CARM Report 2013

Centre for Applications in Natural Resource Mathematics

www.smp.uq.edu.au/CARM

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CENTRE FOR APPLICATIONS IN NATURAL RESOURCE MATHEMATICS (CARM)

Establishment, Aims and Growth
The Centre for Applications in Natural Resource Mathematics (CARM) is in the School of Mathematics and Physics, at The University of Queensland. CARM was established in April 2010 to promote applied mathematics/statistics in the management of fisheries, forestry, water security, conservation, pest and disease management, and adaptation to global change.

CARM has five academic staff, a research assistant, an administration officer and 18 postgraduate students.

We are actively developing links with government and industry, particularly with the Queensland Department of Agriculture, Fisheries and Forestry (DAFF) and CSIRO. We share many post-graduate students with researchers from these institutions and these students are solving applied resource management problems.

Staff

You-Gan Wang: Director
Prof. Wang’s interests are statistical modelling and data analysis in environmental research, in particular for stock assessment and management strategy evaluation. In statistics, his interests are robust inference, dynamic decision theory and model selection in correlated data analysis.

Anthony Richardson: Deputy Director
Assoc. Prof. Richardson has research interests in ecosystem modelling, analysis of large datasets, marine ecology, and climate impacts and adaptation. His aim is to understand changes in marine systems and how they can be better managed.

Peter Baxter: Lecturer
Dr Baxter’s main research focuses on applied ecological modelling, in particular using decision theory with ecological and environmental models to find optimal strategies for invasive species control and threatened species conservation.

Ricardo Lemos: Lecturer
Dr Lemos develops Bayesian spatio-temporal methods and applies them to biological and environmental data. His research interests include high performance computing, multivariate data blending, and fingerprinting of human and natural causes of marine population fluctuations.
Clare McGrory: Lecturer
Dr McGrory is a Bayesian statistician. Her research focuses on developing efficient and practical Bayesian statistical methodology, in particular in the area of variational Bayes and MCMC-based techniques. Her interests include applications in analysing spatial data, wave direction modelling and genomic predictions within cattle breeds.

Shen Wang: Research Assistant
Mr Wang is finishing his PhD from the University of Wollongong and is interested in Markov Chain Monte Carlo, variational Bayesian methods, semiparametric regression, statistical modelling and data analysis. He is also interested in statistical computing and statistical software, such as R, Infor.NET and WinBUGS.

Anna Nourse: Administration
Ms Nourse is responsible the general administration of the office, works closely with the School of Mathematics and Physics finance team and ensures the CARM talks, workshops and other calendar events are organized efficiently. 60% FTE since March 2011.

PhD Students

Andrew Jones
Estimation of genetic effective population size in fisheries

Chang Liu
Optimal dynamic allocation with consideration of return uncertainties and competing projects

Eunice (Chuan) Hui Foo
Stochastic growth models for analysing crustacean data
Kate Helmstedt
Mathematical modelling and optimisation in applied conservation ecology

Katherine Burgess
Feeding ecology, movements and behaviour of *Manta birostris* in Ecuador

Luke Lloyd-Jones
Growth models with individual variability and environmental variables: implications in fisheries stock assessment

Michael Macbeth
Improving the utility of genetic markers in fish populations

Michael O’Neill
Standardisation of catch and effort in fisheries stock assessment

Mingzhu Sun
Applications of mixtures of skew distributions
Na Wang
Sustainability and optimality in fisheries management

Nanxi Zhang
Robust inferences for analysis of longitudinal data

Sarah Pausina
Zooplankton dynamics in Moreton Bay

Tessa Rawson
Conservation planning of the Mediterranean Sea

Viv Tulloch
Ecosystem modelling and fisheries in tropical and temperate systems

Masters Students

Bo Chen
Supervisor: Ricardo Lemos
Honours Students

Alex Coughlan
Understanding effects of climate change on Australian phytoplankton communities

Amelia Armstrong
The size spectrum of zooplankton communities along the Australian east coast: effects of oceanography, season and latitude

Maxime Marin
Oceanography of southeast Queensland in relation to kelp distribution

COMPLETED STUDENT PROJECTS

<table>
<thead>
<tr>
<th>Year</th>
<th>Degree</th>
<th>Student</th>
<th>Project Title</th>
<th>Supervisor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>Ph.D.</td>
<td>Lydie Couturier</td>
<td>The biology and ecology of the manta ray, <em>Manta alfredi</em>, in eastern Australia</td>
<td>A. Richardson</td>
</tr>
<tr>
<td>2013</td>
<td>Ph.D.</td>
<td>Fabrice Jaine</td>
<td>The movement ecology of the manta ray <em>Manta alfredi</em>: a case study off eastern Australia</td>
<td>S. Weeks, A. Richardson, M. Bennett and K. Townsend.</td>
</tr>
<tr>
<td>2013</td>
<td>Ph.D.</td>
<td>Chris Rohner</td>
<td>Biological and oceanographic influences on whale shark abundance and feeding ecology</td>
<td>A. Richardson, M. Bennett, S. Pearce and S. Weeks</td>
</tr>
<tr>
<td>Year</td>
<td>Degree</td>
<td>Name</td>
<td>Title</td>
<td>Author(s)</td>
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</tr>
<tr>
<td>2013</td>
<td>Ph.D.</td>
<td>Lucy Robinson</td>
<td>Potential impacts of future climate change on the distribution of pelagic fish and fisheries off the east coast of Australia</td>
<td>A. Richardson and H. Possingham</td>
</tr>
<tr>
<td>2012</td>
<td>Ph.D.</td>
<td>Chris Brown</td>
<td>Effects of climate change on marine ecosystems and potential management responses</td>
<td>A. Richardson</td>
</tr>
<tr>
<td>2012</td>
<td>Honours</td>
<td>Kate Picone</td>
<td>Plankton dynamics in relation to climate variability</td>
<td>A. Richardson</td>
</tr>
<tr>
<td>2012</td>
<td>Honours</td>
<td>Robbie Pearce</td>
<td>Dynamics of managed consumer-resource systems</td>
<td>P. Baxter and C. Holmes</td>
</tr>
<tr>
<td>2012</td>
<td>Honours</td>
<td>Kirsty Howard</td>
<td>Potential effects of the re-zoning of the Great Barrier Reef Marine Park on commercial fisheries catch</td>
<td>A. Richardson, J. Kirkwood and P. Moss</td>
</tr>
<tr>
<td>2012</td>
<td>Honours</td>
<td>Natalie Kerr</td>
<td>Identifying cost-efficient approaches for managing weeds: applying an economic sensitivity analysis to matrix population models of invasive plant species</td>
<td>Y. Buckley and P. Baxter.</td>
</tr>
<tr>
<td>2011</td>
<td>Honours</td>
<td>Andrew Jones</td>
<td>Genetic estimates of effective population size</td>
<td>Y-G. Wang and J. Ovenden</td>
</tr>
<tr>
<td>2010</td>
<td>Honours</td>
<td>Liza Roger</td>
<td>Comparison of shell structure of two tropical thecosome pteropods (Creseis acria and Diacavolini longirostris) over a 45-year period</td>
<td>A. Richardson</td>
</tr>
</tbody>
</table>

**ONGOING GRANTS**

**ARC**


Hallegraeff, G.M. & Richardson, A.J. (2013-2015). *Climate-driven windblown dust and flood runoff can increase marine diseases by fungal pathogens*. ARC Discovery, $268,000


Richardson, A.J. (2010-2013). *The resilience of marine ecosystems and fisheries to climate change: exploring adaptation strategies*. ARC Future Fellowship, $789,000
ARC Centre of Excellence


Invasive Animals CRC


Harris S., Baxter P., Ramsey D., Caley P., Barclay C., Saunders G., & Elliott C. *Long-term strategy for the Tasmanian Fox Program*. $282,000 (subject to final approval).

Baxter P., Cacho O., McDonald-Madden E., Possingham H. *Reliable pest animal decisions*. Invasive Animals Cooperative Research Centre, $116,000. (subject to final approval).

Others


Helmstedt, K. (Jan 7 to April 5 2013). *Travel award to visit the Institut Henri Poincare (attendance for 1 trimester)*, Fondation Sciences Mathématiques de Paris, €6660.


**TEACHING AND SUPERVISION**

Collectively CARM staff provide access to a wealth of specialised knowledge and skills in research areas in which there is a recognised skills shortage both nationally and internationally. The School of Mathematics and Physics has been encouraging us to contribute to teaching established undergraduate courses. In addition, we have also taken part in expanding student learning opportunities through the introduction of new courses such as our “flagship” course in Natural Resource Mathematics, a special topic in longitudinal data analysis, and a reading course in Bayesian statistics which was run in response to student demand. These courses help to bridge a crucial gap in students’ training, that is, the gap between mathematical theory and the ability to apply these skills in real world or workplace settings.

As well as undergraduate teaching we also provide highly expert supervision to research students from mathematics and other departments who may not otherwise have been able to access this knowledge. For example, recently CARM staff have given training in the highly specialised area of state-space modelling to UQ research students. This was applied to the significant problems of modelling Queensland fish movements and building Bayesian economics models; this work was achieved through CARM’s collaboration with students working in environmental sciences and economics, respectively.
Mathematical skills will be even in more demand in the future as technology advances rapidly and pressure on natural resources increases. In this way, CARM’s active and enthusiastic role in helping to train new generations of scientists in these fields not only brings value to this leading institution, but also strengthens the key capacities that will ensure that our graduates will continue to make Australian scientists internationally competitive into the future.

CARM Flagship Course

MATH2070/MATH7004. Semester 2. (2013 & 2012). Baxter, P.W.J, Lemos, R.T. & Richardson, A.J. This new course in Natural Resource Mathematics started in July 2012. Students taking this course learn to: apply modern mathematical and statistical methods for dynamic systems; model populations and investigate impacts of climate change, overfishing, pollution and habitat destruction; and communicate their work to scientists and decision makers. CARM members have designed the course so students will be employable in a number of growing fields of natural resource management and conservation, especially with State and Federal Governments, universities and NGOs. Student numbers, 2013: 18 / 2012: 9.

Other Courses


Reading Course in Bayesian Statistics. Semester 2. (2013). McGrory, C. Student numbers, 2 (Honours Level). This course introduces Bayesian statistical inference and teaches students how to implement Bayesian inference solutions to real world problems. This course was provided in response to demand from School of Mathematics and Physics honours students.

HRSS3100/7806. Semester 1. (2013). McGrory, C. Research Methodology. This is a service course in which basic statistical methodology is taught to health science students. There are a large number of students (around 330-360) enrolled in this course.

MARS3012. Semester 1. (2013 & 2012). Richardson, A.J & Weeks, S. This an Introduction to Oceanography course that covers physical, chemical and biological oceanography, including remote sensing.

STAT6003/STAT7703/MATH4001. Semester 2. (2013). Wang, Y-G. Longitudinal Data Analysis. This is a new course developed to fill the gap in statistical curriculum in the discipline of Mathematics at UQ.

Guest Lectures

Wang, Y-G. Semester 1 (2013). ‘Efficient designs for sampling and sub sampling in fisheries research’, STAT3003 Experimental design, School of Mathematics and Physics, UQ.

Richardson, A.J. Semester 1 (2013): ‘Marine systems and climate change’, BIOL3236 Biological adaptation to climate change, School of Biological Sciences, UQ.

Thesis Committees

Professor You-Gan Wang:

2012: M.Sc., Kelly Wang -- Optimization of mixed models via estimation of distribution algorithms

2012: PhD confirmation committee, Matt Tehan, SMP

2012: PhD confirmation committee, Kate Helmstedt, SMP

2012: PhD mid-term review, Chooi Ng, SMP

2011: PhD confirmation committee, Nils Krück, SBS

2010: PhD confirmation committee, Bo Gao, SMP
Associate Professor Anthony Richardson:
2013: PhD confirmation committee, Brigitte Sommer, SBS
2013: PhD confirmation committee, Chooi Ng, SMP
2012: PhD mid-term review, Jude Keyse, SBS
2012: PhD mid-term review, Brigitte Sommer, SBS
2010: PhD mid-term review, Carissa Klein, SBS

Dr Peter Baxter:
2013: Ph.D. confirmation committee, Chang Liu, SMP
2012: B.Sc. Honours committee, Sean Maxwell, SBS
2011: B.Mar.St. Honours committee, Kirsty Howard, SBS

Dr Ricardo Lemos:
2013: MSc committee, Bo Chen, SMP

POTENTIAL NEW PHD PROJECTS
CARM has thirteen potential new PhD projects. Information on each of these projects is available on the CARM web site http://www.smp.uq.edu.au/CARM

COMMUNICATION
Presentations


Kate Helmstedt: ‘Cost-efficient fenced exclosures for conservation: large or small?’, July 2013, Mathematics of Planet Earth AMSI conference, Melbourne, Australia.


Peter Baxter: ‘Cost-efficient forest management for endangered woodpecker recovery’, November 2011, ARC Centre of Excellence in Environmental Decisions, The University of Melbourne, Melbourne, Australia.

Peter Baxter: ‘Cost-efficient forest management for endangered species recovery’, Brisbane Applied Mathematics Seminar Series, October 2011, Queensland University of Technology, Brisbane, Australia.


Conferences/Workshops Organised

Bayesian Modelling Using R. (November 2013). McGrory, C. & Alston, C. Introduces the Bayesian approach to statistical inference and teaches participants how to implement some commonly used statistical models in the Bayesian setting using R programming.

R Workshops @ UQ. Workshop 1: Introduction to R (November 2013). Richardson, A.J., & Schoeman, D. R has become the standard tool for data analysis among statisticians and research scientists. Workshop 1: Introduction presented by Anthony Richardson (UQ) and Dave Schoeman (USC) is for people who have had little or moderate experience with R and want to learn how to produce robust analyses and graphics (60 participants). 2013 is the first year CARM introduced registration fees.

R Workshops @ UQ. Workshop 2: Advanced R. (November 2013). Venables, W. R has become the standard tool for data analysis among statisticians and research scientists. Workshop 2: Advanced R presented by Bill Venables (CSIRO) requires participants to several years’ experience of using R or reasonable statistical expertise (20 participants). 2013 is the first year CARM introduced registration fees.

The SMOR seminar series commenced in early 2013, succeeding the earlier CARM/CSTAT seminar series. To date there have been 21 speakers representing 17 institutions across 18 countries. For a list of talks see the CARM website.

**Statistics, Modelling and Operations Research Seminars**

To better engage with the Mathematics Department CARM now runs research seminars jointly with the Operations Research and Statistics research groups.

The SMOR seminar series commenced in early 2013, succeeding the earlier CARM/CSTAT seminar series. To date there have been 21 speakers representing 17 institutions across 18 countries. For a list of talks see the CARM website.

**CARM Student Group Meetings**

Fortnightly CARM Student Group Meetings started in June 2011. These Wednesday meetings expose students to other ideas and ongoing work in the Centre. Students have the opportunity to give an update of what they are doing in a ‘round the table’ discussion followed by a student or staff presentation.
MAJOR COLLABORATIONS

DAFF

Management strategy evaluation of Queensland’s east coast trawl fishery
Objectives: (i) Quantify annual fishing power increases and changes in prawn abundance; (ii) Quantify prawn catchability coefficients; (iii) Develop models and data rules for identifying target fishing effort and catch rates; (iv) Develop multi-species spatial assessment models for evaluating management and stock status reference points.

Assessments of the status of Queensland’s east coast and Gulf of Carpentaria shark fisheries
Objectives: (i) Develop standardised indices of abundance for the major species/taxa; (ii) Review monitoring strategies and developing assessment modelling tools; (iii) Reviewing the status of the “stock” in relation to the commercial catch quota; (iv) Develop empirical management procedures.

Estimation of recreational fish catches
Objectives: (i) Develop hierarchical and conditional mixed models for estimation of recreational fish catch and catch rates; (ii) Investigate the standardisation of recreational survey data collected from multiple survey methods; (iii) From survey to analysis: dealing with differences in the scale survey data are collected at and the scale data are analysed at, (iv) Assess changes in angler avidity and recall bias between survey years and methodologies; (v) Examine appropriate estimation methods for different species; (vi) Develop methods for low abundance or recreational species caught by ‘hard-to-reach’ fishers.

Fishery-dependent monitoring of Queensland’s fisheries: Reviewing routine collection of length and age data, and routine analysis.
Objectives: Review and evaluate efficient sampling programs: Is the right amount of sampling occurring for each species? Are there any significant biases in the sampling programs for each species? Assess whether routine analyses are being carried out correctly, and to develop new analyses for fisheries management.

Physical oceanographic influences on Queensland reef fish and scallops
Objectives: (i) review recent advances in the study of physical oceanographic influences on fisheries catch data and describe the major potential influences on Queensland reef fish and saucer scallops; (ii) collate Queensland’s physical oceanographic and fisheries data; (iii) develop stochastic population dynamics models for reef fish and saucer scallops, which can link environmental influences (e.g., sea surface temperature) to catch rates, biological parameters (e.g., growth, reproduction, natural mortality) and ecological aspects (e.g., spatial distribution); (iv) forecast the dispersion of reef fish and scallop larvae in the southern GBR region.

East Queensland grey mackerel stock assessment
Objectives: Develop a regional, sex- and age-structured population model for the east Queensland grey mackerel; estimate east coast wide and regional quota levels; suggest regional management responses.
Other External Collaborations

Australia
Institute of Geography and Limnology, Charles Darwin University; University of New England; University of Adelaide; University of Melbourne; CSIRO; Queensland University of Technology; University of Sydney; University of the Sunshine Coast.

Other
Chinese Academy of Sciences, China; Harvard University, USA; Landcare Research, New Zealand; University of Glasgow, UK; University of the Western Cape, South Africa; University of Cape Town, South Africa; Sir Alister Hardy Foundation for Ocean Science, UK; University of Alberta, Canada.

Ricardo Lemos April USA Visit - Research collaboration with UC Santa Cruz and NOAA staff, under project LEMOS 12 UQNSRSF. Full names of collaborators: Bruno Sansó (UCSC) and Roy Mendelsohn (NOAA).

For a graphic representation, see cover page.

UQ Collaborations

We have ongoing collaborative research with the following UQ institutions:

School of Civil Engineering: Coal seam gas modelling (ARC Linkage grant) and water discharge at Three Gorges Dam.

School of Geography Planning and Environmental Management: Joint supervision of PhD and honours students, thesis committees, lectures.

School of Biological Sciences: Joint supervision of PhD and Honours students, Thesis committees, Guest lectures.

ARC Centre of Excellence for Environmental Decisions (CEED): Joint supervision of PhD and Honours students.

Centre for Medical Diagnostic Technologies in Queensland (MedTeQ), Centre for Magnetic Resonance (CMR) and Imaging Research Laboratory: Joint research.

Queensland Alliance for Agriculture and Food Innovation (QAAFI): Exploring collaborative opportunities in the area of genomic research for cattle, image analysis, population modelling.

Sustainable Minerals Institute and Seqwater: Potential opportunities to collaborate with the Sustainable Minerals Institute and Seqwater via ARC linkage grants on Phytoremediation of mined land and water quality.

Centre for Clinical Research and Royal Brisbane and Women’s Hospital: Establishing joint PhD student supervision.

Visitors

Dr Olena Kravchuk, (5-12 October), The University of Adelaide
Professor Bhaswati Ganguli and Professor Sugata Sen Roy, (September 28 to October 14), University of Calcutta, India
Dr John Ormerod, (19 to 23 August), University of Sydney
Prof. Bean San Goh, (14 to 15 February), Curtin University Sarawak, Malaysia
Prof. Laiqing Chen and fellow researchers, (January 25), Guangzhou Academy of Social Sciences, China
Dr Jianwen (Owen) Xu, (July 10, 2012 to July 5, 2013), Department of Statistics and Actuarial Science at Chongqing University in China, visited UQ (funded by his University).
Prof. Bruno Sansó, (October 29 to November 4, 2012), Department of Applied Mathematics and Statistics, University of California Santa Cruz, USA
Richardson, A.J. & Baxter, P.W.J. (September 17 to 18, 2012), post-doctoral fellow, North Australian Marine Research Alliance, Charles Darwin University, Australia

Prof. Denis Leung, (June 18 to July 25, 2012), Ethel Raybould Visiting Fellow, Singapore Management University, Singapore. (Ethel Raybould Fellowship)

Dr Liya Fu, (January 11, to December 31, 2011), visiting postdoc fellow, School of Mathematics and Statistics, Xi’an Jiaotong University, China

SERVICE

External Committees

Forum on technical developments in the detection and eradication of red imported fire ant’, February and December 2012, Baxter, P.W.J. Peter Baxter was a member of ‘Forum on technical developments in the detection and eradication of red imported fire ant’ which submitted an evaluation report to the national management group (via the tramp ant consultative committee) for the national red imported fire ant eradication program.

Memberships and Awards

Resource Modeling Association (RMA) Board of Officers, Baxter, P.W.J: Peter Baxter was recently appointed a Director of the RMA. Peter is an active RMA member, serving as the Conservation Editor for its journal Natural Resource Modeling as well as hosting the 2012 World Conference on Natural Resource Modeling.

Biometrics Editorial Board, Wang, Y-G: Invited to join the Biometrics Editorial Board as an Associate Editor (July 2013-June 2015). Biometrics is one of the top ranked journals in statistics (A*).

International Statistical Institute, Wang, Y-G: Elected as a member of the International Statistical Institute, the worldwide network of statisticians in all statistical disciplines.

Outreach and Media


Richardson, A.J. (May 2013). ‘Maximising your publishing success’, UWA Oceans Institute, The University of Western Australia

Richardson, A.J. with Poloczanska, E.S., Schoeman, D., Burrows, M. & Brown, C.J. (May 2013). ‘Climate change and marine life: global analysis and collaboration’, UWA Oceans Institute, The University of Western Australia

Wang, Y-W. (January 2013) ‘Predicting the top 100 songs in Australia’s JJJ Hottest 100’, The Vine

Richardson, A.J. (July 2013). Tertiary Studies Expo, RNA Showgrounds, Brisbane

Richardson, A.J. Contributing Author to the IPCC Fifth Assessment Report Chapter 30 on the Regional Oceans due out in 2014. As part of the Marine Climate Impacts and Adaptation team at CSIRO, produced the 2012 Marine Climate Change in Australia Report Card. This informs the general public and helps support the development of the Government’s policy response to the impact of climate change on marine biodiversity. This was reported by SBS World News, Channel 9 MSN, ABC News 24, Sky News Australia, The Australian, French Tribune, Times of India, Science daily press release, AFP, ABC online, Brisbane Times, The Queensland Times, NEWS.com.au, Hume Weekly, UPI.com, Revmodo, FIS Australia, IBTimes.co.uk, The Conversation, International Business Times, Cosmos, Hungarian National Association of Radio Distress- Signalling and Infocommunications (RSOE), Fiji Times, Ocean Sentry, Mercopress, FRDC, uk.news.yahoo.com, and AdelaideNow.

PUBLICATIONS


Marine Biology, 66, 1-86.


YEAR 2012


management, *Reviews in Fish Biology and Fisheries*, 22, 827-834.


**YEAR 2011**


YEAR 2010


