, AIMS@JCU has facilitated the research of 78 marine science students in Townsville through 126 awards of financial and/or operational support. The postgraduate, honours and travel support has been financial with students receiving either stipends, project costs or stipends and project costs; travel awards have been competitively awarded annually. All AIMS@JCU student members have access to AIMS@JCU facilities such as the commuter vehicle (running daily between JCU and AIMS free of charge), the AIMS@JCU Aquashed within the Marine and Aquaculture Research Facilities Unit (MARFU) at JCU and the Controlled Environment Facility (CEF) at AIMS.

AIMS@JCU Travel Grants

So far, AIMS@JCU has awarded 45 travel grants helping AIMS@JCU student members to present their research nationally and internationally. Assisted by these awards, AIMS@JCU student members have presented at conferences all around the globe including Brazil, USA, Mexico, Tahiti, Thailand, Vietnam and within Europe. Within Australia, students used these grants to travel to Perth, Darwin, Adelaide, Melbourne, Hobart, Wollongong, Cairns and Sydney.

Number of students participating at conferences worldwide:



Research Director Report

During the course of the last two years AIMS@JCU has undergone some major changes that will hopefully strengthen and improve the progress, outputs, reputation and future of the group. The last two years have seen the focus of AIMS@JCU shift to primarily student based support, with all three Postdoctoral Scientists completing their tenure and moving on to other opportunities. This shift in focus has meant that additional support could be provided to students through increased member numbers and funding opportunities. The research structure of the Joint Venture also changed during this period with the previous research theme areas phased out to allow all students with collaborations between AIMS and JCU to be eligible for support. This move was made to try to broaden the scope and membership of the Joint Venture and allow support to change quickly with funding opportunities. Concomitant with these changes were structural changes to the management and funding of AIMS@JCU.

Membership of the AIMS@JCU Management Committee changed during the last two years and alterations to internal processes has led to the current scenario where one representative from each institution takes primary responsibility for guiding the Joint Venture. This change will streamline decision making and prioritisation of effort within AIMS@JCU. The final, and most significant change to AIMS@JCU during this period, was the negotiation of a new funding model. With the expiration of federal funding in 2011, the partner institutions were faced with the task of determining how to support AIMS@JCU into the future. As a testament to the progress, outputs and potential of the AIMS@JCU Joint Venture, both partners agreed to continue to support AIMS@JCU into the future

AIMS Beach Series
Image courtesy of Visual Echo Photography www.visualecho.com.au

to ensure high quality marine research conducted collaboratively between these two institutions could continue. This speaks volumes for the efforts of AIMS@JCU members and students and how this work is viewed by both partners.

The core strength of AIMS@JCU continues to be the dedication and excellence of its student members. The Joint Venture has worked hard to foster, support and facilitate these research efforts as much as possible. I would like to take a moment to thank all of the students for their support of AIMS@JCU, for continuing to produce high quality research outputs, and for participating in AIMS@JCU events such as the annual Seminar Day. I also want to take time to thank all of our members who support AIMS@JCU student research projects. The time, effort and support provided by supervisors has played a large role in the success of AIMS@JCU and its student members.

Special thanks need to go to all the current and former Management Committee and Research Program Leaders for all of their help in shaping and guiding the Joint Venture to this point. Finally, Lauren Gregory and Vanessa Adams deserve acknowledgement for their efforts to make sure AIMS@JCU runs smoothly for all of our members and that everyone is informed about activities and issues.

Although AIMS@JCU has come through the last two years a very changed entity, I believe these changes will work to the advantage of the Joint Venture and all of its members. AIMS@JCU is a strong, unique and widely recognised venture that has served as a model at other institutions and will continue to break new ground and produce high quality research into the future.

Dr. Michelle Heupel

AIMS Beach Series
Image courtesy of Visual Echo Photography www.visualecho.com.au

AIMS@JCU Governance

AIMS@JCU has been governed by a Management Committee consisting of four members: two from each partner institution, plus a nominated alternate representative from each partner institution.

The Management Committee is responsible for making research and operational decisions for the Joint Venture in consultation with the Research Director.

The Management Committee meets quarterly with the Research Director.

AIMS@JCU Management Committee Members from AIMS:

- Mr David Mead
  General Manager
- Dr Julian Caley
  Research Group Leader
  Conservation and Biodiversity
- Dr Chris Battershill (alternate representative)
  Research Group Leader
  Marine Biotechnology

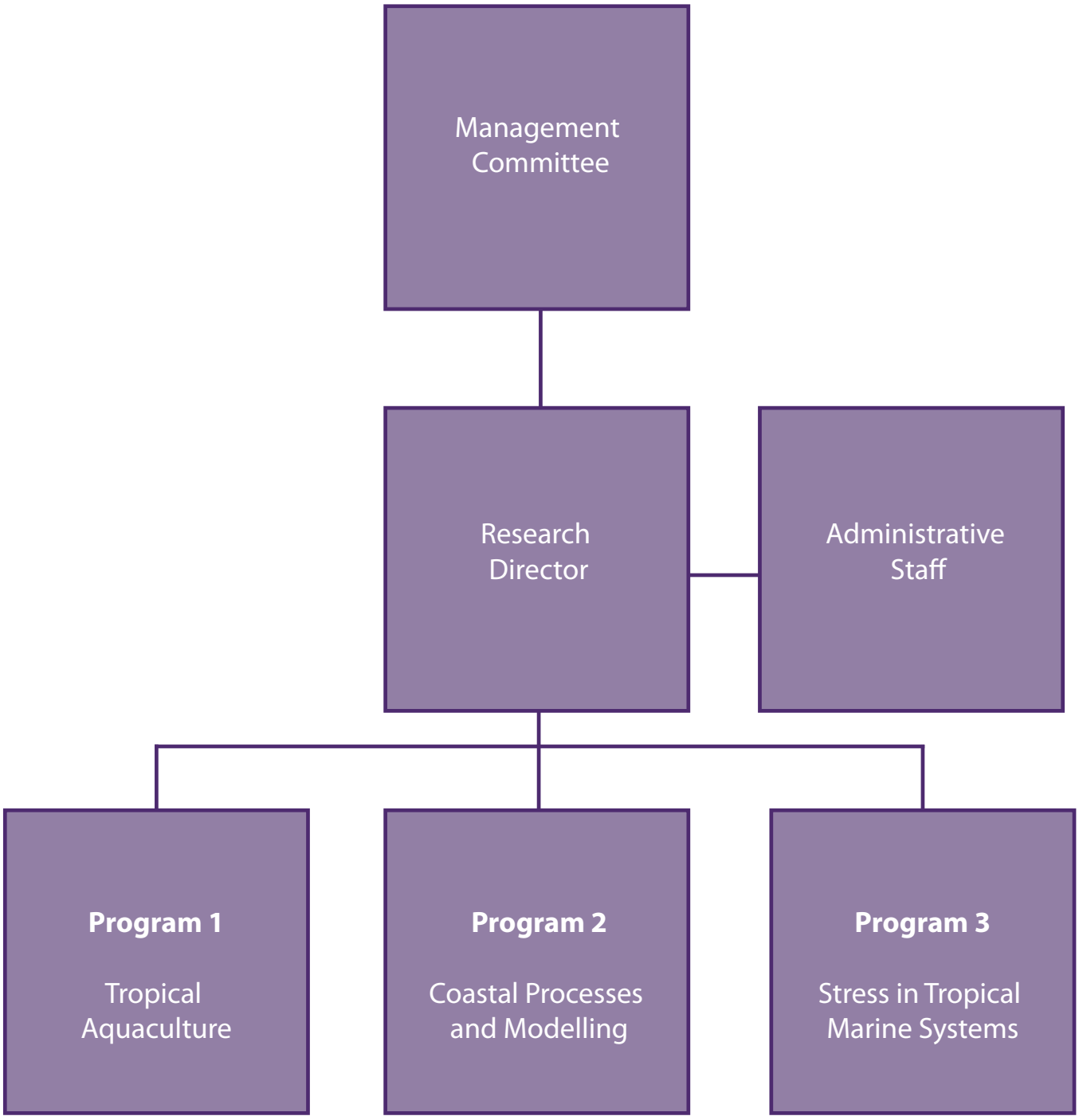
AIMS@JCU Management Committee Members from JCU:

- Professor Chris Cocklin
  (Until January 2010)
  Deputy Vice-Chancellor Research and Innovation
  School of Earth and Environmental Sciences
- Professor Jeff Loughran
  (From January 2010)
  Pro-Vice-Chancellor
  Faculty of Science, Engineering & IT
- Professor Helene Marsh
  Dean of Postgraduate Studies
- Professor Michael Kingsford (alternate representative)
  Head of School of Marine and Tropical Biology

AIMS@JCU Office:

- Dr Michelle Heupel
  Research Director
- Lauren Gregory
  Office Administrator
- Vanessa Adams
  Office Administrator

AIMS@JCU Structure:



Management Committee Member Profiles

Mr. David Mead

David Mead is the AIMS General Manager and is responsible for day to day operations of the Institute. In this role he manages a broad spectrum of areas including health and safety, field and ship operations, engineering & technical and corporate services. Additionally, he oversees the business and commercial aspects of the institute and is involved in developing external revenue opportunities and in the strategic planning of research.

David has an honours degree in mechanical engineering and tertiary qualifications in business (Master of Business Technology). Prior to taking up this position, David worked as a senior manager at Snowy Hydro Limited for 14 years, a renewable energy generation and electricity retail company. During this period he had a diverse range of roles from strategic planning and business development though to leading teams responsible for improving maintenance and asset management systems and processes. This work culminated in David being awarded the inaugural Steve Maxwell National Maintenance Leadership Award. Prior to Snowy Hydro Limited David worked for several years at BHP Research as a research engineer undertaking mathematical and numerical modelling of rock fracturing under explosive loadings.

Dr. M. Julian Caley

Julian Caley is a Principal Research Scientist with AIMS. His marine research has ranged through population and community ecology, macroecology and evolutionary biology. He has used many different model organisms in his research depending on the question of interest, but most of his recent work has concentrated on the evolution and evolutionary ecology of reef fishes with an emerging interest in the evolution of coral symbiosis. In particular, his current research explores ecological and contemporary evolutionary processes that generate and maintain biodiversity. Julian received his Ph.D. from the University of Sydney in 1992 and has since held four prestigious research fellowships at the University of British Columbia and James Cook University. He has supervised many research students and has published numerous scientific papers. In addition to his responsibilities as a research leader at AIMS, he has been involved from the beginning in the establishment of the AIMS@JCU joint venture as a member of the Institutional Steering Committee and then as a Member of its Board and Management Committee. Julian is also a graduate of the Australian Institute of Company Directors.

Dr. Chris Battershill

Chris Battershill was the Leader for the "Supporting Sustainable Use of Marine Biodiversity" Research Team at AIMS until January 2011, having lead teams in Marine Biotechnology and Microbiology at AIMS and in New Zealand. He is now based at the University of Waikato and is the Chair of Coastal Science. Chris is personally active in research associated with Biodiversity Assessments, Conservation Ecology, New Species Aquaculture (particularly for production of biomedicinal compounds), Biodiscovery and Chemical Ecology.

Chris completed postdoctoral fellowships at the University of Canterbury in conjunction with the National Cancer Institute (US), SeaPharm/Harbour Branch Oceanographic Institute (US), and at AIMS. Highlights of his research career include enhancing discovery and production of marine biomedicinal leads and research examining the chemical ecology and dynamics of biodiverse seafloor habitats.

Research projects have been carried out from the high tropics to the Antarctic. Publications include co-authorship of 3 books on marine taxonomy and experimental design, over 100 international peer reviewed publications. He is an adjunct Professor at the University of Western Australia and James Cook University; Inaugural Leader of the Biotechnology and Aquaculture Node of the Western Australian Marine Science Institution.

Prof. Chris Cocklin

Professor Cocklin was appointed to the position of Deputy Vice-Chancellor, Research and Innovation in August 2008. He was previously Pro-Vice-Chancellor of the Faculty of Science, Engineering and IT at JCU (from February 2007). Prior to that he was employed for 10 years at Monash University, where he served as Head of the School of Geography and Environmental Science and as the inaugural Director of the Monash Environment Institute.

Professor Cocklin's interests are in resources and environmental policy, agriculture and rural communities, global environmental change, sustainable development, and corporate environmental management. He is a member of the Queensland Premier's Advisory Council on Climate Change and a Director of the Reef and Rainforest Research Centre, and the AIMS@JCU Joint Venture.

Prof. Jeff Loughran

Professor Jeff Loughran was appointed to the position of Pro Vice-Chancellor (Faculty of Science and Engineering) at JCU in March 2009. His previous appointment at JCU was Acting Pro-Vice-Chancellor of the Faculty of Science, Engineering and Information Technology (July 2008). Prior to that he was employed as Professor and Head of the School of Engineering at James Cook University (2006-2008). He has had senior academic positions within engineering at JCU since 1992. Prior to 1992 he worked in a senior research capacity at the Sugar Research Institute in Australia (10 years).

Professor Loughran's research and teaching interests are in the area of computational mechanics, specifically finite element and particle methods. At an applied level he has published widely in the following areas: geomechanics, plasticity and discontinuous media; large strain coupled problems in porous media with evolving boundary conditions; modelling of hyperelastic materials; constitutive models –inelastic and time dependent; particle methods –DEM applied to mining and bulk solids; mechanical design and durability modelling; transient dynamic modelling of quasi-brittle fracture; biomechanics.

Professor Loughran has delivered many national and international keynote addresses at conferences and symposia. Over the course of his career, Professor Loughran has published over 140 articles (refereed journal and conference papers and consulting reports to industry). His competitive research earnings (grants) exceed $3M. In addition to being on the AIMS@JCU Management Committee, Professor Loughran is a member of the following Boards: Australian Tropical Herbarium, Cyclone Testing Station, and the Tropical Landscape Joint Venture. He is a Director of the Queensland Cyber Infrastructure Foundation, UniNet Ltd. and Rockfield technologies Australia Pty. Ltd.

Prof. Helene Marsh

Helene Marsh is Dean of Graduate Research Studies and Distinguished Professor of Environmental Science at JCU. The focus of her research has been dugong population ecology with an emphasis on life history, reproductive ecology, population dynamics, diet, distribution, abundance and movements. Helene has collaborated widely with colleagues in other disciplines including Anatomy, Anthropology, Botany, Biochemistry, Genetics, Geography, GIS, Law, Psychology, Sociology and Statistics.

The policy outcomes of Helene's research include significant contributions to the science base for the Dugong Sanctuary established in Torres Strait; dugong management in the Great Barrier Reef Marine Park, especially the Dugong Protected Areas and no-take areas to protect dugongs in various zoning plans. Helene's research has also provided the conceptual basis for the 'Back on Track' Program currently being conducted by the Queensland EPA. She has acted as a consultant to governments and NGS in many countries in the dugongs range.

Helene was awarded a Pew Charitable Trust Fellowship in Marine Conservation in 1998, a Distinguished Service Award by the Society of Conservation Biology in 2008, the Aldo Leopold Award by the American Society of Mammalogists in 2009 and was made a Fellow of the Australian Academy of Technological Sciences in 2010. These awards recognise her contributions to dugong research and conservation. She has authored more than 200 scientific publications.

Prof. Michael J. Kingsford

Michael Kingsford is currently Head of the School of Marine and Tropical Biology at James Cook University. The School is a recognised world leader in tropical marine studies. He is also coordinator of the Area of Research Strength, Marine Science at JCU, member of the International Advisory Committee of the Great Barrier Reef Research Foundation, Immediate Past President of the Australian Coral Reef Society and the former Director of One Tree Island Research Station in the southern Great Barrier Reef.

Mike has published extensively on the ecology of reef fishes, jellyfishes and biological oceanography. His projects have encompassed a range of latitudes and include a well respected book on temperate marine environments. A major focus of his research has been on connectivity of reef fish populations and how the findings can assist managers of marine parks. In addition to research and leadership, he teaches undergraduate and postgraduate students and supervises many postgraduate students.

Dr. Michelle Heupel

As Research Director for AIMS@JCU Michelle Heupel worked part-time for the Joint Venture while continuing to conduct scientific research and supervise postgraduate students. This continued research productivity led to the award of an Australian Research Council Future Fellowship in November 2010. Commencement of the Fellowship in January 2011 led to Michelle's resignation as Research Director for AIMS@JCU but she is still an active member and supporter of the group. Michelle's current position is jointly held between AIMS and JCU allowing her to continue to provide a connection between the two institutions and to support AIMS@JCU student projects.

Michelle's research focus is marine ecology, primarily examining the movement and behaviour of elasmobranch fishes (shark and rays). Her research utilises acoustic monitoring to define long-term movement and presence patterns of fish in specific habitats and the response of individuals to environmental change. This research helps define long-term dependence on key habitats such as inshore nursery areas and coral reefs. Current projects focus on use of inshore and reef habitats by predatory fish and have revealed interesting movement patterns. Sharks have been observed to utilise Cleveland Bay based on tide, temperature and habitat type, and have also been observed to leave the region prior to landfall of Tropical Cyclone Yasi. It is hoped that these findings along with more recent detailed studies of reef predators will help better define how these species use habitats, how environmental changes influence their use of habitat, and how all of these factors play into conservation and management of these species through marine park zoning and other management measures.

Michelle's research will continue to draw on the facilities and strengths of AIMS and JCU, including the AIMS@JCU Joint Venture.

2009-2010 AIMS@JCU Student Seminar Day

The highlight of the AIMS@JCU calendar each year is the student seminar day. These have always been successful and well attended. The fourth annual seminar day in 2010 was no exception, again providing an opportunity for students to show case their cutting edge research. Top presentations are awarded funding to support conference travel. The event is an important mechanism for students to share research findings with the broader AIMS and JCU scientific communities as well as compete for financial prizes.

The 2009/2010 AIMS@JCU seminar day was held April 2010 at JCU and was covered by local media. A total of 21 speakers were involved in the day and 12 poster presentations were given. Presentations were all of excellent quality, making the prize judging very difficult. First place talk was awarded to Emily Howells. Emily's talk was titled "Genetic resilience of *Symbiodinium* populations: the role of coral endosymbionts in adaptation to climate change". Emily was awarded $2,000 towards conference travel as the top judged presentation.

Due to high placement of Heidi Luter and Raechel Littman for both the second place talk prize and the poster award these prizes were combined and $1,000 was awarded to each as a combined Best Poster/Second place talk award. Heidi presented her talk: 'Microorganisms are not responsible for the disease-like syndrome affecting the marine sponge *Ianthella basta*' and poster: 'Prevalence of disease in *Ianthella basta* populations from the Palm Islands and Torres Strait'. Raechel presented her talk: 'Responses of the coral holobiont to heat stress' and poster: 'Bacterial communities of juvenile corals infected with different *Symbiodinium* (dinoflagellate) clades'. Unfortunately Raechel was unable to use her prize money before finishing her PhD.

Prize Winners:

Emily Howells - International Society for Reef Studies conference in The Netherlands

Emily utilised her award to attend the Euro International Society for Reef Studies (ISRS) Symposium 2010: Reefs in a changing environment. Held in Wageningen in the Netherlands under snowy conditions, the conference had a strong European turn-out but was also attended by a number of prominent scientists and PhD students from Australia, Japan, Singapore, Israel, the USA and Mexico. Session topics discussed over four days of oral and poster presentations included ecology, physiology, connectivity, genomics and climate change impacts on coral reefs.

Emily gave a talk on adaptive variation in thermal tolerance between populations of coral symbionts and attended talks on research investigating mechanisms of adaptation and acclimatization that corals may use to respond to changes in their environment.

Heidi Luter - World Sponge Conference in Girona, Spain

Heidi used her award from the 2010 AIMS@JCU student seminar day to attend the VIII World Sponge Conference in Girona, Spain from September 20-24, 2010. Heidi presented a talk entitled 'Microorganisms are not responsible for the disease-like syndrome affecting the marine sponge *Ianthella basta*' in the session on Organism and Cell Biology.

In addition, she also presented a poster on the 'Extraordinary tissue regeneration in the marine sponge *Ianthella basta*', which won her a prize at the conference. The conference itself was relatively small, with only 265 delegates, making it a prime opportunity to interact with experts in her field.

2009 Awards

Honours Awards

Karen Chong-Seng
Are corallivorous fishes vectors for coral disease?

Alexander Vail
Non-Lethal Predator Effects on Settlement of Reef Fish

Heather Welladsen
The effects of ocean acidification and temperature on the physiology of giant clams and their symbionts

Travel Awards

David Abrego
84th Australian Coral Reef Society

Emmanuelle Botte
15th International Symposium on Pollutants Responses in Marine Organisms

Ana Cano-Gomez
International Symposium for World Association of Veterinary Laboratory Diagnosticians

Paulina Cetina Heredia
84th Australian Coral Reef Society

Darren Coker
8th Indo Pacific fish conference and 2009 Australian Society for Fish Biology workshop and conference

Emily Howells
Student course "Light and Photosynthesis on Coral Reefs", Jan-Feb 2009, Universidad Nacional Autonoma de Mexico

Jasmine Jaffres
9th International Conference on Southern Hemisphere Meteorology and Oceanography

Luiz Felipe Mendes de Gusmao
Australian Marine Sciences Association 2009 Marine Connectivity

Eneour Puill-Stephan
11th Pacific Science Inter-congress in conjunction with 2nd Symposium on French Research in the Pacific

Yui Sato
84th Australian Coral Reef Society

Francois Seneca
11th Pacific Science Inter-congress in conjunction with 2nd Symposium on French Research in the Pacific

Gergely Torda
Australian Marine Sciences Association 2009 Marine Connectivity

Alexander Vail
8th Indo Pacific fish conference and 2009 Australian Society for Fish Biology workshop and conference

Patricia Warner
Australian Marine Sciences Association 2009 Marine Connectivity

2010 Awards

Honours Awards

Emily Chick
Evaluating Tropical Sea Cucumbers for Integrated Multi-Trophic Aquculture: What can energy budgets tell us?

Ingrid Cripps
The effects of ocean acidification on predator-prey interactions in reef fish

Travel Awards

Nicola Browne
Australian Marine Sciences Association 2010

Ana Cano-Gomez
Australian Society Microbiology

Jessica Haapkyla
European International Society for Reef Studies

Emily Howells
International Society for Reef Studies European Meeting: "Reefs, Science and Society"

Lachlan McKinna
American Geophysical Union Ocean Sciences Meeting 2010

Yui Sato
2nd Asia Pacific Coral Reef Symposium Committee

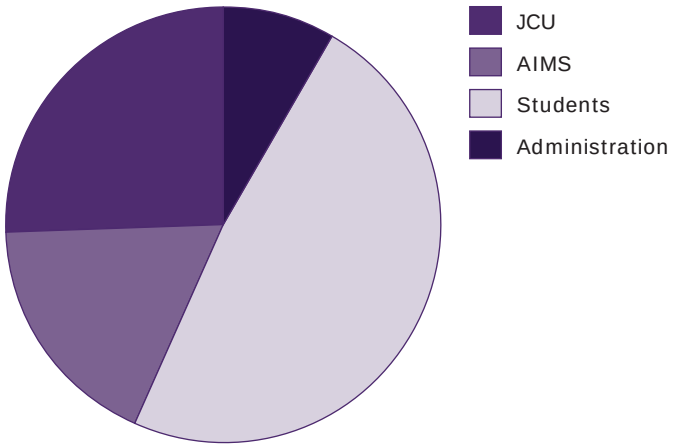
Gergely Torda
Marine and Tropical Sciences Research Facility Conference 2010

Patricia Warner
2010 Summer Institute in Statistical Genetics

Matthew Wassnig
Australasian Aquaculture 2010 International Conference and Trade Show

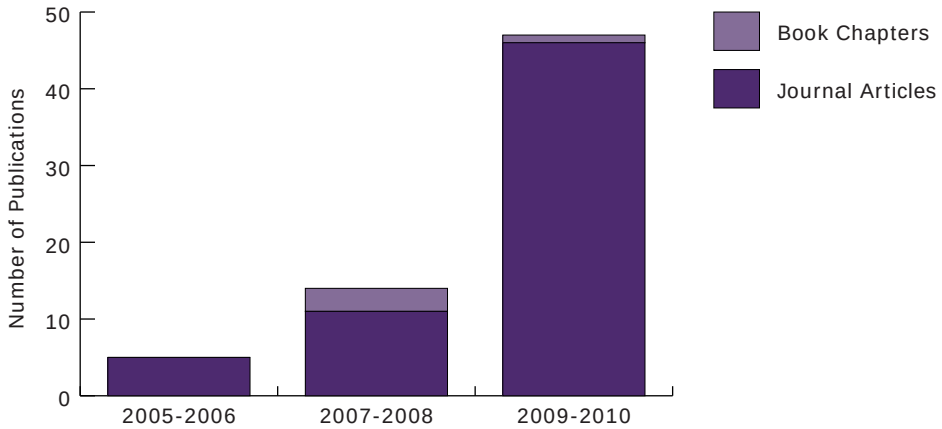
Membership Structure

AIMS@JCU strives to maintain a balanced membership. The group has a strong student membership and balanced support from both institutions. The current membership breakdown is shown below. Administration includes the Management Committee, Research Director and administrative staff. Other staff members are shown by affiliation (AIMS or JCU).



AIMS@JCU Publications

During 2007-2008 the group had a total output of 256 papers in referred journals, 18 book chapters and 4 books. In 2009-2010 the group was exceptionally productive with 525 papers in refereed journals, 22 book chapters and 1 book. The AIMS@JCU scholarship students have remained highly productive. As many of the students near the end of their candidature the 2009-2010 period was showed a marked growth in scholarship student publication.



A selection of the 2009-2010 members publications are provided in the following pages with AIMS@JCU postdoctoral fellows and students in bold.

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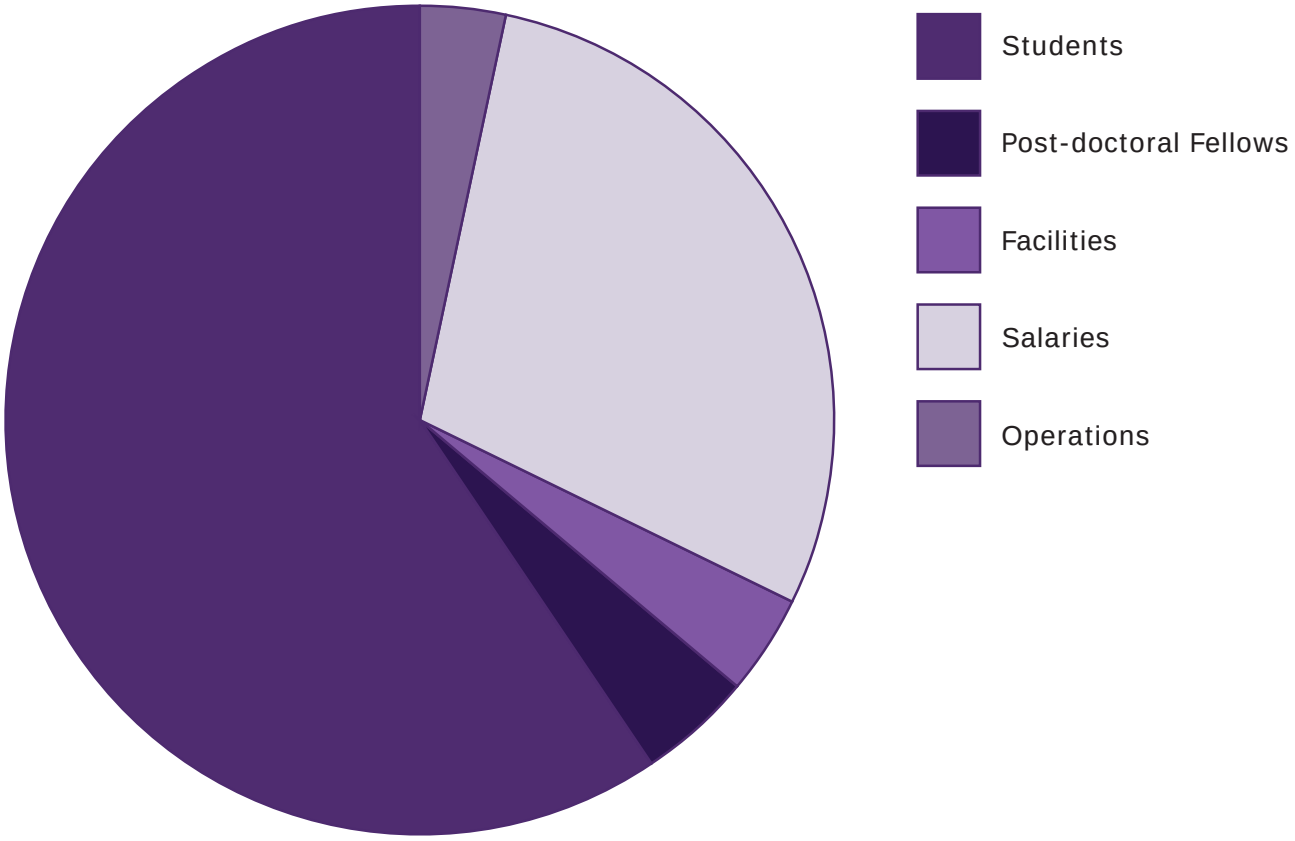
AIMS@JCU Financial Statement

Financial accounting of operating income and expenditure for the years ending 12/31/2009 – 12/31/2010:

		2009 $	2010 $
Opening Balance		930,726	540,797
Income			
	Interest	15,257	15,873
	Other Revenue	0	0
	Total Income	15,257	15,873
Expenditures			
	Salaries	98,130	108,628
	Post-Doctoral Positions	29,854	0
	Program Coordination and Administration	15,238	9,061
	Commuter Vehicle	13,391	13,812
	Scholarships	237,573	168,515
	Other Awards	11,000	13,000
	Total Expenditure	405,186	313,016
Ending Balance		540,797	243,654

One of the primary objectives of AIMS@JCU is to support student research both financially and through facilities and supervision. The average allocation of the AIMS@JCU budget strongly reflects this goal.

Average Budget Allocation 2009-2010:



AIMS Beach Series - Image courtesy of Visual Echo Photography
www.visualecho.com.au

Significant Scientific Outcomes:

- **Discovery of a major new pathogen of aquaculture prawns, and development of a rapid method to detect, accurately identify and quantify pathogens to enable timely and appropriate treatment of outbreaks.**
- **A greater understanding of the potential of settlement ponds for aquaculture wastewater treatment and development of models to more effectively manage nitrogen and produce a by-product – biochar- with potential in soil amendment.**
- **A greater understanding of the digestive enzymes and lipid requirements during embryonic and larval development of commercially important crustaceans, as the basis for development of feeds and feeding strategies in their aquaculture.**
- **Identification of finfish, seaweed and sea urchin species and their dietary preferences towards development of an integrated aquaculture model that increases nutrient utilization and farm productivity while decreasing nutrient loss and environmental impacts.**
- **A greater understanding of the reproductive biology and ecology of a high value aquarium shrimp species to support its future sustainable production through aquaculture rather than wild harvest.**

Image provided by Matt Salmon (AIMS staff member)

Tropical Aquaculture

Staff Members

Dr Chris Battershill AIMS
Ms Elizabeth Evans-Illidge AIMS
Dr Mike Hall AIMS
Mr Matt Kenway AIMS
Dr David McKinnon AIMS
Dr Matthew Salmon AIMS
Dr Greg Smith AIMS
Dr Stephen Whalan AIMS
Mr Finn Bamgartner JCU
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AssocProf Michael Oelgemöller JCU
AssocProf Leigh Owens JCU
Prof Paul Southgate JCU
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Steven Gamble
Jerome Genodepa
Vasiliki Tziouveli
Matthew Wassnig
Heather Welladsen
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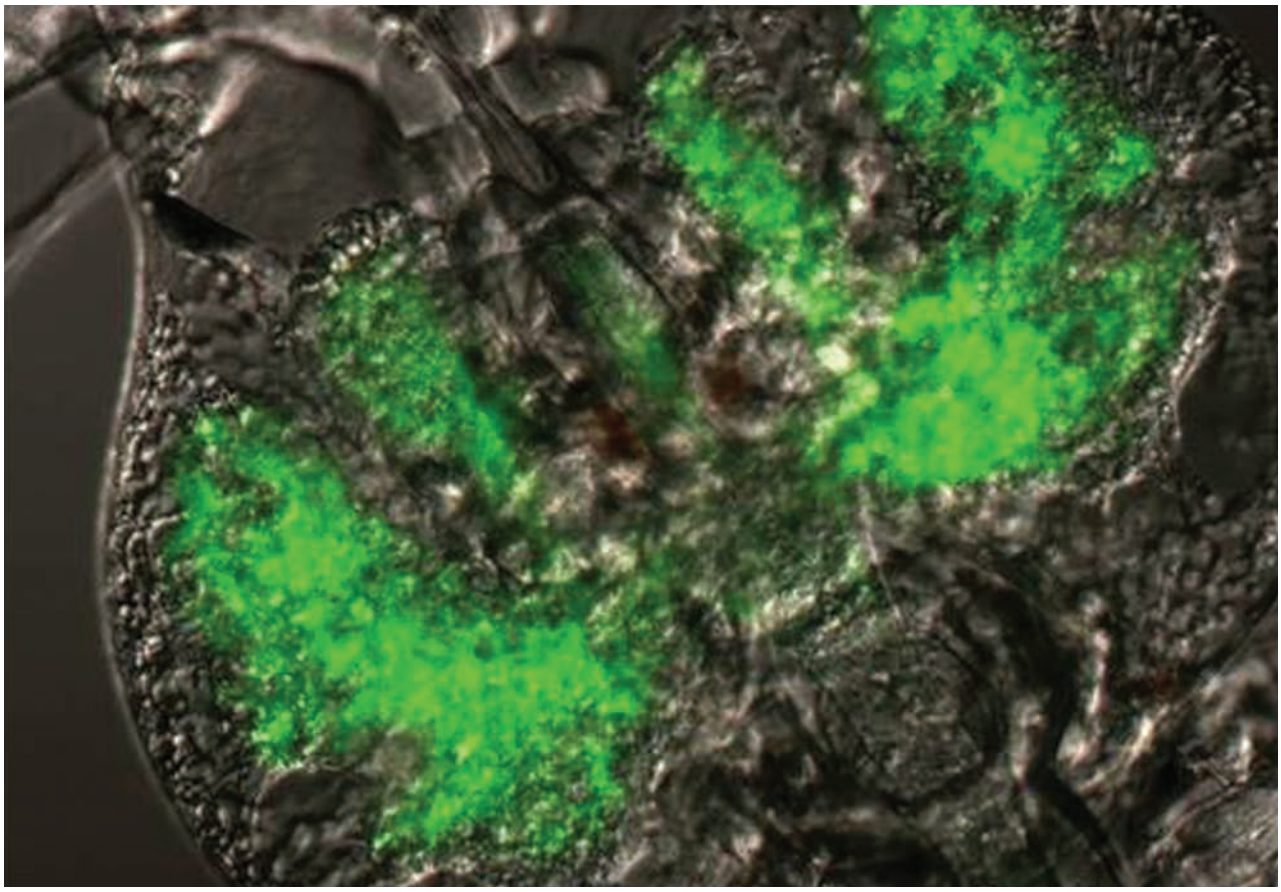

Image provided by Evan Goulden (AIMS and UNE PhD student)

General Program Information

Tropical Aquaculture has been a core research program within AIMS@JCU. It is built on a synergistic partnership between Tropical Aquaculture at AIMS, and across two faculties via the School of Marine Biology & Aquaculture and the School of Veterinary & Biomedical Sciences at James Cook University. The program now has excellent resources: staff and students working on aquaculture projects have direct access to pristine coastal seawater and state-of-the art land and sea-based aquaculture facilities including those provided by AIMS@JCU, as well as biotechnology and veterinary science laboratories, including molecular microbiology.

Image provided by Ana Cano-Gomez (AIMS@JCU student)

Aquaculture is the fastest growing primary industry in Australia for the production of seafood and bio-products. The AIMS@JCU Tropical Aquaculture team has expertise in the established industry sectors (penaeid prawns, pearl oyster, finfish) and in emerging, developing aquaculture sectors (tropical rock lobsters, sponges, crabs, freshwater prawns and marine ornamentals). It also has strong research capabilities in the mitigation of environmental effects of high density culture systems (ponds, fish cage and recirculating systems) and in developing aquaculture for remote communities.

The key research themes within the Tropical Aquaculture Program are:

- Hatchery technology
- Environmental impacts
- Emerging species

Program Highlight:
Tropical Aquaculture

MOLECULAR TRACKING TECHNIQUES FOR *VIBRIO HARVEYI*-RELATED BACTERIA AND DESCRIPTION OF *VIBRIO OWENSII* NOVEL SPECIES.

Within the bacterial genus *Vibrio* the number of species has increased notably, especially for the Harveyi clade. This clade includes nine species with strains described as highly pathogenic to humans and marine animals. Within the Harveyi clade, *V. harveyi* and related species, have been recognized as some of the most significant pathogens to marine reared animal species, causing major economic losses in the aquaculture industry worldwide. Ana Cano-Gomez and her colleagues reviewed the existing techniques used for identification of *V. harveyi*–related species and explored the potential prospects of designing specific molecular techniques to detect these pathogens. The difficulty in the diagnosis of *V. harveyi*-related infections resides in the failure of standard identification techniques, such as phenotypic tests and 16S rRNA analysis, due to the existence of several species in the Harveyi clade sharing nearly indistinguishable phenotypes and genotypes.

Implications of this research and describing a new species, *Vibrio owensii*

Using molecular methods highlighted in their previous review on identification techniques, Ana and her colleagues isolated and identified virulent *Vibrio* strains from diseased cultured larvae of the ornate spiny lobster (*Panulirus ornatus*) at AIMS, and from tiger prawn (*Penaeus monodon*) at a NQ prawn farm. The authors demonstrated that while the two bacterial isolates shared many characteristics with *V. harveyi*, *V. campbellii* and *V. rotiferianus*, the strains could be differentiated from all other vibrios described previously. The new species was named *Vibrio owensii* to honour Professor Leigh Owens as the most recognised specialist in the biology of *V. harveyi*-related species. Thanks to a robust analysis of multiple genes, this team proceeded to develop tools for identification, detection and quantification of *V. harveyi*-related species based on multiplex PCR or real-time PCR technologies.

Images opposite provided by Ana Cano-Gomez (AIMS@JCU student)

Program Highlight:
Tropical Aquaculture

Why is this research important?

Although *V. harveyi* was recognized as the most significant member of the *V. harveyi*-related group, studies have suggested that its common misidentification with other vibrios could have undervalued the importance of *V. campbellii*, *V. rotiferianus* and recently *V. owensii* as pathogens of marine reared and wild species of fish, crustaceans, shellfish, and corals. The contribution of Ana Cano-Gomez and her colleagues to the field of *Vibrio* molecular-based identification is therefore of economic importance for the accurate detection and timely appropriate treatment of bacterial infections in the aquaculture industry in order to prevent the spread of these pathogens. The selection of the most appropriate tool can be adapted to the aim and technical capabilities of users, from farmers to microbiology researchers, by finding a balance between accuracy, reliability and cost. This research has made an important step forward in the development of molecular methods to directly detect and quantify *V. harveyi*-related pathogens.

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V. owensii DY05T colonies isolated from moribund *P. ornatus* larvae on TCBS agar

Luminescent strain oz07 of *V. campbellii* isolated from diseased larvae of *P. ornatus* at AIMS

Dr. Mike Hall

Australian Institute of Marine Science

Mike Hall is a Principal Research Scientist at the Australian Institute of Marine Science (AIMS) in Townsville within the Sustainable Use of Marine Biodiversity Program. He leads a research team in tropical aquaculture on economically important marine organisms with a particular focus on technological developments for new and emerging aquaculture candidates and industry development.

Mike's university years were spent in the USA (Florida Institute of Technology) and the UK where he obtained his BSc and PhD from the University of Wales. He has previously held research positions at the Max-Planck-Institute in Germany and research and teaching appointments at the University of Bristol in England. He joined AIMS in 1992 with his research focussed on wealth creation through the development of aquaculture particularly on domestication of species and more recently on hatchery technologies specifically for tropical rock lobsters for seafood and marine ornamentals for the marine aquarium trade. He has published extensively in the scientific literature, has lead several industry related research projects and has collaborations with research organisations in North America, Europe and Asia.

Specific R&D focus is placed on:

- understanding the relationship between stress and health
- the role of microbes in larval rearing systems
- the development of generic hatchery production systems
- the development of larval feeds for the production of high quality and health larvae

During this reporting period, Paul Southgate stepped down as the JCU Tropical Aquaculture program leader and was replaced by Dr. Chaoshu Zeng.

Prof. Paul Southgate

James Cook University

Paul Southgate's major research interests are culture of tropical molluscs and development of hatchery foods for aquaculture.

His research with molluscs focuses primarily on pearl oysters and he leads the Pearl Oyster Research Group at JCU. He leads a number of international research projects focused on mariculture development to provide income generating and livelihood opportunities in Pacific island countries, east Africa, Mexico and south-east Asia. Paul's research with hatchery foods focuses on development of novel live-foods and micro-particulate diets for bivalve, fish and crab larvae, and the use of micro-particulate diets to investigate nutritional requirements of larval stages.

Dr. Chaoshu Zeng

James Cook University

Chaoshu Zeng is a Senior Lecturer at the School of Marine and Tropical Biology, James Cook University, where he leads the Tropical Crustacean Aquaculture Research Group. Chaoshu's research interests encompass broad areas, including development of aquaculture techniques for commercially important species, particularly crustaceans; nutrition and formulated feed development for broodstock, larvae and juveniles; toxicology of nutrients to commercially important crustaceans; physiology and behaviour of marine larvae and juveniles. His current research focuses are on the development of hatchery/nursery techniques and the investigation of nutritional requirements for the mud crab *Scylla serrata*, the blue swimmer crab *Portunus pelagicus*, the Australian indigenous giant freshwater prawn *Macrobrachium rosenbergii* and a variety of tropical ornamental species. He also works on the development of intensive culture techniques for tropical copepods as prey for marine larvae.

Sarah Castine

Nitrogen transformation and removal from settlement ponds of tropical aquaculture systems

Originally from South Australia, Sarah has now been in Townsville for six years. During this time she has conducted her BSc Hons and a 9 month contract at AIMS investigating the environmental impacts of sea cage aquaculture. She is currently completing her PhD thesis with the goal to submit by the end of the year.

Sarah's passion to see the aquaculture industry develop in an environmentally sustainable manner has lead to her investigating wastewater treatment for land-based aquaculture systems with Drs. David McKinnon, Rocky de Nys, Nicholas Paul and Dirk Erler. Settlement ponds have been adopted by the Australian aquaculture industry, as a means of treating wastewaters. However, there is some debate about the efficacy of such ponds for removing dissolved nutrients. Despite the prevalence of settlement ponds, the processes of nitrogen removal and transformation acting within these ponds are poorly understood.

In the first component of her project Sarah evaluated the performance of settlement ponds using nitrogen isotope tracer techniques. She found that the beneficial bacterial pathways of denitrification and anammox, which remove biologically available nitrogen from wastewaters, are being stifled. This results in waste nitrogen being recycled within the settlement ponds or discharged when wastewater is released to the environment. Subsequent trials were conducted to elucidate the pathways by which nitrogen is recycled within the sediments of settlement ponds and to determine why denitrification and anammox are extremely low. Nitrate limitation and inhibition by hydrogen sulphide were suspected to be limiting denitrification and anammox and the majority of nitrogen was recycled through immobilisation into bacterial and algal cells and assimilation into the sediments. Having established a model for nitrogen transformation, the last component of Sarah's PhD was to investigate ways to enhance nitrogen management during wastewater treatment by stripping suspended solids and converting them to biochar. The biochar was characterised and found to have elevated levels of phosphorus and low levels of heavy metals which makes it ideal for use as a soil amendment.

Ana Cano-Gomez

Molecular diagnosis of *Vibrio* infections in the larval rearing system of the ornate spiny lobster *Panulirus ornatus*

Ana completed a Bachelor of Marine Science and specialised in Molecular Biology in Spain where she had the opportunity to get a traineeship in a Biotechnology company. She came to Townsville to complete a Master of Applied Science in Biotechnology at the School of Veterinary and Biomedical Sciences at JCU. Following this, Ana got an AIMS@JCU scholarship in 2008 to do a PhD in Molecular Microbiology to investigate the diagnosis of *Vibrio* infections in the ornate spiny lobster.

Infection by pathogenic *Vibrio harveyi* bacterial species has been identified as a relevant problem in the crustacean aquaculture industry, causing severe economic losses worldwide and preventing the breeding of new potential aquaculture candidates. The sustainability of this industry and the rearing of potential new species requires fast and reliable techniques for the identification, detection and monitoring of pathogenic vibrios. However, the complex phylogeny *V. harveyi*-related species and the diversity of virulence mechanisms among strains make the identification of strains challenging. This project carried by Ana, Leigh Owens (JCU), Mike Hall and Lone Hoj (AIMS), aimed a refined phylogeny of this complex group of pathogens as a base to design precise diagnostic tools to prevent and manage infections in the rearing system of the ornate spiny lobster *Panulirus ornatus.*

Using molecular methods highlighted in their previous review, Ana and her colleagues delineated and characterized two virulent strains of a new species, *V. owensii,* isolated from diseased *P. ornatus* and *P. monodon* larvae. Following this, a robust phylogenetic study revealed the common misidentification of *V. harveyi* with other closely-related species, also now considered relevant pathogens to reared and wild fish, shellfish, crustacean and corals. Following this, the team proceeded to develop diagnostic tools for detection and identification of *V. harveyi*-related species based on multiplex PCR or real-time PCR platforms. The contribution of this project to the field of *Vibrio* molecular-based identification is therefore of economic importance for the diagnosis of bacterial infections in the aquaculture industry. The techniques would be useful as management tools to avoid high-cost intervention when not essential, and as research tools to study the dynamics of the pathogens and the effect of different treatments for infection control. For *P. ornatus* larvae, the results from several trials suggested that colonisation factors and toxins secreted by *V. owensii* are probably involved in the mass mortalities observed in early-stage larvae. Experimental infection of *P. ornatus* larvae with DY05T indicated that proteinaceous toxins secreted by this strain are lethal to the animals, causing similar mortalities rates to the larvae than live bacteria.

Ana will be submitting her thesis in November 2012. As a PhD graduate with experience in microbiology, biochemistry and bioinformatics, and highly specialized in the design of molecular diagnostic tools, Ana and is looking for positions at universities, research institutions or the biotechnology industry.

Jerome Genodepa

Digestive enzyme dynamics during early life stages of the mud crab, *Scylla serrata* and the spiny lobster, *Panulirus ornatus*

Jerome's interest is on mud crabs and he has been involved in mud crab research and aquaculture production in the Philippines for many years. He is experienced in both hatchery and grow-out culture but his research is focused on problems affecting mud crab hatchery production. He worked on the development of formulated diet for mud crab larvae for his Master of Science thesis at James Cook University from 2000 to 2003, after which he went back to the Philippines. Jerome returned to JCU to pursue his PhD in July 2007 under the AIMS@JCU Scholarship.

His PhD research focused on digestive enzyme dynamics during larval development of the mud crab (*S. serrata*) and the spiny lobster (*P. ornatus*) under the supervision of Dr. Chaoshu Zeng, Prof. Paul Southgate and Dr. Michael Hall. His choice of larval digestive enzymes as topic was an off shoot of his previous research which showed that all stages of mud crab larvae were able to ingest formulated diet but only the later stages were able to survive and grow on such diets. A reason for this is that larvae in general are known to have limited capacity for mechanical digestion of food and have to rely primarily on chemical digestion with the aid of enzymes. Larval digestive capacity can therefore be better understood by looking at digestive enzymes.

Jerome examined the enzyme activities during embryonic development and during intermittent food availability in first feeding larvae of mud crab and spiny lobster. He also looked at the influence of prey density and food type on digestive enzyme activities, the changes in enzymes activities during the moult cycle and the developmental changes in digestive enzyme activities during larval ontogeny. The outcomes of his research can be used as basis in the development of feeds and feeding strategies for mud crab and lobster larvae. Jerome has successfully delivered his pre-completion seminar and he is back in the Philippines. He is currently writing his thesis and plans to submit by March 2012.

Scott Seymour

Utilising biodiversity of the tropical Australian macroalgae for integrated aquaculture

Scott grew up in Werribee, Victoria and has completed a Bachelor of Applied Science (Human Movement) from University of Ballarat, and a Graduate Diploma of Education (Secondary) from the Australian Catholic University in 2001. He taught for one year in Hoppers Crossing (Victoria) then one year on Rarotonga, Cook Islands. From there Scott came to Townsville to study aquaculture at James Cook University in 2004. He completed his Bachelor of Science (Aquaculture) with Honours in 2007 and began his PhD in 2008.

In Australia, much of the aquaculture industry focuses on the monoculture farming practices. Within this style of farming, high nutrient loads in effluent water can lead to lost farming efficiency and changes in the surrounding environment. Some countries, particularly in Europe, are developing integrated aquaculture practices which incorporate macroalgae culture with finfish culture to increase nutrient utilisation, decreasing environmental impacts whilst increasing farm productivity. Scott's research over the next three years aims to identify candidate seaweed species from tropical Australian waters (particularly around the Townsville region) for integration with prawn and finfish farming in Australia. His research will also work beyond the prawn/finfish – seaweed system, aiming to develop a prawn/finfish – seaweed – sea urchin (*Tripneustes gratilla*) integrated system. This work is an extension of Scott's honours research (conducted in 2007) which focussed on the potential of Caulerpa seaweeds for nutrient removal from aquaculture effluent. His interest in developing sustainable aquaculture systems is led by a desire to improve the industries environmental sustainability whilst increasing the efficiency and productivity of aquaculture ventures. Farms utilising integrated aquaculture systems have the potential of increasing productivity and profitability through diversification.

Research so far has demonstrated that the urchin, *T. gratilla*, has proven to be a generalist herbivore has distinct preferences amongst tropical macroalgae flora. Determining preference is an important step in developing a palatable diet, however results have proven that preference does not directly indicate the performance of the diet in achieving urchin growth or gonad development. Scott's research has identified some algae species which do promote growth and gonad development in conjunction with a suite of algae species which may provide a role as a feeding stimulant in processed diets.

Scott is currently employed full-time by James Cook University as a research worker within the MBD Energy biofuels project. He expects to submit his thesis at the end of January 2012.

Vasiliki Tziouveli

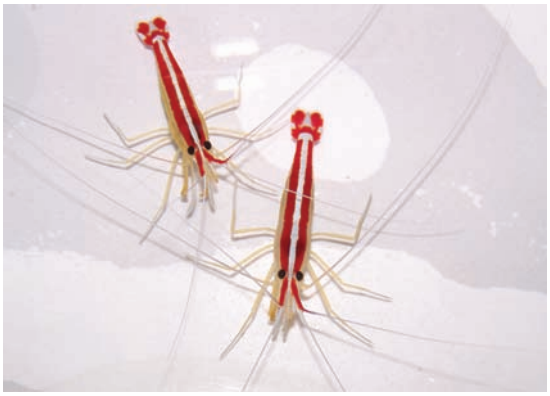
Steps to establish a highly reproductive population of *Lysmata amboinensis* shrimp in captivity and to improve larviculture through examination of larval feeding organs and provision of suitable broodstock and larval diets

Kiki grew up in Greece, studied Marine Biology at the University of Liverpool, UK and completed an Honours project on cephalopod behaviour at the Port Erin Marine Biological Station, Isle of Man. She then moved to Townsville to complete a PhD at James Cook University, North Queensland, funded by AIMS@JCU and also supported by Cairns Marine Aquarium Fish, the biggest suppliers of sustainably collected aquatic species. For her PhD project, Kiki chose to study the marine ornamental shrimp *Lysmata amboinensis*.

The market for live aquarium species supports a multi-million dollar industry. *Lysmata amboinensis*, also known as the white-striped cleaner shrimp, is one of the four high-valued marine ornamental shrimp, worth approximately AU$65-85 per individual. The popularity of *L. amboinensis* however, is causing concerns amongst scientists, due to reliance on wild collection and the potential to negatively affect the health of the already sensitive reef systems by removal of a key species. Despite sustainability concerns and apparent economic importance of *L. amboinensis*, there is surprisingly little information on captive breeding of the species and efforts to culture *L. amboinensis* have been largely unsuccessful. The main problem appears to be larval rearing, due to poor larval survival and prolonged larval phase of up to 150 days. Manipulating the broodstock diet to improve egg and resulting offspring quality, and the larval diet to provide key nutrients to the larvae for higher survival rate and shorter developmental time, has been the focus of this PhD study, in an effort to progress hatchery production of the species. Establishing captive breeding pairs of *L. amboinensis* has also been addressed during this study, due to the rare among decapods reproductive system of the genus, namely protandrous simultaneous hermaphroditism.

In summary, more detailed knowledge on the reproductive biology/ecology of *L. amboinensis* and information on appropriate nutrition for broodstock and larvae are vital to the development of a captive breeding program for the species and form the main focus of Kiki's PhD project.

At present, Vasiliki is finalising her thesis after receiving the reports from the external examiners and preparing MS for publication, while working at an Aquarium in Japan as a Marine Biologist/Researcher.



Xugan Wu

Lipid nutrition of early life history of the blue swimmer crab *Portunus pelagicus* and the ornate rock lobster *Panulirus ornatus*, with emphasis on highly unsaturated fatty acids

Xugan grew up in China and completed his Master of Science in aquaculture nutrition at Shanghai Ocean University in 2004. After his Masters, Xugan became a lecturer at Shanghai Ocean University. He taught two courses for bachelor students and performed some research on crab lipid nutrition. In 2008, Xugan came to Australia and started his PhD at JCU with an AIMS@JCU scholarship. His research focused on lipid nutrition of early life history of the blue swimmer crab *Portunus pelagicus* and the ornate rock lobster *Panulirus ornatus*. Xugan was looking for the optimal fatty acids nutrition for the two commercially tropical crustacean species, particularly for the highly unsaturated fatty acids (HUFA), i.e. 20:5n3, 22:6n3 and 20:4n6.

There were 12 proposed experiments in Xugan's project. The first six experiments were conducted to investigate the ontogenetic changes of lipid composition during the embryonic development, larval development and the starvation of newly hatched larvae for both species. This provided an important baseline for the HUFA manipulation experiments. The results showed the optimal HUFA nutrition of both species were very different, e.g. the lobster phyollosoma had higher DHA/EPA ratio requirement, but lower ARA and HUFA requirements than crab larvae. Those differences suggested lipid requirement is species-specific for the tropical crustacean larvae. Tho findings will help our understanding of lipid nutrition for tropic crustacean, particularly those commercially important species. Some of results will assist us to select larval food and improve their hatchery technology.

Xugan has finished all experiments for his PhD study and he completed his pre-completion seminar in August 2011 at JCU. Xugan has travelled back to China to finish writing his thesis.

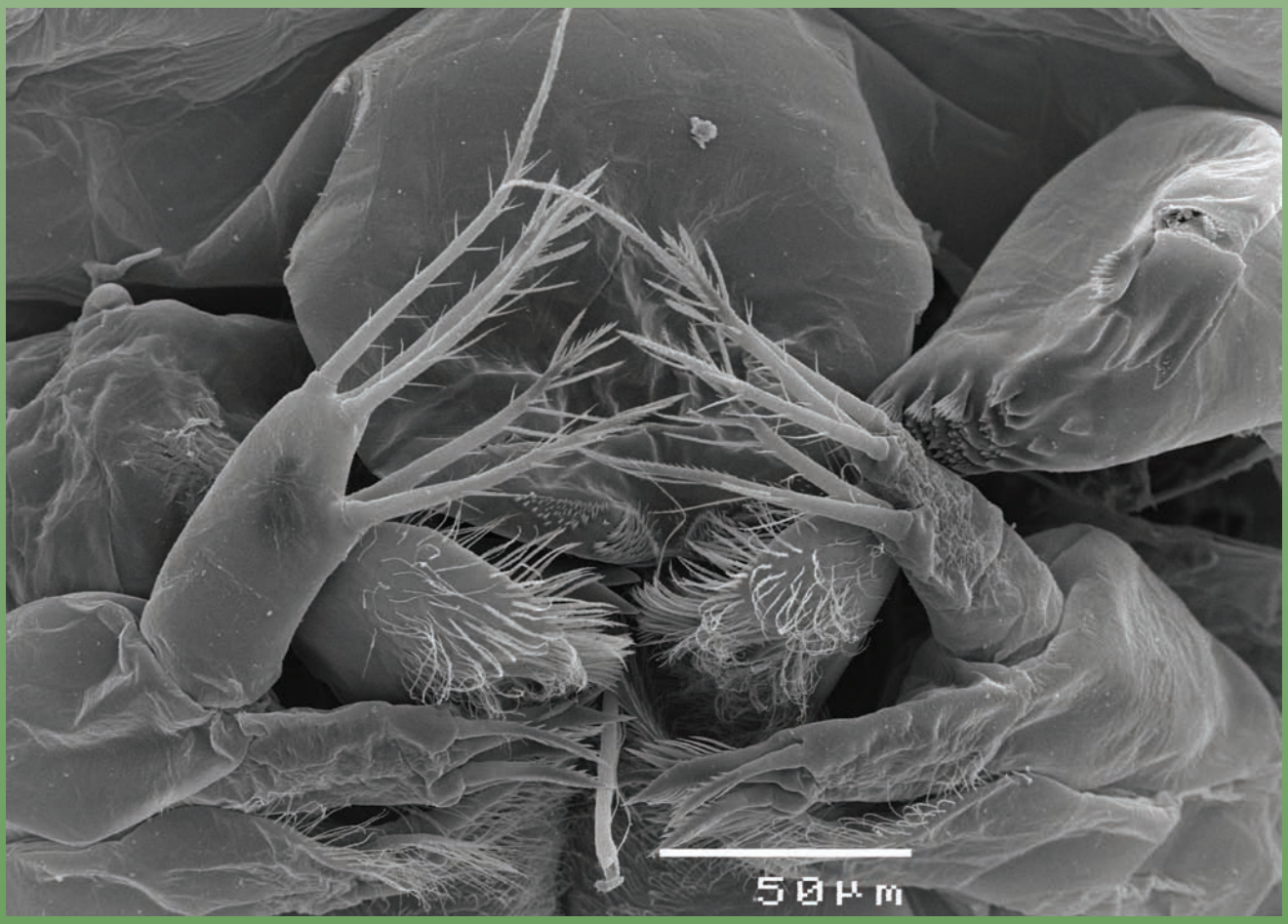
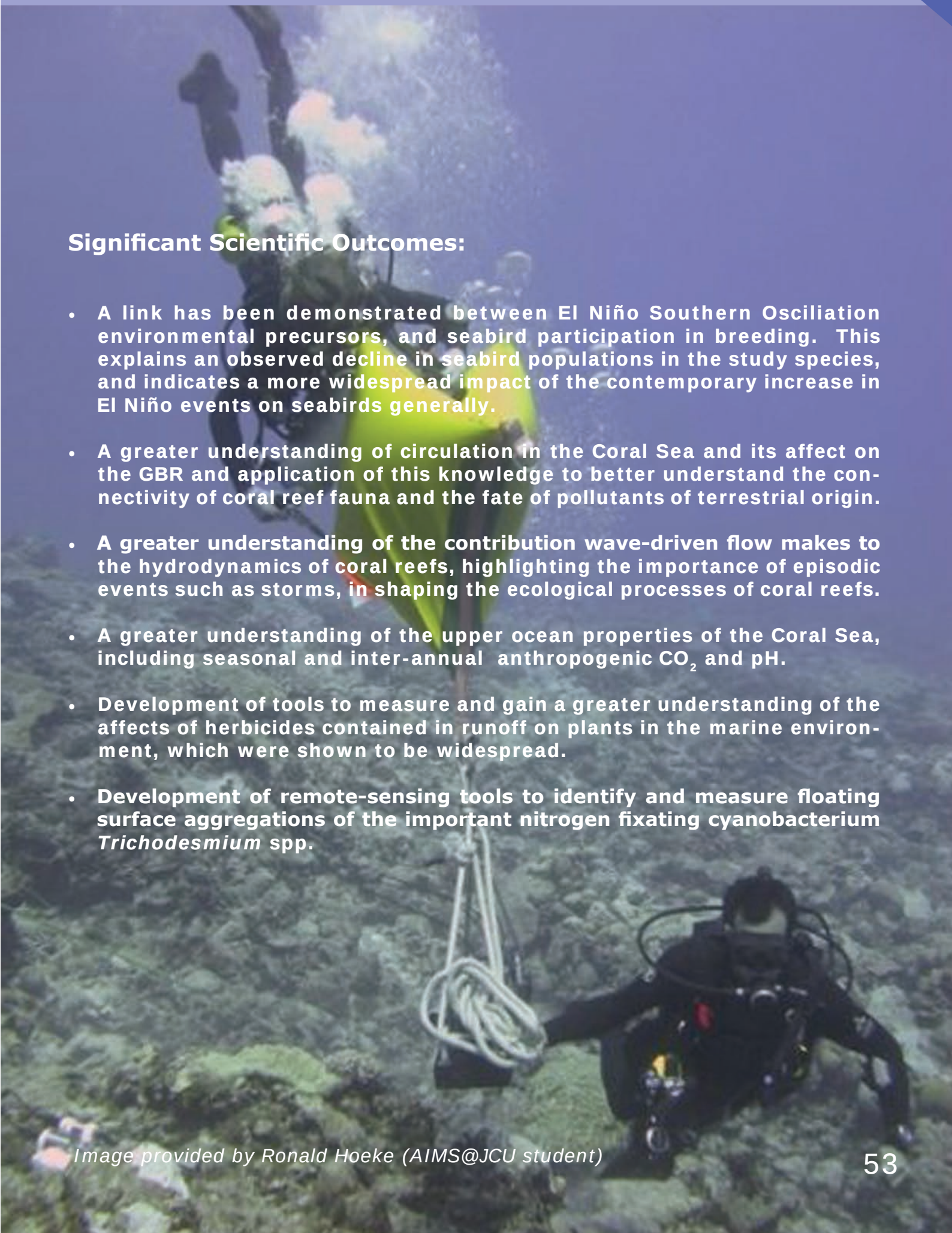


Image provided by Vasiliki Tziouveli (AIMS@JCU student)



Significant Scientific Outcomes:

- **A link has been demonstrated between El Niño Southern Osciliation environmental precursors, and seabird participation in breeding. This explains an observed decline in seabird populations in the study species, and indicates a more widespread impact of the contemporary increase in El Niño events on seabirds generally.**
- **A greater understanding of circulation in the Coral Sea and its affect on the GBR and application of this knowledge to better understand the connectivity of coral reef fauna and the fate of pollutants of terrestrial origin.**
- **A greater understanding of the contribution wave-driven flow makes to the hydrodynamics of coral reefs, highlighting the importance of episodic events such as storms, in shaping the ecological processes of coral reefs.**
- **A greater understanding of the upper ocean properties of the Coral Sea, including seasonal and inter-annual anthropogenic CO_2 and pH.**
- **Development of tools to measure and gain a greater understanding of the affects of herbicides contained in runoff on plants in the marine environment, which were shown to be widespread.**
- **Development of remote-sensing tools to identify and measure floating surface aggregations of the important nitrogen fixating cyanobacterium *Trichodesmium* spp.**

Image provided by Ronald Hoeke (AIMS@JCU student)

Coastal Processes and Modelling

Staff Members

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Severine Choukroun
Carol Devney
Ronald Hoeke
Jasmine Jaffrés
Deane Ludman
Marie Magnusson
Lachlan McKinna
Adam Ruxton
Scott Seymour
Conni Sidabalok
Maren Ziegler

Image provided by Sarah Castine (AIMS@JCU student)

General Program Information

The Coastal Processes and Modelling research program within AIMS@JCU brings together the two organisations' staff and complementary capabilities to focus on coastal processes of special interest in tropical environments.

Improving our understanding of biological, physical and chemical processes in the coastal zone is essential to the effective management of this culturally and economically important region.

The major themes within the program are:

- Hydrodynamic modelling and hydrological processes, including sediment dynamics;
- Water quality, catchment coastal interactions, and near-shore processes;
- Biogeosciences and environmental change;
- Biological and chemical oceanogrphy;
- New observing technologies.

Image provided by Sarah Castine (AIMS@JCU student)

Program Highlight:
Coastal Processes and Modelling

SEABIRDS ON THE GBR DETECT EL NIÑO EVENTS BEFORE THEY ARE OFFICIALLY REGISTERED

El Niño events have long been known to threaten species' reproduction, recruitment and survival. However, effects of the El Niño Southern Oscillation (ENSO) vary temporally and spatially across the Pacific Ocean. Seabirds are traditionally recognised as being impacted by El Niño events through seasonal-scale crashes in prey availability. However, Carol Devney and Brad Congdon's research on long-term population dynamics of tropical seabirds on the GBR has demonstrated links between seabird breeding participation and thermocline depth and surface chlorophyll that occur well in advance of El Niño-generated sea-surface temperature (SST) anomalies. Changes in thermocline depth are a precursor to changes in the ENSO in the western tropical Pacific and are also known to effect fish-eating seabirds.

To investigate the influence of thermocline depth on reproductive success in the western tropical Pacific, Carol Devney, Mike Short and Brad Congdon used 18 years of data on population dynamics of three tropical seabirds and environmental descriptors for ENSO precursors and associated environmental variation. They found that for the Sooty Tern and Common Noddy populations decreased as the average thermocline depth deepened. Additionally, for these two species, the surface chlorophyll concentration was significantly positively related to breeding participation.

Images provided by Carol Devney (AIMS@JCU student)

Program Highlight:
Coastal Processes and Modelling

Why does change in thermocline depth affect these pelagic seabird species?

The mechanisms by which thermocline depth changes may influence prey accessibility to foraging seabirds are unknown. The two most likely possibilities are changes in the distribution of subsurface predators and changes in the distribution of prey. Most tropical seabirds rely on subsurface predators such as tuna or marine mammals to drive prey to the surface. Early stage El Niños drive thermocline shoaling in the central and western tropical Pacific, causing tuna foraging resources to decline as the area of highest productivity moves into the central Pacific, redistributing subsurface predators. Variation in thermocline dynamics may also influence the concentration of forage fish, by, for example, inducing aggregation or dissociation of vertically migrating prey. The redistribution of both predators and prey are likely to impact pelagic seabird populations.

Why is this research important?

The relationship between advanced El Niño sensitivity and seabird dynamics has been documented previously in two other studies, though no mechanisms were demonstrated. This study demonstrates a link between seabird behaviour and El Niño characteristics that develop up to a year later. These findings add to increasing evidence that El Niño conditions not only interfere with major seasonal-scale processes, but also add additional fine-scale within-season trophic stresses. Also, the significant population fluctuations in tropical seabirds at Michaelmas Cay, northern GBR, may be directly linked to contemporary increases in the frequency and intensity of El Niño events, suggesting that similar impacts may be occurring in declining populations declines seabirds throughout the GBR. This improved understanding of the impact of global climate shifts, will inform better management of the GBR area.

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Assoc. Prof. Scott Smithers

James Cook University

Scott Smithers is a coastal geomorphologist in the School of Environmental and Earth Sciences at James Cook University. Scott has particular research interests in the geomorphology of coral reefs and reef islands. At present Scott is working on projects in the Indian Ocean, the Pacific - including the Great Barrier Reef, and in the Caribbean. These projects focus on reefs in both mid-ocean and shelf settings.

Scott's current research focuses on: reef island formation, sediment budgets and morphodynamics; sediment dynamics and the Holocene growth of inshore turbid-zone reefs; interannual and Holocene sea-level change records from coral microatolls; records of environmental conditions and change from coral skeletons. Improving the understanding of the relationships and feedbacks between coral reef geomorphology and reef ecology is a central theme in most of Scott and his student's research.

Scott's research looks at different scales, investigating how reefs intrinsically change through time as they grow under natural and anthropogenically affected environmental conditions and what this means for reef habitats and biodiversity from one end of the spectrum, and questions seeking to better understand how associated shifts in reef biota, abundance and productivity impact on reef geomorphology define the other.

Recent publications in journals such as Global Change Biology and in the journal Geology are indicative of the interdisciplinary nature of this research.

Richard Brinkman

Australian Institute of Marine Science

Richard Brinkman is a physical oceanographer/numerical modeller with research interests that fall within the broad topics of coastal oceanography and physical-biological interactions on continental shelves. Richard has significant expertise in conducting observational and modelling based research on shelf dynamics, coupling of shelf and ocean circulation, and physical-biological interactions at regional and local scales on both east and west coasts of Australia.

A particular focus has been on understanding mesoscale circulation characteristics on Australia's tropical continental shelves. This has involved a long-term observational study of the Leeuwin current system at Ningaloo Reef, and the low frequency circulation pathways on the Great Barrier Reef. Richard works primarily in multi-disciplinary teams where understanding physical processes at various time and space scales provides critical context for understanding biological and ecological systems. He maintains strong research collaborations with other researchers (e.g. JCU, UWA, CSIRO) and has a commitment to post graduate training through the supervision of PhD students at JCU and UWA.

Severine Choukroun

Sea surface circulation in the GBR and adjacent Coral Sea

Severine is originally from France and first came to Australia to undertake internships at the CSIRO in Melbourne (in 2002) and at AIMS in 2003 as part of her master degree in Physical oceanography and ocean engineering. She then worked as a Research Assistant in physical oceanography for AIMS and NOAA in Hawaii before starting her PhD at JCU in 2005.

This project investigates the surface circulation patterns and eddy variability of the Coral Sea and the Great Barrier Reef (GBR). Analytical techniques on data derived from satellite tracked surface drifters, current meters moorings deployed in the GBR and satellite imagery were utilised to obtain a representative of the Coral Sea circulation and its affect on the GBR. Coral Sea inflow and the circulation in the GBR are key parameters to understand the connectivity of coral reef fauna. Knowledge of connectivity patterns is important to enable the formulation of realistic management strategies to ensure successful conservation of reef biodiversity. Another aspect of the research has focused on resolving the flushing time of waters in the GBR which has important implications for research into the influence of pollutants from terrestrial origin. These results, including diffusion and kinetic energy quantification, are also invaluable for hydrodynamic model calibrations and validations, providing for the first time, an evaluation of the parameters from in situ measurements.

Severine is now working as a PostDoc for the ARC Centre of Excellence and the School of Engineering and physical Sciences under the supervision of Prof Geoffrey Jones and Peter Ridd. This project focuses on understanding the regional circulation of Kimbe Bay and its influence on fish larval transport.

Carol Devney

Climate variation and population dynamics in tropical terns

Carol has a BSc. in Environmental Chemistry from the Colorado School of Mines in the USA. In 2004, she completed a Grad. Dipl. of Research Methods at JCU and enrolled in an MSc. in 2005. An AIMS@JCU Scholarship allowed her to upgrade her research project to a PhD.

Carol's PhD research focuses on the total impacts of climate variation on tropical seabird populations across the GBR and the potential capacity of these species to resist predicted climate change-associated reductions in prey availability. She is supervised by Dr. Brad Congdon of the School of Marine & Tropical Biology- Cairns, JCU, and by Dr. Julian Caley of the Australian Institute of Marine Science.

Highlights from this research have included a novel discovery that breeding for Sooty terns *Onychoprion fuscata* and Common noddies *Anous stolidus* was poor the year prior to an El Niño event, rather than during the events as expected. This phenomenon could be explained by changes in chlorophyll concentrations and thermocline depth in the western tropical Pacific that long preceded registered shifts in the El Niño Southern Oscillation. However, not all species examined were impacted by the ENSO, or other climate variables, in the same way. This appears to be a result of differences in the way species forage and raise their young. Other findings have included sighting at least one seabird living on the GBR, the Black noddy *A. minutus*, will be unlikely to rapidly respond to predicted future changes in sea-surface temperature by changing its foraging behaviour or chick growth characteristics, and instead will require adaptive changes over many generations.

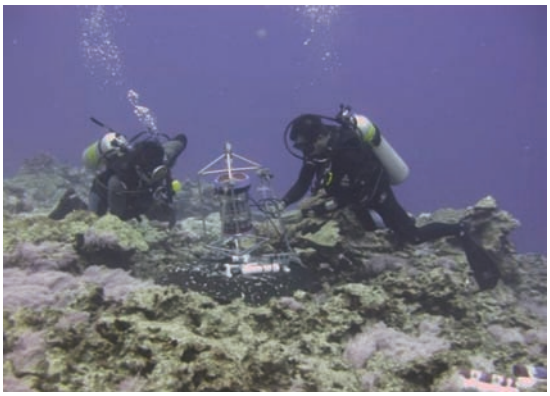
Carol's thesis was submitted for international review in April 2011 and she is still waiting to hear the results of this assessment. She is currently undertaking a number of projects and collaborations which have stemmed from her PhD research but her time is mostly consumed with home duties as she is pregnant with her 3rd child and is mum to Lewis (1.5 yrs) and Jolene (3.5 yrs). She hopes to achieve a position as an environmental advisor when her home commitments lessen.

Ronald Hoeke

An investigation of wave-dominated coral reef hydrodynamics

Prior to commencing PhD research at JCU, Ron completed Bachelor and Master of Science degrees from the Florida Institute of Technology and subsequently worked as an oceanographic survey technician for NOAA's Coral Reef Conservation Program in Hawaii. After completing his PhD research, he accepted a position with the CSIRO Sea Level and Coasts group.

The project's focus was the physics and numerical modeling of the contribution of wave driven flow to the hydrodynamics of coral reefs. The research was jointly supported by AIMS@JCU, the US National Oceanographic and Atmospheric Administration (NOAA) via a grant to the University of Hawaii, and the US Geological Survey (USGS). Supervisors included: Prof. Peter Ridd (JCU); Dr. Richard Brinkman (AIMS); Dr. Curt Storlazzi (USGS); Prof. Mark Merrifield (University of Hawaii).



In a strictly practical sense, research findings include import steps necessary in applying numerical solutions of Navier-Stokes equations and to the steep and rugous bathymetry of coral reefs. More broadly, the findings also highlight the importance of episodic events (e.g. storms), which have an important roll in shaping the ecological and geological processes of coral reefs. Physical reasons were developed why subtle changes in the frequency and severity of these episodic events may lead to very large changes in these ecological and geological processes, a prerequisite to understanding how coral reefs and associated coastal environs may by impacted by climate variability and change.

Ron Hoeke completed his PhD research in 2010. It was a difficult choice, but Ron decided to leave his position of many years with NOAA in Hawaii and make the move to Melbourne to join the CSIRO Aspendale facility last October. His work since has been centred on assisting Pacific Island nations to understand and predict inundation (flooding from the sea) and other impacts associated with storms, a topic of high concern in the Pacific region, particularly in the face of projected sea-level rise. Future plans include research into how climate change projections, including ocean acidification, will affect patterns of erosion and accretion of Pacific Islands, as well as coral reefs continued viability as natural breakwaters.

Jasmine Jaffres

The oceanographic and geochemical effects of mixed layer depth variability and increasing anthropogenic CO_2 on the inorganic carbon system of the Coral Sea

Jasmine is originally from Switzerland and moved to Australia in 2002. She completed her BSc(Hons) in Marine Science and paleoclimatology with first class in 2005.

Her PhD thesis has been accepted in 2011. In the thesis, the upper ocean properties of the Coral Sea are investigated, including the seasonal and interannual characteristics of the mixed layer depth, CO_2 and pH.

Jasmine is now part of the Marine Geophysical Laboratory group and is currently researching wave properties in coastal regions of Australia under the supervision of Prof. Mal Heron.

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Marie Magnusson

Effects of priority herbicides and their breakdown products on estuarine microphytobenthic communities in the Great Barrier Reef Lagoon

After completing her MSc in marine ecotoxicology in Sweden, Marie spent six months at JCU volunteering for Assoc. Prof. Kirsten Heimann and Dr. Raphael Wűst in a research project focussing on using fossil diatom assemblages as predictors of paleoclimate. This collaboration made Marie interested in working with microalgae and in 2005 she was fortunate enough to be able to combine this with her interest in ecotoxicology when she started the research for her PhD under the supervision of Assoc. Prof. Kirsten Heimann (JCU), Dr. Andrew Negri (AIMS) and Assoc. Prof. Michael Ridd (JCU).

Benthic microalgae form an integral part of shallow-water systems around the world and are major contributors to primary productivity and biomass in estuarine environments. They are also central in sediment chemistry, nutrient fluxes and benthic/pelagic coupling, and detrimental effects on benthic microalgal communities therefore hold the potential to carry severe consequences to ecosystem levels.

Herbicides have repeatedly been detected in the water and sediments along the Queensland coast in Australia. The effects of photosystem II (PSII) inhibiting herbicides on local microphytobenthos at increasing levels of biological organisation and complexity was therefore researched. Some important results are: Inhibition of photosynthetic yield (Y(II), a measure of the efficiency of photosynthesis) measured with PAM-fluorometry has been validated as a suitable toxicological endpoint, clearly related to algal growth; Local, tropical species of microalgae are more or equally sensitive to herbicides compared to standard ecotoxicology test-species; PSII inhibitors act additively in mixtures; Despite derivation of similar IC50s, neither acute nor standard 72-h growth-inhibition toxicity tests with single species algal cultures can accurately predict the response of an intact, multispecies community under long-term herbicide-exposure stress, due to the possibility of community composition changes and pollution induced community tolerance and possible shifts in energy-acquisition path-ways; high concentrations of herbicides, particularly diuron, were detected in sediments and porewaters from the Tully, Herbert and Johnstone Rivers. Diuron was also detected in the Daintree River; environmental contamination of the highly potent insecticide imidacloprid was also confirmed in the Tully River during this study, along with higher than expected concentrations of the organochlorine dieldrin.

Marie finished her PhD in 2009, and was immediately employed in a Postdoctoral research position in the JCU/ MBD Bio Carbon Capture and Storage (Bio CCS) project lead by Ass. Prof. Kirsten Heimann and Prof. Rocky de Nys. We are working closely with industry to develop large scale cultivation of microalgae to deliver livestock feeds, biodiesel and other bio-oil products. It is a very exciting and promising project, with lots of new challenges for Marie, who is spending a lot of time in the laboratory developing methods, as well as supervising several PhD and MSc students in a dynamic and stimulating environment.

Lachlan McKinna

Optical detection and measurement of nitrogen fixing Cyanobacteria *Trichodesmium* within the Great Barrier Reef

Lachlan is originally from Cooktown, North Queensland and completed his BSc (Hons) with a Mathematics/Physics double major at JCU in 2006. His PhD project examined methods for the detection and quantification of the Nitrogen fixing cyanobacterium *Trichodesmium* spp. within the Great Barrier Reef (GBR) using ocean colour remote sensing. His supervision team comprised Prof Peter Ridd (JCU), Dr Miles Furnas (AIMS) and Dr Yvette Everingham (JCU).

Within his PhD, Lachlan developed an algorithm for detecting floating surface aggregations of *Trichodesmium* using MODIS satellite imagery. In addition, Lachlan successfully explored methods for discriminating and quantifying *Trichodesmium* using ship-borne, above-water hyperspectral radiometry. The optical variability within decaying surface aggregations of *Trichodesmium* was also studied. This research comprised over three months cumulative sea time aboard both the RV Cape Ferguson and RV Lady Basten. Highlights of Lachlan's PhD project include presenting his work to international audiences at two Ocean Optics conferences and the 2010 American Geophysical Union Ocean Sciences Meeting.

Lachlan completed his PhD thesis in October 2010 and is presently a Postdoctoral Fellow at Curtin University, Western Australia. His current research is funded by an Australian Research Council Linkage Grant between Curtin University, the University of Queensland, the Australian Institute of Marine Science, the Ocean Biology Processing Group – NASA, and the University of Massachusetts Boston. This collaborative project aims to develop remote sensing algorithms that operate robustly in shallow waters of the GBR. Although now based in Perth, Lachlan's present research brings him back to the GBR for field work.

Coastal Processes and Modelling

Image provided by Carol Devney (AIMS@JCU student)

Significant Scientific Outcomes:

- **A greater understanding of the environmental stressors that impact coral health, including sedimentation, high particulate carbon and low salinity associated with high rainfall events and exposure to pollutants.**

- **A greater understanding of the genetic and molecular processes and attributes which disrupt the critically important symbiotic partnership between coral and the algae *Symbiodinium*, leading to and following coral bleaching:**
  - **The level of success of the *Symbiodinium*-coral partnership is species specific**
  - **Discovery of measurable genes up- or down- regulated prior to coral bleaching**
  - **Changes in susceptibility to coral disease pathogens**
  - **Regulation of the redox balance, and the role of anti-oxidant capacity of the coral-algal holobiont**
  - **Understanding the chemical ecology that drives and maintains the coral-algal-bacterial associations**
  - **Sub-lethal but measurable molecular perturbations.**

- **A greater understanding of factors that contribute to reef resilience and the capacity for reef recovery after disturbance:**
  - ***Symbiodinium* populations are not well-connected between reefs, but rather highly adapted to local conditions and reliant on within-reef availability to re-recruit after a disturbance**
  - **The practice of forming chimeras (genetically distinct juvenile corals fuse to form one individual) is likely to be widespread and capable of enhancing genetic diversity and therefore resilience.**

- **A greater understanding of other reef organisms (other than corals) and their vulnerability to stress:**
  - **Survival of reef-dwelling fish is dependent on access to healthy live coral (compared to bleached or dead coral)**
  - **Ocean acidification may change the symmetry of larval ear bones of fish, with long-term survival consequence**
  - **There appears to be little redundancy between functional groups of a coral reef**
  - **A reef sponge was shown to harbor a stable microbial community over a wide latitudinal gradient.**

Image provided by Patricia Warner (AIMS@JCU student)

Staff Members

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Dr David Bourne AIMS
Dr Julian Caley AIMS
Dr Neal Cantin AIMS
Dr Walt Dunlap AIMS
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Dr Brad Congdon JCU
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Ingrid Cripps
Vivian Cumbo
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James Moore
Allison Paley
F. Joseph Pollock
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Jessica Stella
Meir Sussman
James Tan CH
Gergely Torda
Alexander Vail
Jeroen van de Water
Patricia Warner

General Program Information

Global warming, fishing, pollution, habitat loss or degradation, competition and social aggression are all examples of different types of stress which are common in marine systems. Although the action of stress is on the individual, stress influences the dynamics of populations through to ecosystems.

Understanding how stress acts is important to predict the response of an individual, population, community or ecosystem to change in its environment. Furthermore, as a variety of stressors can cause similar stress responses, understanding the physiological and molecular basis of stress responses may enable us to identify the particular stressors responsible for degradation of marine organisms in the field and in aquaculture.

This program incorporates: technological development; the biology of stress including ecology, genomics and evolution; and the application of research to practical problems.

The key research themes within the Stress in Tropical Marine Systems Program are:

- Cellular processes involved in stress responses
- Ecological and population responses to stress
- Evolution of stress tolerance

Images provided by Eneour Puill-Stephan (left); Heidi Luter (top, right) and Patricia Warner (bottom, right) (AIMS@JCU students)

Program Highlight:
Stress in Tropical Marine Systems

EFFECTS OF CLIMATE CHANGE ON CORAL DWELLING FISH POPULATIONS

Global climate change has caused extensive and widespread habitat degradation in coral reef ecosystems through impacts such as coral bleaching. Bleaching events have been shown to have negative effects on abundance and diversity of coral-dwelling fish. While the decline in abundance of coral-dwelling fish after bleaching events has been documented, it is not known if this is due to movement to non-bleached coral or due to increased in situ mortality. To examine the impacts of coral bleaching on coral-dwelling fish, Darren Coker and his colleagues, Morgan Pratchett and Philip Munday, performed aquarium experiments to directly test whether the condition of coral habitat influences predation of damselfish.

How does coral bleaching impact predator-prey interactions for coral-dwelling fish?

Coral bleaching may have different effects on predation rates. Firstly, predation rates on coral-dwelling fishes may decline if predators avoid bleached corals. Secondly, coral dwelling damselfishes associated with bleached and recently dead coral hosts may be more visually conspicuous compared to healthy, or algal-covered colonies, and thus more susceptible to predation. Moreover, coral-dwelling fishes may become increasingly susceptible to predation after host coral bleaching if they exhibit weaker associations with degraded coral hosts. These effects on predation rates were examined with aquarium experiments to test the effects of bleaching on predator and prey habitat associations as well as directly testing whether the condition of coral habitat influences predation of coral-dwelling fish.

Images provided by Darren Coker (AIMS@JCU student)

Program Highlight:
Stress in Tropical Marine Systems

The aquarium based experiments in this study demonstrated that while the predator, *Pseudochromis fuscus*, prefers to associate with live coral or algal-covered habitat, it was found to strike at prey associated with bleached and recently dead corals more than fish associated with healthy coral habitats. This is likely due to the increased visual prominence of prey against bleached and dead corals. Direct measurement of mortality rates in prey species, *Pomacentrus moluccensis* and *Dascyllus aruanus*, demonstrated a pattern of increasing mortality with increasing degradation of coral hosts (healthy<bleached<recently dead<algal covered).

Why is this research important?

This study has created an improved understanding of the impact on predation of coral dwelling fish, caused by coral bleaching – an event predicted to occur more frequently due to global climate change. It showed that the extensive coral reef habitat degradation and loss that results from these events, may also cause a decreased abundance of coral-dwelling fish through a higher vulnerability to predation. This improved knowledge about the impact on prey populations and consequent flow-on effects in trophodynamics of coral reef ecosystems, will inform future interventions by reef managers.

References:

Coker, D.J., Pratchett, M.S. and P.L. Munday. 2009. Coral bleaching and habitat degradation increase susceptibility to predation for coral-dwelling fishes. Behavioural Ecology 20: 1204-1210.

Image provided by Darren Coker (AIMS@JCU student)

Prof. Bette Willis

James Cook University

Bette Willis is a Professor in the School of Marine and Tropical Biology at JCU, where she has led an active research group addressing questions relating to the impacts of stress on the biology and ecology of scleractinian corals for the past 20 years. Currently, she is a Chief Investigator in the ARC Centre of Excellence for Coral Reef Studies and co-chairs the GEF/World Bank Working Group on Coral Disease in the Coral Reef Targeted Research program. Her early research was directed towards understanding the evolutionary implications of mass spawning and hybridization in corals. Most recently, a major research focus has been to determine the ecological significance of coral disease on the Great Barrier Reef and potential environmental drivers. A second focus has been to evaluate the potential for algal endosymbioses to enhance the capacity of corals to cope with climate change. Overall, her research strives to understand factors that underpin the health of reef corals and the replenishment of reefs, from mechanisms of innate immunity to those enabling acclimatization or adaptation to thermal stress.

Dr. Madeleine Van Oppen

Australian Institute of Marine Science

Madeleine van Oppen was trained in marine ecology in the Netherlands. After having studied zooplankton communities and herbivorous coral reef fish (MSc), she began to apply genetic tools to study the ecology and evolution of cold-water seaweeds (PhD 1995, Netherlands), and African cichlid fishes (postdoc, UK). In 1997, she started her research on reef corals at JCU. She moved to AIMS in 2001, where she leads a program on the genetics/genomics of adaptation/acclimatisation and resilience of corals to climate change. Recently, she has expanded this research program to include the development of genetic tools for certain coral reef management strategies and an assessment of the impacts and likely success of these management strategies (e.g., introduction of beneficial alleles into certain populations through managed translocation of corals). She has been awarded a prestigious 4-year Australian Research Council Future Fellowship to study coral-associated viruses, which she started on May 3rd 2011.

The research will look at:

- acclimatisation and adaptation of corals to increased sea water temperatures (e.g., the role of zooxanthellae in coral physiology, heritable genetic variation for heat tolerance, the molecular basis of the coral bleaching response, identification of genes for thermal tolerance),
- genetic connectivity of coral reefs, and
- the role of viruses in the health, stress tolerance and evolution of reef corals

Darren Coker

The role of live coral in moderating key ecological processes for coral reef fishes

Originally from New Zealand, Darren's interest for marine life started when he snorkelled across reefs and wrecks in the Solomon Islands at the age of six. Following the completion of high school he moved to Australia and completed his undergraduate and postgraduate studies in Marine Biology at James Cook University.

Darren is now completing his PhD under the supervision of Dr Morgan Pratchett, Dr Philip Munday, Dr Aaron McNeil and Dr Nicholas Graham in combination with the ARC Centre of Excellence and Australian Institute of Marine Studies in Townsville. His PhD titled 'The role of live coral in moderating key ecological processes for coral reef fishes' investigates the importance of live coral for coral reef fishes, with a view to predicting the likely extent of fishes that may be affected by sustained and ongoing loss of corals due to global climate change. This includes investigating the influence of habitat loss through impacts to live coral and the role of competition, predation and recruitment in affecting changes in the communities of coral-dwelling fishes.

Some research highlights to date have been that small reef fish using live coral for shelter are visually more vulnerable to predators when colonies bleach. Fish are exposed to higher levels of predation and have lower survivorship rates when associated with colonies that have bleached or died. However, these site attached fish will not vacate bleached colonies, possibly in anticipation of recovery, but will readily vacate a colony that dies and attempt to relocate to alternative healthy colonies. Movement, if successful, will allow them to take up residence on healthy colonies but will expose them to increased predation and intraspecific competition as they move from the safety of their coral and compete for new habitat. Through the use of patch reefs Darren has been able to show that reefs subjected to biological and physical disturbances have a significant impact on fish recruitment. While abundance and species richness was similar between reefs with different levels of live coral cover and structural complexity, associated fish communities were significantly different with marked differences in associated species. Many species of fishes depend on live coral at settlement even if they are not obligately dependent on live coral as an adult.

Darren is on track to finish his PhD in February 2012.

Vivian Cumbo

The establishment and development of symbiosis in coral larvae

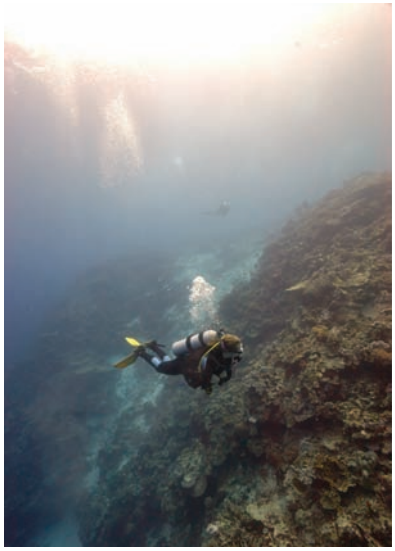
Vivian grew up in Sydney, Australia and completed her BSc Hons in Microbiology and Marine Biology at the University of NSW. Her honours thesis investigated the antimicrobial compounds in the scleractinian corals *Montipora digitata* and *Montipora tortuosa*. Having always been interested in corals and coral reef ecosystems, Vivian commenced her PhD research on corals and climate change in 2006 under the supervision of Dr Andrew Baird, Dr Madeleine van Oppen and Professor Terry Hughes.

Coral reefs thrive because of the symbiotic partnership between corals and *Symbiodinium*. While this partnership is one of the keys to the success of coral reef ecosystems, surprisingly little is known about coral symbiosis, in particular, the establishment and development of symbiosis in host species that acquire symbionts anew in each generation. Vivian's research used larvae of the genus *Acropora* to explore initial patterns of association between the host and *Symbiodinium* spp., and how environmental conditions affect the establishment and development of symbiosis. She tested how competition among *Symbiodinium* types affects these processes, and whether these competitive effects are mediated by environmental conditions. Finally, she described the poorly known symbiosis between coral and the recently described alga, *Chromera velia*. Her research demonstrates that *Acropora* larvae are promiscuous, establishing symbiosis with multiple different types of *Symbiodinium*. Prevailing environmental conditions strongly dictate the types of *Symbiodinium* taken up by the larvae. Competition among symbiont types influences infection dynamics, with mixed symbioses collapsing under high temperatures, therefore suggesting competition among symbionts within the host is costly to the symbionts and may be deleterious for the coral holobiont. *Acropora* larvae establish symbiosis with *C. velia*, suggesting this alga may be endosymbiotic in corals. However, clumps of *C. velia* were also seen digesting larval tissue, suggesting this symbiont can also become parasitic under certain conditions.

Vivian submitted her PhD thesis in June 2011. She is currently a National Science Foundation Postdoctoral researcher, based at California State University, Northridge in Los Angeles in Dr Peter Edmund's laboratory. She conducts majority of her research in southern Taiwan and Moorea, French Polynesia. Here she investigates the effects of climate change and ocean acidification on the early life stages of brooding corals.

Jessica Haapkylä

Dynamics and drivers of coral diseases in the Indo-Pacific



Jessica is originally from Finland. She first became interested in coral reefs after she dived in the pristine waters of Palmyra Atoll, central Pacific. She has now studied coral reefs for over 10 years in different locations around the world. Her main interest is coral disease ecology.

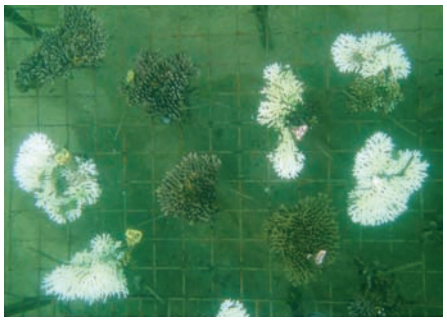
Jessica started her PhD at James Cook University in 2007 under the supervision of Prof. Bette Willis, Dr. Britta Schaffelke (AIMS) and Dr. David Bourne (AIMS). Her fieldwork was conducted at three locations: the Wakatobi Marine National Park, South-East Sulawesi, Indonesia, at Magnetic Island, central GBR and at Heron Island, southern GBR.

Jessica's thesis is the first to describe the importance of monsoonal rainfall as a driver of coral disease in the Indo-Pacific. Her results highlight the role of sedimentation, high particulate organic carbon and low salinity in the onset of coral disease outbreaks. In her thesis, she also describes latitudinal differences in coral disease dynamics. Jessica is aiming to finish her thesis by the end of the year 2011.

Emily Howells

Coral symbionts in warming seas: population dynamics, adaptation and acclimatisation of *Symbiodinium*

Emily moved to Townsville to obtain a bachelor degree in Marine Biology at James Cook University. She completed an honours project with AIMS@JCU support in 2006 on the population genetics of zooxanthellae (*Symbiodinium* spp.) in Great Barrier Reef soft corals. After a break from study, she commenced her PhD under the supervision of Prof. Bette Willis, Dr. Madeleine van Oppen and Dr. Line Bay in 2008 at James Cook University (School of Marine and Tropical Biology, ARC Centre of Excellence for Coral Reef Studies and AIMS@JCU) and the Australian Institute of Marine Science. Her project investigates how *Symbiodinium* partners influence the resilience of corals to warming seas through processes of genetic connectivity, genetic adaptation and physiological acclimatisation.



Population genotyping of a common and widespread type of *Symbiodinium* on the Great Barrier Reef (GBR) revealed limited genetic connectivity over small spatial scales (1-13 km), which is attributed to poor dispersal capabilities of *Symbiodinium* cells with infrequent recruitment between reefs facilitated by currents in the GBR lagoon. A negative consequence of this limited connectivity is low re-seeding potential of populations following disturbance which can result in losses of genetic diversity under frequent or severe mortality events, hence reducing population resilience. On the other hand, limited connectivity may have enabled *Symbiodinium* populations to adapt to local environmental conditions. Evidence for such local adaptation within a *Symbiodinium* type was found in populations from a relatively warm and cool region of the GBR. Fixed differences in photosynthetic performance and mortality rates of *Symbiodinium* populations were observed under heat stress following acclimation periods of 3 weeks and 12 months and had a strong influence on the fitness of corals inoculated with *Symbiodinium* from either the warm or cool adapted population. If *Symbiodinium* populations can continue to adapt to changes in temperature this may afford corals some resilience to rising sea temperatures, however rates of adaptation in *Symbiodinium* remain to be quantified. The role of acclimatisation in determining thermal tolerance was investigated during reciprocal transplantation of corals between the relatively warm Central GBR and cool Southern GBR. An inability to acclimatise to temperatures outside of historical thermal regimes (at both high and low temperatures) was supported by observations of impaired photosynthesis, reduced coral growth, bleaching and mortality in transplanted corals during winter (Southern GBR) and summer (Central GBR). These findings demonstrate the importance of adaptive rather than acclimatory determinants of variation in thermal tolerance for *Symbiodinium* which strongly influence the performance of coral symbioses under different thermal regimes.

Emily is currently writing up her PhD results and is aiming to submit her thesis at the end of 2011.

Charlotte Johansson

Managing coral reefs – the importance of working with functional groups to conserve ecosystem resilience

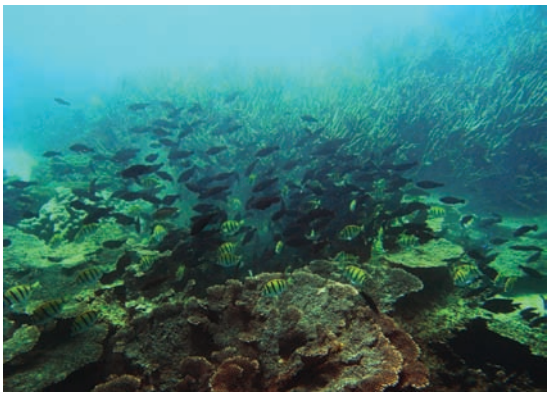
Charlotte completed her MSc at Stockholm University in 2006 on the functional behaviour of a Western Indian Ocean population of parrotfish. Charlotte has since been working at the Australian Institute of Marine Science (AIMS) examining the effects of the rezoning of the Great Barrier Reef on fish populations before commencing a PhD in 2009.

This PhD research titled "Managing coral reefs – the importance of working with functional groups to conserve ecosystem resilience" explores variations in four functional groups of herbivorous fish on Ningaloo Reef in Western Australia. This research aims to understand how these variations can influence the resilience of coral reefs. Charlotte is supervised by Prof D. Bellwood at JCU and co-supervised by Dr M. Depczynski at AIMS Western Australia.

To date this research has provided valuable insight to reef ecosystems under low anthropogenic pressures. Ningaloo Reef shows strong habitat variations in the distribution of herbivorous fish and functional groups and the most effective herbivore in this system is not fish but the very abundant sea urchin *Echinometra mathaei*. Additionally this research show that herbivorous fish species prefer habitats with complex structures, such as back and fore reefs, compared to macroalgal lagoons. Using herbivores as a homogenous functional group can therefore be highly misleading. Sub-functional groups on Ningaloo Reef are showing signs of low redundancy and can therefore be highly susceptible to changes to the ecosystem. Careful monitoring and management of herbivores from a detailed functional approach is required to buffer the resilience of Ningaloo Reef.

This research has so far resulted in one published paper and two submitted manuscripts. Further, a fourth manuscript is in preparation and will be submitted by the end of 2011. The thesis is expected to be submitted in 2012.

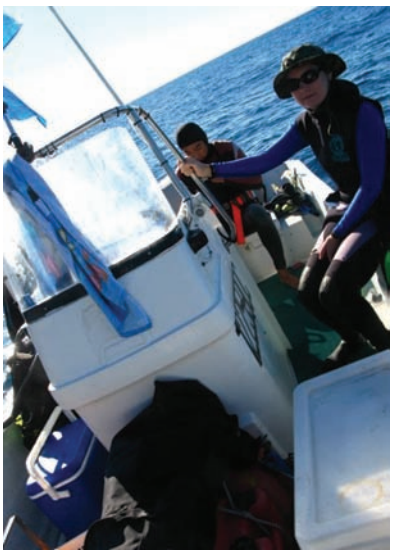
Johansson CL, Bellwood DR, Depczynski M (2010) Sea urchins, macroalgae and coral reef decline: a functional evaluation of an intact reef system, Ningaloo, Western Australia. Mar Ecol Prog Ser 414:65-74.



Raechel Littman

Coral associated bacteria and the role of bacterial pathogens in coral bleaching

Raechel completed her Masters in environmental policy and worked in Washington DC prior to her PhD in marine biology. She then decided to pursue science as a career and studied the microbial ecology of coral and found that that the type of symbiotic algae associated with the coral determined the resilience of the bacterial community during bleaching. She determined that bacterial communities differed on coral at different locations. She also found an appearance of microbial pathogens during a natural bleaching event suggesting bleached coral may succumb to opportunistic pathogens.



Raechel completed her PhD in February 2011 and is currently working as a postdoc in the veterinary department of the University of Melbourne. She is working on diagnosing toxic cyanobacteria blooms and uses bioinformatics to describe the transcriptomics of parasites.

Heidi Luter

Causes and Impacts of Sponge Disease on the GBR and Torres Strait

Heidi, originally from Colorado, completed her Masters of Applied Science at JCU in 2006 where she studied the effects of size and spatial competition on the bioactivity of a thin encrusting sponge. This project sparked an ongoing interest in sponges, which led her to apply for a PhD investigating the causes and impacts of sponge disease on the Great Barrier Reef and Torres Strait under the supervision of Dr Nicole Webster (AIMS), Dr Steve Whalan (JCU) and Prof Rocky de Nys (JCU). The main aims of the project were to determine the prevalence and etiological agents of disease in a common GBR sponge (*Ianthella basta*) and to examine the effects of environmental stressors on the sponge-microbe symbioses.

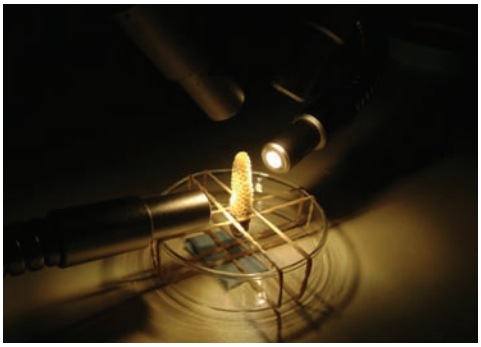
Results from this project revealed that a disease-like syndrome is affecting a large percentage of *I. basta* in Torres Strait (66%) and the Palm Islands, central GBR (44%). Symptoms of the disease-like syndrome include discolored, necrotic spots leading to tissue degradation, exposure of the skeletal fibers and disruption of the choanocyte chambers. Despite a comprehensive comparison of bacteria, viruses, fungi and other eukaryotes, no putative pathogen(s) could be implicated in the formation of brown spot lesions and necrosis. In addition, neither increased temperatures nor sedimentation was successful at inducing the disease-like symptoms observed in the field; therefore, an environmental origin of the syndrome is also unlikely. Another major outcome of this project is that the microbial community of *I. basta* is stable across a latitudinal gradient and under varying stressors, with three dominant symbionts always observed (*Alphaproteobacteria*, *Gammaproteobacteria* & Thaumarchaea). Given the apparent stability, these results indicate that *I. basta*'s associated microbes' likely play an important functional role(s) in this sponge.

Heidi recently submitted her thesis and is working for the AIMS Bioresources Library while awaiting thesis reviewer comments.

Adrian Lutz

Coenzyme Q and plastoquinone redox balance as a physiological determinant of oxidative stress in coral-algal symbiosis

Adrian grew up in Switzerland and completed his MSc in biology at the University of Basel. He first came to Townsville in 2005 to work with Madeleine van Oppen for his thesis on the genetic connectivity of *Seriatopora hystrix*. He returned to Townsville in 2007 to work under the supervision of Walt Dunlap, David Miller and Madeleine van Oppen. His PhD investigates the potential antioxidant role of coenzyme Q and plastoquinone in coral symbiosis.



The majority of tropical marine anthozoans harbour in their gastrodermal cells symbiotic dinoflagellates of the genus *Symbiodinium* (zooxanthellae). Although the gross metabolic benefits of this symbiosis are well recognised, it is poorly understood how symbiotic interactions are established and regulated at physiological and molecular levels. In particular, the disruption of coral-algal symbiosis known as "coral bleaching" is a subject of contemporary significance in global climate change research. Coral bleaching in coral-algal symbiosis is widely accepted to be caused by enhanced production of reactive oxygen species (ROS) within the photosynthetic apparatus of zooxanthellae and the mitochondria of the coral that overwhelms the antioxidant capacity of the holobiont causing cellular damage.

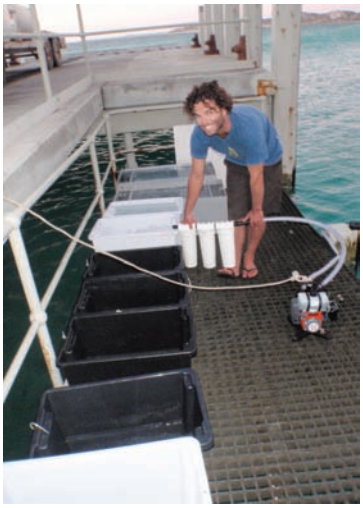
While the antioxidant properties of the reduced forms of coenzyme Q (CoQ) and plastoquinone (PQ) have been well studied, very little is known about the regulation of the reduction/oxidation (redox) balance in the metabolic pools of these quinone electron carriers in marine invertebrates and their algal symbionts. In order to gain insight in the response of the coral-algal symbiosis to oxidative stress, Adrian and his colleagues have developed a technique for the simultaneous determination of the redox state of the plastoquinone and coenzyme Q pools by high pressure liquid chromatography-mass spectrometry (HPLC-MS). This allows for simultaneous quantification of the redox state of plastoquinone in the algae and of coenzyme Q in the coral within the same sample. Using a chemistry, biochemistry and experimental ecology approach, this project investigates how the coral-algal symbiosis regulates these redox states under different environmental conditions, specifically under oxidative stress caused by elevated temperatures.

Adrian is currently busy writing up his thesis and preparing publications of his results. He has presented parts of his research at international and national conferences (Euro ISRS 2010 Wageningen, Netherlands; ACRS Symposium 2009 Darwin, Australia) and won an award for a highly commended student presentation (ACRS Symposium 2010 Coffs Harbour, Australia).

Eneour Puill-Stephan

Chimerism and allorecognition in the broadcast spawning coral *Acropora millepora* on the Great Barrier Reef

After completing his Masters on fish physiology in France, Eneour decided in mid 2005 to come over to Australia in order to study corals. He was awarded the AIMS@JCU scholarship and started a PhD on corals in early 2006.

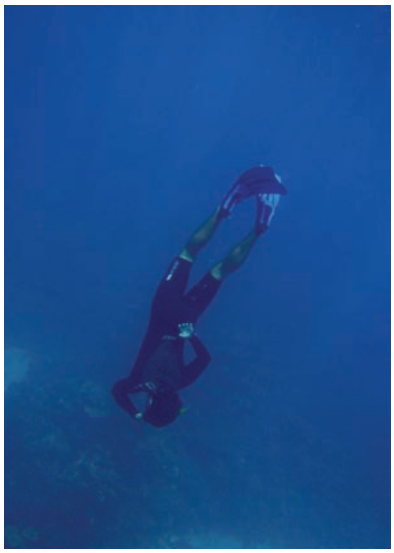


The project, supervised by Dr. Madeleine van Oppen, Pr. Bette Willis, Dr. Lynne Van Herwerden and Dr. Karine Pichavant-Rafini, explored the extent and the occurrence of chimerism in wild populations of the broadcast spawning coral *Acropora millepora* in adult corals. In parallel, the potential for chimera formation was tested in coral juveniles in experimental conditions during a period when allorecognition appeared to lack precision.

The broadcast spawning coral *Acropora millepora* exhibited high potential (in experimental studies) for chimera formation following aggregated larval settlement, with 47% of juveniles originating from aggregated settlement. Additionally, genotyping at 9 microsatellite loci revealed that 50% of juveniles tested were chimeras. Also, the lack of a mature allorecognition system seemed to contribute to chimera formation, at least during the the first two months post-settlement, where fusions occurred among juveniles of all kinship levels. Then, the extent of chimerism was explored in wild populations of *A. millepora*, using up to 12 polymorphic DNA microsatellite loci, and revealed that 3% of the colonies sampled were found to be chimeras.

Taken together, the high potential for chimera formation following aggregated larval settlement found in experimental studies and the occurrence of chimerism in wild populations of *A. millepora* suggest that chimerism is likely to be an important strategy in the early life cycle of broadcast spawning corals and may be more widespread in corals than previously thought. Chimerism and associated increased genetic diversity within colonies are likely to have important implications for the resilience of reef corals, potentially enhancing their capacity to compete for space and respond to environmental stressors and pathogen infection.

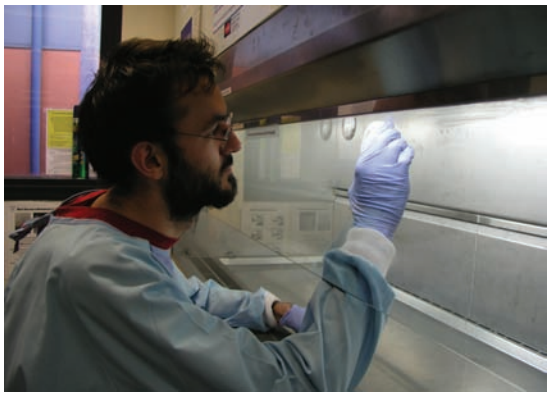
The thesis was accepted in June 2011 and Eneour graduated in September 2011. He is now working as a Experimental Scientist (Technician) at AIMS under the supervision of Dr. Madeleine van Oppen, on a project funded by the Great Barrier Reef Foundation.



Jean-Baptiste Raina

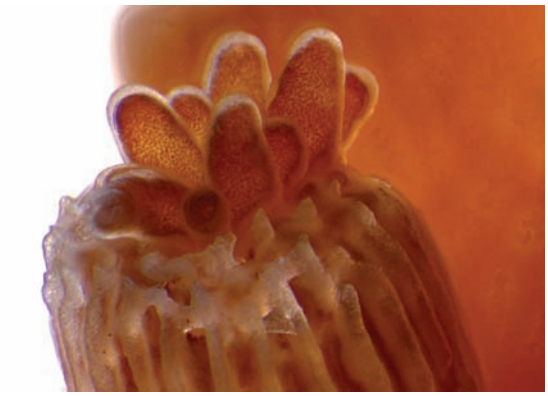
Coral associated bacteria and their role in the biogeochemical cycle of sulfur

Originally from France, Jean-Baptiste completed his Master of Applied Science at JCU in 2008 during which he did a 6 months research project on the coral-bacterial symbiosis. This short project was developed further into a PhD, under the supervision of Dr. David Bourne and Prof. Bette Willis. The main aim of the project is to better understand the chemical compounds that drive coral-bacteria association.



The main outcome of this project so far is the identification of a sulfur molecule, dimethylsulfoniopropionate (DMSP), structuring coral-bacteria association. This compound is a by-product of photosynthesis and is synthesised in large amounts by *Symbiodinium* spp., the endosymbiotic algal partner of reef-building corals. An important proportion of bacterial communities present in healthy corals can metabolise this compound and use it as a carbon and sulfur source to sustain their growth. Furthermore, the breakdown product of DMSP is a gas called dimethylsulfide implicated in solar radiation back-scatter and climate regulation via its role in cloud formation. Another major outcome of this project is the discovery of genes coding for DMSP degradation enzymes in virus, indicating the yet uncharacterised role that marine viruses are playing in sulfur metabolism in corals.

Jean-Baptiste is currently working on an accurate characterisation of the DMSP production of one of the most common reef-building coral in the Indo-Pacific, the genus *Acropora*. He is planning on submitting his thesis in mid 2012.



Francois Seneca

Transcriptomics on coral acclimation and adaptation to climate change

Francois studied coral reefs ecology as an undergraduate at the University of Hawaii and received a Bachelor of Science in Zoology in 2004. His PhD research at James Cook University has focused on the molecular stress response of the reef-building coral species, *Acropora millepora*, during a natural bleaching event on the Great Barrier Reef of Australia, and has found evidence that corals show signs of severe molecular perturbation weeks before any visual signs of bleaching could be observed in the field. Francois' previous work has also included the discovery and characterisation of a novel coral stress gene family, and the effects of land based pollutants on different coral life stages. His PhD research was completed in December 2010.

Francois' current project title is: "Hope for the future of coral reefs: does localized exposure to harsh thermal conditions indicate adaptation at the sub-population level?" He is currently a post-doctoral scholar in the laboratory of Professor Stephen Palumbi at the Hopkins Marine Station of Stanford University in California. His project aims at determining if certain coral populations showing enhanced resilience to elevated temperature are adapted or simply acclimated to harsher thermal regimes. He is broadly interested in understanding how marine invertebrate species respond to physical changes in their environment with the goal to predict the consequences of further global climate change on these organisms. Francois' research concentrates on the detection and measurement of change in gene expression levels within the cells of organisms exposed to different stressor stimuli. Studying gene expression patterns under stressful conditions can help to understand the mechanisms behind observed physiological disturbances and therefore explain the symptoms of a specific stress in an individual.

Francois' current research interests aim to address the big question: can reef-building corals adapt to future global climate change? In recent years, his group has studied a very special population of corals found in the shallow waters of an Ofu Island lagoon in American Samoa. These corals experience extreme fluctuations in daily average temperature and pH, the maxima of which are similar to the predictions for the environmental conditions on coral reefs worldwide 50 - 100 years from today. Francois' goal is to determine if these hardy individuals are only acclimatized or in fact adapted to their harsher conditions. In the latter case, it may be expected that similarly adapted populations across the tropics may act as potential sources for the dissemination of those genetic traits needed for coral survival in the face of future global climate change. Recognition of these potential refugia will be essential to successful management of climate change effects on coral reef ecosystems and designating such valuable populations as conservation priorities.

Gergely Torda

Assessment of ecological connectivity in corals: implications for their recovery from major perturbations and their potential to adapt to climate change

Greg is originally from Hungary and came to Australia in January 2009 to start a PhD on ecological connectivity in corals, leaving behind a junior researcher position with the Hungarian Academy of Sciences. He completed his Master's degree in Zoology at the Szent Istvan University, Hungary, and did a two year postgraduate research and coursework program on marine ecology at the University of Las Palmas de Gran Canaria, Spain. Greg's early research was on behavioural ecology of birds and marine mammals. Later he specialised in GIS applications, focusing on landscape ecology, including habitat connectivity and the development and application of ecologically scaled landscape indices.

His PhD research "Assessment of ecological connectivity in corals: implications for their recovery from major perturbations and their potential to adapt to climate change", supervised by Dr. Madeleine Van Oppen, Prof. Bette Willis, and Dr. Petra Lundgren, aims to obtain estimates of ecological connectivity and its temporal stochasticity for two common pocilloporid coral species on the Great Barrier Reef (GBR), *Seriatopora hystrix* and *Pocillopora damicornis*. This will be achieved by genetically characterising new recruits at a small number of locations in the Palm and Lizard Islands and comparing these with the genetic characteristics of adult populations at a wider range of populations. Recruits may then be genetically assigned to potential source populations, which ultimately provides a measure of ecologically significant connectivity between various reefs. By generalising the results, Greg's research will contribute to understanding the pace and magnitude of a key process involved in the restoration of degraded reefs: immigration from neighbouring reefs, and hence will provide invaluable information for managers when refining the zoning plan of the GBR.

Greg is currently in the last year of his PhD, aiming to submit in August 2012. He has spent over 100 field days to collect over 2500 samples of adult colonies and coral recruits, and has processed these samples by genetic tools that he had developed. The results of the genetic analyses are currently under analysis and will be presented in 3 papers during the next 12 months, as well as on an oral presentation at the ICRS 2012 conference. Apart from the AIMS@JCU support, the research receives funding from RRRC through MTSRF 2.5i.3, and Greg holds an Endeavour International Postgraduate Research Scholarship and a James Cook University Postgraduate Research Scholarship.

Patricia Warner

Reproductive ecology and population genetic approaches to assessing connectivity in the brooding coral, *Seriatopora hystrix*

Patricia is from Florida, USA and completed her undergraduate studies at Tulane University, New Orleans, Louisiana. She started her PhD with AIMS@JCU in 2008 supervised by Prof. Bette Willis (JCU) and Dr. Madeleine van Oppen (AIMS). Her project under the running title of Reproductive ecology and population genetic approaches to assessing connectivity in the brooding coral, *Seriatopora hystrix* aims to combine ecological and reproductive information with genetic data at local geographical scales in order to understand the small-scale process and patterns that lead to GBR-wide connectivity of *S. hystrix* populations.

The original idea for this project evolved from a relatively unknown aspect of coral reproductive biology: brooding coral sperm and fertilisation. Due to the difficulty of directly observing sperm in situ and the complexity of determining timing in sperm release, the first experiment of the study employed a genetic parentage analysis of coral larvae within a mapped population of adults to assess the distance of sperm dispersal and analyze mating system parameters. In addition, colonies of the same population have been continuously sampled for reproductive monitoring from which it has been observed that unlike broadcast spawning species, *S. hystrix* colonies of this central GBR population produce larvae year-round. Building up from these intrapopulation investigations, 17 populations of *S. hystrix* have been sampled and genotyped from 9 different locations in the Palms and Lizard Islands for both host and symbionts. ITS 2 genotypes of symbionts have revealed that *S. hystrix* colonies on exposed and deeper margins of islands harbour a different symbiont type to that of their sheltered, shallower side counterparts. Moreover, host genetic structure indicates that gene flow between populations on either side of islands (sheltered vs. exposed) within regions (10s km) is more limited than that between populations of the same habitat (e.g. sheltered) between regions (~500 km). The final compilation of the data from these complimentary studies will tell the story of a *S. hystrix* from the beginning of reproduction to connectivity within and between reefs at local and regional scales with the intent to elucidate patterns described for this species over extensive geographical areas.

Currently, all the field and labwork have been completed for this project and data analysis and writing is in progress. Five manuscripts are in preparation for publication and the thesis is expected to be submitted early 2012.

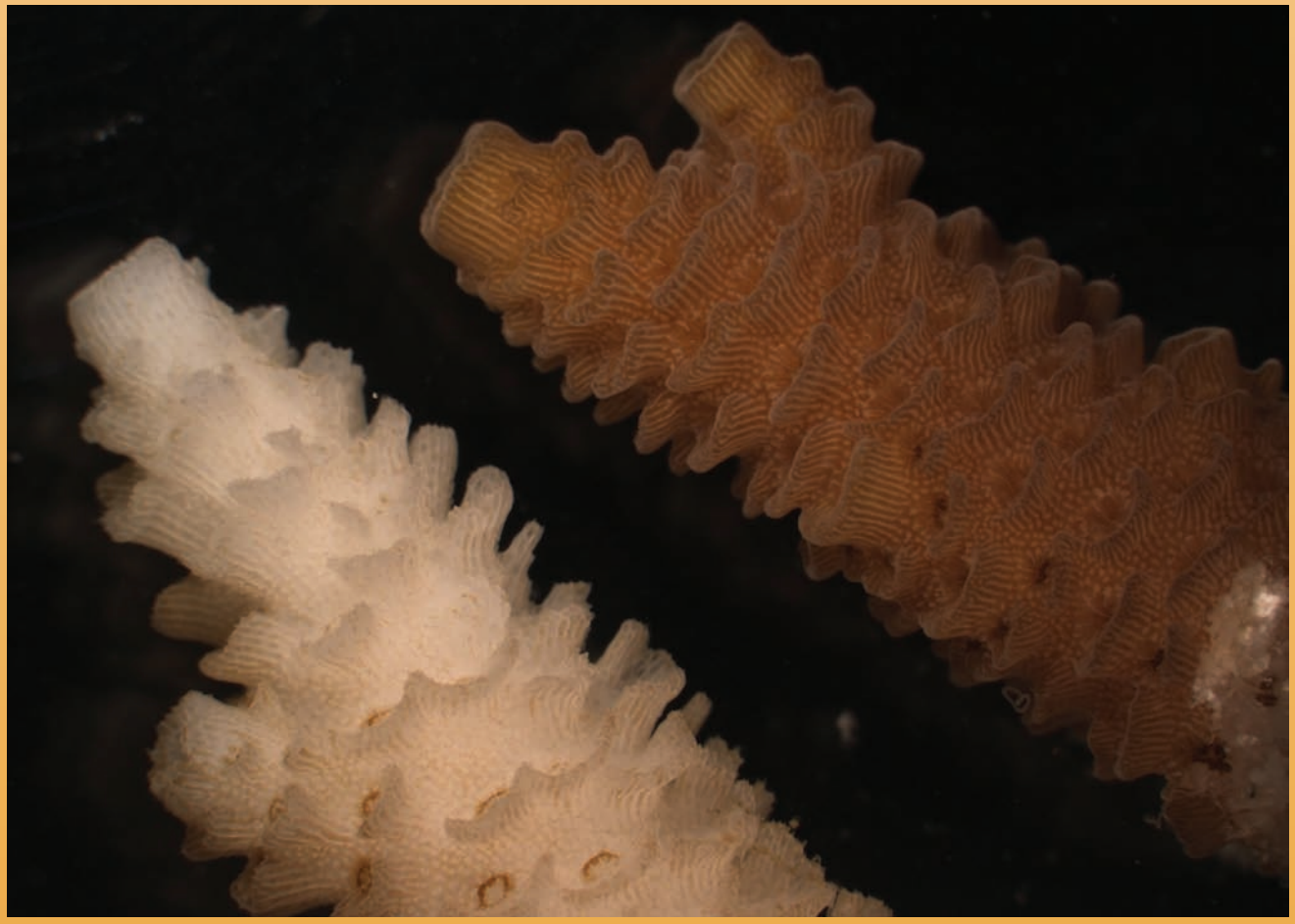


Image provided by Adrian Lutz (AIMS@JCU student)

Future Directions

Overview

The Commonwealth Government funding allocation that supported AIMS@JCU formally ended in 2010. However, after noting the many successes in capturing synergies and building collaborative strengths between the two organisations (see Joint Venture in Review - page 6), AIMS and JCU have agreed to support a strategic alliance into the future, based on the most successful aspect of the joint venture – that of joint supervision of post-graduate research students. The research program approach of the joint venture has been dropped to broaden the research focus of the strategic alliance to include the full scope of research undertaken by the two organisations.

The overall mission of the new strategic alliance is to produce and foster high quality research by integrating the strengths and areas of synergy between the two institutions and advance tropical marine science in Australia, by training the next generation of marine researchers and increasing the capacity for marine science at both AIMS and JCU. Jointly supervised post-graduate research students will be the main vehicle to delivering on this mission, along with a focus on effective science communication and supporting students' integration into the wider scientific community.

At a practical level, AIMS@JCU infrastructure will continue to be supported by each institution, including MARFU, aquaculture facilities at AIMS and the optic-fibre link; dedicated AIMS@JCU scholarships and top-up funds will be made available each year; student science communication will be supported, including contestable funding for conference travel; and vehicles will be provided to facilitate transport between AIMS and JCU.

AIMS@JCU has evolved into a streamlined strategic alliance that continues to build strength in the marine science synergies of AIMS and JCU and support the emergence of new areas of marine science including novel cross-disciplinary approaches.

New Research Director

At the start of 2011, Michelle Heupel moved on from the AIMS@JCU Research Director position to take up an ARC Future Fellowship at AIMS. The Management Committee for AIMS@JCU is pleased to announce the appointment of Libby Evans-Illidge from the Australian Institute of Marine Science as the new Research Director.

Elizabeth (Libby) Evans-Illidge:

Libby has been at AIMS for 17 years where her role has included leadership of sponge biology and aquaculture research and management of Australia's largest and most comprehensive marine bioresources library. The latter has incorporated negotiation and management of contracts that facilitate access to the bioresources library for biodiscovery research and benefit sharing agreements with resource management jurisdictions in Australia. She has participated in numerous policy development forums on access and benefit sharing, both nationally and internationally, including with the Convention on Biological Diversity, the United Nations Convention on the Law of the Sea (UNCLOS) and the development of new domestic policy and legislation in Australia. She also maintains active research interests in aquaculture as a production method for bioactive compounds and biomaterials and in 1999 with colleagues at AIMS, JCU and communities, initiated research into bath sponge aquaculture and its environmental impact and management, at Palm Island and in Torres Strait.

Alongside the part-time AIMS@JCU research director role, Libby will continue her role as manager of the AIMS Bioresources library and hopes to soon begin work on a new project (funded by the NERP) to develop an e-atlas for Torres Strait. Libby looks forward to leading AIMS@JCU in new directions to maximise the synergies and leverage the strengths of the two partner organisations.

Thomas Camus

Development of culture and storage techniques for tropical copepods as live food for aquaculture hatcheries

Thomas grew-up in France and completed a Bachelor of Science in Marine Biology at Hawaii Pacific University in June 2005. He arrived at JCU in February 2006 and started a Master of Applied Science in Aquaculture. While he was completing the course work component of the MAppSc, Thomas started to take interest into copepods biology and ecology, as well as their potential as live food source for marine hatcheries. He developed the idea of doing research with these fascinating creatures, of which we know very little, especially in tropical environments.

Thomas did a minor research project in 2007, investigating the effect of various photoperiod regimes on the productivity and development of *Acartia sinjiensis*, a calanoid copepod. The data of this experiment was eventually published in Aquaculture, but more importantly provided him with lots of idea for futures research.

After completing his minor project, Thomas started a Master by Research with supervisors Chaoshu Zeng (JCU) and David McKinnon (AIMS). His area of interest was to improve culture and storage method for tropical copepods. He likes to find new candidate species and assess their productivity in culture, see how easily (or not) they are to culture in laboratory condition and try to figure out culture protocols for the species with interesting potential. Thomas' species of interest have been *Acartia sinjiensis*, *Bestiolina similis*, *Euterpina acutifrons*, *Pseudodiaptomus* sp..

Thomas upgraded to a PhD in January 2010 and continued to research various candidate species, or the influence of a variety of culture parameters on their productivity in culture. He has published 4 papers so far and is working on another 3 publications before completing my thesis. Thomas will attend the 11th Conference in Copepoda in Merida, Mexico, in July where he will make an oral presentation about cannibalistic behavior in *Acartia sinjiensis*.

Leanne Currey

Investigation of red throat emperor movement in relation to marine protected areas and responses to environmental change

Leanne moved to Townsville for undergraduate study and completed her BSc (honours) degree in 2003 at James Cook University. After a contract at the Northern Fisheries Centre (DEEDI), she spent the next six years working on a number of fishery projects with the Fishing & Fisheries Research Centre at JCU. In March this year, Leanne commenced her PhD and was awarded an AIMS@JCU scholarship for research support over the next three years. After focussing on the life histories of a number of fishery important species, Leanne's PhD project will investigate the movement of redthroat emperor (*Lethrinus miniatus*) on the Great Barrier Reef (GBR).

Little information is available regarding the spatial use and movement patterns of this species, as previous conventional tag recapture studies report limited success. The few recaptures of externally tagged individuals indicate small-scale movement from release locations, yet two individuals travelled over 200km across deep water. It is uncertain whether large scale movements are typical for adult *L. miniatus* or whether northerly shifts in distribution (e.g. caused by tropical cyclones) are a direct response to changes in the environment. Information on fish movement is therefore important to management of the GBR fishery, as the only stock assessment reported for *L. miniatus* assumes no movement among reefs (due to lack of data). However, if movement among reefs does occur, efficacy of marine park areas for this species may be reduced or alternatively *L. miniatus* may benefit from multiple MPAs.

Leanne will use acoustic telemetry to track individuals in the Capricorn Bunker region of the GBR, and as this region comprises different management zones, it will allow testing of movement of *L. miniatus* among reefs and management zones. Acoustic transmitters equipped with pressure sensors will enable the presence and depth of individual fish to be detected by underwater receivers. The sex of each tracked individual will be differentiated by plasma hormone levels to determine any sex-specific movement patterns. These data will be used to describe the short- and long-term movements of *L. miniatus* to address fundamental knowledge gaps in the ecology of this species. With larger, older *L. miniatus* typically found at the northern end of their distribution, a net movement or northerly migration has been hypothesised for this species. In combination with the acoustic tracking investigating reef-scale movement, broader GBR-scale movement will be analysed using otolith microchemistry of samples collected along the Queensland coast.

Leanne's PhD research aims to describe movement patterns (area and depth utilisation) of *L. miniatus* in the Capricorn Bunker region in relation to the efficacy of MPAs and environmental changes, identify any sex-specific movement patterns and use otolith microchemistry to determine the direction of net movement of *L. miniatus* on the Great Barrier Reef.

Joleah Lamb

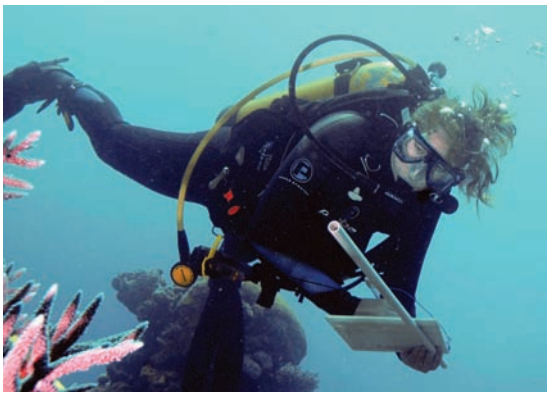
Identifying and managing impacts and drivers of coral disease associated with reef based tourism

Joleah completed a B.S. in Neurobiology at the University of Oregon in the USA in 2005. During her undergraduate study she assisted in the investigation of *Drosophila* central nervous system development for cancer research at the University of Oregon Institute of Neuroscience and Molecular Biology. Her interest in disease research led her to the Oregon Center for Clinical Investigations where she coordinated clinical pharmaceutical studies for the treatment of neurological diseases and disorders.

After learning that disease was recognised as a major factor in the accelerating degradation of coral reefs in many regions of the world, Joleah soon relocated to Australia and completed her MAppSci in Tropical Marine Ecology and Fisheries Biology at JCU in 2009. Her research focused on using coral disease prevalence to assess the effect of concentrating tourism activities on offshore reefs in the Great Barrier Reef Marine Park (GBRMP). In 2011, she was awarded an AIMS@JCU research scholarship to undertake her PhD under the supervision of Bette Willis (JCU), Britta Schaffelke (AIMS) and Garry Russ (JCU).

Joleah's PhD aims to identify the effects of reef-based recreation and tourism on coral health. Currently, outdoor recreation, including tourism, are focusing more and more on the world's remaining natural marine areas. Although first-hand experience of coral reefs is one of the best ways to promote public awareness of conservation issues, achieving the dual objectives of providing recreational opportunities and preserving natural environments is challenging. To date, the effects of various visitor management strategies on coral health have not been evaluated in marine environments. Joleah plans on examining the effects of both spatial and temporal visitor management strategies on coral disease prevalence in Australia and overseas.

In addition, a major tool of recreation management of the GBRMP is spatial zoning for multiple-use. While it has been suggested that marine protected areas could enhance the resilience of coral reefs, their utility in mitigating disease in coral populations has not been assessed in Australia. Joleah's research aims to evaluate whether current management practices associated with recreation activities are useful for mitigating coral disease on reef corals by assessing the efficacy of marine reserves on the Great Barrier Reef.



Samantha Munroe

Reef predator movements and the effects of environmental change on their use of marine protected areas

Sam graduated with a BScH in Biology from Acadia University, Canada in 2010. Her honours research looked at the ectoparasitic assemblages of Atlantic sturgeon (*Acipenser oxyrhincus*) found in the coastal waters of Atlantic Canada. After graduation, Sam worked for several environmental non-profit organisations, including the Sierra Club of Canada, where her work focused on marine management and urban water conservation. Before accepting her AIMS@JCU scholarship in March, she spent three months volunteering work at the Bimini Biological Field Station, a shark research laboratory based in the Bahamas.

Sharks exhibit a wide range of behavioural adaptations in the majority of marine environments and have a large impact on community structure. A growing body of literature is attempting to quantify shark movements and diet to better understand their role in their communities. Data is also being used to create better management solutions for endangered populations and ecosystems as a whole. However, for the majority of shark species there is little information on habitat use or diet, limiting our ability to create comprehensive management solutions. Sam's work will isolate potential interactions between the diet and spatial distribution of sharks residing in Cleveland Bay, Townsville. This study will lead to a better understanding of their role and develop a more comprehensive picture of food web dynamics in this coastal environment.

Stomach content analysis is a common method for evaluating the diet of an organism, however it is time consuming, labour intensive, and specimens do not always produce data. Stable isotope analysis is a less demanding method now being used to quantify animal diets. Traditional isotope analysis determines the composition of heavy carbon and nitrogen isotopes in an animal's tissues. Carbon concentrations indicate the primary producer of the system within which the animal feeds and can be used to determine the food sources for organisms. Nitrogen concentrations increase at predictable increments with each trophic level and can be used to estimate trophic position in a food web. Limited variation in carbon and nitrogen values among individuals would indicate a selective possibly specialized diet, whereas high levels of variation indicate a broad generalised diet. By sampling blood and muscle tissues of different shark species, Sam will quantify the carbon and nitrogen isotope levels. Using this information in combination with passive tracking data of the same individuals, dietary breadth of a given population can be compared with its distribution.

The combination of these techniques will hopefully provide new insights into the foraging behaviours of these species, understand how these species effect marine ecosystems, and create better management policies in coastal communities.

Muhammad Azmi Abdul Wahab

Effects of environmental stress on the host-microbe symbiotic synergies in larval and adult sponges

Muhammad made the move from Singapore to Australia in 2006 to pursue a Bachelor degree in Aquaculture at James Cook University. Upon completing his degree, Muhammad worked as a research assistant, under Prof. Rocky de Nys and Dr. Nicholas Paul, developing methods to extend the shelf-life of *Caulerpa lentillifera*, more commonly known as "green caviar". In November 2010, he completed his honours year in which he revealed reproduction, larval behaviour, settlement cues, and post-settlement processes (i.e. survival and growth) in the commercial bath sponge *Coscinoderma matthewsi* under the supervision of Prof. Rocky de Nys and Dr. Steve Whalan.

Sponges (Porifera) are a highly diverse and abundant phylum which performs key structural and ecological functions in aquatic ecosystems. The remarkable pumping abilities demonstrated by many sponges (up to 24 000L of seawater day-1 1kg-1 sponge) are critical to their role in bentho-pelagic coupling processes of oxygen consumption, carbon cycling, silicon cycling and nitrogen cycling. Sponges also have complex symbiotic relationships with prokaryotes and eukaryotes, with the former participating in primary and secondary production within their hosts. A clear understanding on processes that influence adult population distribution is therefore central in addressing issues relating to management and conservation of this important group.

Muhammad's research focuses on the intertidal dictyoceratid sponge *Carteriospongia* sp. which occurs in sheltered, shallow, intertidal zones where they can be exposed to air at extreme low tides. The intertidal environment is considered to be stressful to sponges due to high temperature and salinity fluctuations, high level of sedimentation and susceptibility to desiccation. Interestingly, *Carteriospongia* sp. has not been found in exposed shorelines (high energy) or on deeper reef slopes. Muhammad is interested in understanding processes that contribute to the distribution of this sponge and how it manages to cope in living in this stressful environment. Using a combination of field and laboratory experiments, he will investigate the contributions of sexual and asexual (fragmentation) reproduction for the supply of recruits to the population. Additionally, Muhammad will look at larval behaviour and settlement processes to understand dispersal potential for this species. He will also investigate post-settlement success (i.e. health and survival) in both juveniles and adults in the intertidal and sub-tidal zones. Muhammad is also interested in understanding sponge-microbe symbiotic associations and sponge gene regulation processes under stressful conditions such as that experienced in the intertidal zone.

In the field at Heron Island – August 2011

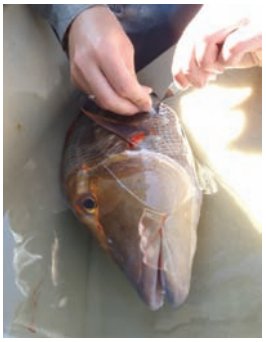
Leanne Currey

Five months after commencing her PhD, Leanne headed back to Heron Island for a month of fishing and diving field work with supervisors Dr Michelle Heupel and Dr Colin Simpfendorfer. She is investigating the movement patterns, both among reefs and at a broader scale along the Great Barrier Reef, of the important fishery species redthroat emperor (*Lethrinus miniatus*). Utilising the setup of underwater "listening stations" (acoustic receivers) around Heron, One Tree and Sykes reefs as well as otolith microchemistry techniques, Leanne's project will provide greater insight into whether long-distance movements are common for this species and whether these movements are sex-specific or vary with environmental conditions. The focus of this second field trip was to download the acoustic receivers monitoring the movements of the tagged redthroat emperor, deploy some additional receivers to enhance coverage of detection and collect more biological samples for microchemistry and sex differentiation.

Reef fishing

In April, twenty animals were fitted internally with acoustic transmitters and released among the array of receivers, with the aim to obtain long-term data on the movement patterns of these fish. The logged data was acquired by retrieval, download and replacement of each receiver, and revealed that tagged individuals were indeed detected by the array! So far, variability in movement patterns has been observed over the 134 days. Some fish remained within the detection range of the single receiver closest to the initial release site, whereas others ventured past four or five receivers, over 6km in distance. Analysis of this information will relate the depth profiles (up to 50m) to tides, time of day and environmental conditions and more data in February will provide further information over time. An exciting find was a recapture of one individual, only 80m from the release location after 132 days at liberty, supporting the frequent presence of some individuals at one location.

During the line fishing days, blood was taken from each retained fish and gonads and otoliths were removed. The blood plasma will be analysed to determine the sex of each individual via hormone levels and compared to the gonads. If this technique can successfully differentiate between sexes, it will be used to determine if movements observed are sex-specific e.g. during the spawning season, therefore plenty of time will be spent in the laboratory next year.



Surgery to fit fish with acoustic transmitter

Drawing blood for hormone analysis

Acoustic receiver positioned on substrate

Cover image: Releasing a tagged individual

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Image provided by Gergely Torda (AIMS@JCU student)

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