ANNUAL REPORT

2019-2020

Contents

Welcome and introduction

We are pleased to present the 2019-2020 annual report for the CSIRO-UTAS PhD Program in Quantitative Marine Science (QMS), now in its 5th year under the renewed 5-year commitment that began 1 July 2015, and in its 15th year of operation overall.

The purpose of the QMS program is to enhance the quality and number of Australian PhD graduates in quantitative marine science, and to develop scientists with skills appropriate for potential employment by CSIRO and other organisations in the quantitative marine science field.

In early 2020 the program was reviewed by a CSIRO/UTAS panel. The review outcomes were positive and encouraging, and also pointed to some pathways for improvement, specifically a review of coursework that we will undertake in the coming year.

Key Challenges, strategies, and achievements

- UTAS funding for scholarships continues at adequate levels. All UTAS academic units have targets for research higher degree enrolments. These targets are becoming difficult to meet solely from traditional sources of funding such as Research Training Program scholarships. Full or partial funding of students by the QMS program, industry, Centres of Excellence, ARC Discovery Projects and the Centre for Marine Socioecology are all looked on favourably when admission decisions are made.
- The QMS program continues to attract a higher number of international students than domestic students. This may become a challenge for the program as UTAS implements quotas on the ratio of domestic to international students.
- We continue to rejuvenate the project offerings on the QMS website to better reflect current supervision expertise and attract quality applicants.
- We are continually working to keep the course offerings relevant. We will continue to monitor the new structure and review the coursework this coming year.
- QMS conference funding continues to provide skilling and networking opportunities for our candidates, such as speaking at international symposia and conferences, enhancing the QMS brand.

It is a great pleasure to be part of the program, and we are very proud of our students.

Sincerely

Peter Strutton, Director, QMS Program

Current steering committee membership

- Peter Strutton (IMAS, Director/Chair)
- Zanna Chase (IMAS)
- Klaas Hartmann (IMAS)
- Richard Matear (CSIRO)
- Peter Thompson (CSIRO), now retired. A new CSIRO member will be appointed.
- Simon Wotherspoon (IMAS, ex-officio)

Statistics on enrolments, scholarships, submissions, and graduations

Summary of student enrolments

The QMS Program was launched in 2004. Since then a total of 73 students have graduated from the Program, approximately 6 graduations per year. The enrolments per year for the current and previous 5-year contract are shown below.

Financial Year	Number of Students	*International*	*Domestic*
2010-2011	**3**	*2*	*1*
2011-2012	**9**	*6*	*3*
2012-2013	**6**	*4*	*2*
2013-2014	**3**	*3*	*0*
2014-2015	**10**	*6*	*4*
2015-2016	**15**	*11*	*4*
2016-2017	**9**	*9*	*0*
2017-2018	**6**	*3*	*3*
2018-2019	**4**	*3*	*1*
2019- 2020	**7**	*7*	*0*
Applications Accepted (not commenced)	**2**	*2*	*0*

QMS full + top-up scholarships awarded 1 July 2019- 30 June 2020

Rani Ekawaty (International)
Qianjiang Xing (International)
Sofia Gabriel (International)
Yu Wang (International)
Ahmad Widyatmoko (International)
Charley Gros (International)
Xihan Zhang (International)

QMS top-up scholarships awarded 1 July 2019- 30 June 2020

None

Graduates 2019-2020

Name	Supervisors	Research Project
Jessica Ericson	Patti Virtue Peter Nichols	Mapping the lipid content and composition of Antarctic krill across space and time: A quantitative approach to estimating krill recruitment in the present and future Southern Ocean
Madeline Green	Sean Tracey Sharon Appleyard William White	Population Connectivity of Sharks in the Western South Pacific
Vicki Hamilton	Mark Hindell Karen Evans	Using Tooth Growth Chronologies to Investigate Responses of Marine Mammals to Variability in the Marine Environment
Thibaut Houitte de La Chesnais	Gretta Pecl Sean Tracey Beth Fulton	The Role of Cephalopods in the Structure and Functioning of Marine Ecosystems
Javier Porobic	Stewart Frusher Beth Fulton	An ecosystem-based management framework for the Juan Fernandez ridge fisheries
Samantha Twiname	Gretta Pecl Chris Carter Alistair Hobday Quinn Fitzgibbon	Mechanistic Understanding of Climate-Driven Range Shifts: Using thermal tolerances of rock lobster to predict future change
Roxanna Vasile	Klaas Hartmann Sean Tracey Eric Oliver Alistair Hobday	Rock Lobster Larval Dispersal Modelling
Alessandro Silvano	Guy Williams Steve Rintoul	Observations of Ocean –Ice Shelf Interaction at the Totten Glacier
Swan Sow	Philip Boyd Tom Trull	Microbial Oceanography of the Southern Ocean Water Masses
Ana Berger	Max Nikurashin Bernadette Sloyan	Variability and dynamics of the Indonesian Throughflow
Curtis Champion	Sean Tracey Alistair Hobday Gretta Pecl	Responses to Warming Waters: Range extension in marine fishes from South-East Australia
Yannick Rousseau	Reg Watson Julia Blanchard Beth Fulton	Predicting the future of global seafood production

Submitted theses 2019-2020

Name	Supervisors	Research Project
Ajitha Cyriac	Helen Phillips Nathan Bindoff Ming Feng	Eastward Flows, Ocean Mixing and Air-Sea Interaction in the Southeast Indian Ocean
Asher Riaz	Andreas Klocker Nathan Bindoff Terence O'Kane Max Nikurashin	Closing the Energy Cycle in Global Ocean Models
Samantha Peel	Nicole Hill Simon Wotherspoon Scott Foster	Statistical Issues for Mapping Biodiversity in the Southern Ocean
Ram Patel	Helen Phillips Andrew Lenton Pete Strutton Joan Llort Jordi	The Physical and Bio-Optical Structure of Southern Ocean Eddies in Observations and Models
Saurabh Rathore	Nathan Bindoff Helen Phillips Ming Feng	The impact of recent Indian Ocean warming on the circulation, watermass distribution and air-sea interaction in the Indian Ocean
Romain Forestier	Julia Blanchard Craig Johnson Kirsty Nash Asta Audzijonyte	Modelling biodiversity related ecosystem processes as a Complex Adaptive System

Summary of graduates

Since 2010 there has been a total of 60 students have graduated from the program.

Year	Number of students	Year	Number of students
2010	8	2019	8
2011	5	2020	3
2012	5	**Total**	60
2013	9		
2014	3		
2015	5		
2016	5		
2017	6		
2018	3		

Overview of current student projects

Student	Started	Citizenship	Scholarship	Topic	Primary Supervisor	CSIRO Supervisor
Abhishek Savita	5/06/2017	Int	IMAS	Global and regional sea level sensitivity to changing ocean water mass properties and circulation processes	Domingues, Catia	Marsland, Simon
Stephen Bradshaw	12/7/2017	Dom	IMAS	Environmental drivers of Southern Rock Lobster productivity	Hartmann, Klaas	Haddon, Malcolm
Florence Briton	3/12/2018	Int	QMS/ IFREMER	Evaluation of Harvest Control Rules for Mixed Fisheries Under Catch Quota Management	Gardner, Caleb	Little, Rich
Sandra Curin Osorio	20/04/2017	Int	BECAS	Identifying Fish Stocks Prone to Interdecadal Productivity Shifts Across Different Worldwide Marine Ecosystems	Frusher, Stewart	Geoff Tuck
Florian Devloo-Delva	15/05/2017	Int	SET	From Rivers to Ocean Basins: Quantifying Sex-specific Connectivity in Sharks	Burridge, Chris	Feutry, Pierre
Emilio Echevarria	28/06/2017	Int	IMAS	Global to Coastal Implications of Surface Current Modulation of the Wind-Wave Field	Holbrook, Neil	Hemer, Mark
Rani Ekawaty	1/8/19	Int	QMS	Harvest Strategies for Tasmanian Coastal Fisheries Shared Between Recreational and Commercial Sectors	Gardner, Caleb Hartmann, Klaus	Davies, Campbell
Sofia Gabriel	28/10/19	Int	QMS	Examining Habitat use and Behaviour of White Sharks	Semmens, Jayson	Patterson, Toby
Kirianne Goossen	18/01/2016	Int	QMS	Microbial oceanography of Australian Coastal Waters	Bowman, John	Bodrossy, Lev
Charley Gros	4/3/20	Int	QMS	Quantifying and Predicting Vulnerable Marine Ecosystems (VMEs) on the Antarctic Continental Shelf	Nicole Hill	Dunstan, Piers Welsford, Dirk
Freddie Heather	21/06/2017	Int	IMAS	Development of a new class of size-structured ecological model for assessing human impacts on coastal food webs	Stuart-Smith, Rick	Bax, Nic
Nicholas Hill	22/01/2018	Dom	Heather Brown	Harvest Strategies for Data Poor Tasmanian Coastal Fisheries	Gardner, Caleb	Little, Rich
Zeya Li	5/11/18	Int	COSE	Understanding ENSO Event Modulation of Marine Heatwaves	Holbrook, Neil	Zhang, Xuebin
Stephy Libera	3/4/2019	Int	QMS	The Ocean's role in driving Antarctic Sea Ice Trends	Hobbs, Will	Matear, Richard
Jiale Lou	28/03/2017	Int	ARCCSS	Predictability of the Interdecadal Pacific Oscillation	Holbrook, Neil	O'Kane, Terence
Maxime Marin	11/10/2017	Int	IMAS	Marine heat waves in the southeast Indian Ocean	Phillips, Helen	Feng, Ming
Jan Jaap Meijer	1/08/2017	Int	IMAS	An Observational Study of the Role of Standing Meanders in Slowing the ACC and Transporting Heat to Antarctica	Phillips, Helen	Rintoul, Stephen
Kieran Murphy	28/11/2016	Int	IMAS	Life in the fast lane: understanding individual to community level processes of squid in a changing climate	Blanchard, Julia	Richards, Shane
Amy Nau	2/06/2015	Per Res	TGRS	Mapping the Middle: Analysis of the water column using acoustic and optical methodologies	Lucieer, Vanessa	Martin, Tara

Nic Pittman	18/06/2018	Dom	IMAS	Climate-Driven Variability in Tropical Pacific Productivity	Strutton, Pete	Matear, Richard
Brett Stacy	17/12/18	Int	QMS	Optimising Data Collection and Robust Tag-Based Assessment Strategies for Exploratory Fisheries	Hartmann, Klaas	Ziegler, Philippe Burch, Paul
Yu Wang	3/2/19	Int	QMS	Mesoscale Eddy Energetics and the Shelf-Open Ocean Tracer Exchange in the East Australian Current Region	Nikurashin, Max	Pena-Molino, Beatriz Sloyan, Bernadette
Ahmad Widyatmoko	2/3/19	Int	QMS	Applying New Tracking Technologies and Optimal Foraging Theory to Understand Small Scale Fisheries and Address Illegal Fishing	Tracey, Sean	Wilcox, Chris Hardesty, Denise
Qianjiang Xing	16/09/19	Int	QMS	How the Complexity of Continental Breakup Controls Ocean Circulation	Klocker, Andreas	Rintoul, Steve
Xihan Zhang	11/5/19	Int	QMS	The Role of Small Scale Ocean Dynamics for the Equilibration of the Antarctic Circumpolar Current and for its Sensitivity to Winds	Nikurashin, Max Doddridge, Ed	Pena-Molino, Beatriz Rintoul, Steve

QMS sponsored conference travel

QMS funded $10,000 in travel for 2019/2020. Students were awarded funds in the last round of 2019. No travel funding occurred in 2020 because of COVID 19 restrictions:

- **Maxime Marin**, AGU Ocean Sciences Meeting 2020, San Diego, $2,500
- **Abhishek Savita**, AGU Ocean Sciences Meeting 2020, San Diego, $2,500
- **Yannick Rousseau**, Marine Socio-Ecological Systems International Symposium (MSEAS 2020), Japan, $2,500
- **Asher Riaz**, AGU Ocean Sciences Meeting 2020, San Diego, $2,500

QMS supported write-up scholarship

Name	Date started	Amount Awarded
Rich Cottrell	14/9/2019	$8,000
Yannick Rousseau	2/9/2019	$8,000
Swan Li-San Sow	1/7/2019	$8,000
Ana Berger	6/4/2020	$8,000

QMS supervisors

UTAS Supervisor	Number of current students	CSIRO Supervisors	Number of current students	Supervisors from other institutions	Number of current students
Audzijonyte Asta	1	Appleyard, Sharon	1	Hogg, Andrew (ANU)	1
Bindoff, Nathaniel	7	Bax, Nic	1	Massom, Rob (AAD)	1
Blanchard, Julia	5	Bodrossy, Lev	1	Welsford, Dirk (AAD)	1
Bowman, John	1	Burch, Paul	1		
Boyd, Phillip	1	Davies, Campbell	1		
Burridge, Chris	1	Dobrohotoff, Peter	1		
Carter, Chris	2	Dunstan, Piers	1		
Chase, Zanna	1	Feng, Ming	2		
Coleman, Richard	1	Feutry, Pierre	1		
Domingues, Catia	2	Foster, Scott	1		
Edgar, Graham	1	Fulton, Beth	2		
Frusher, Stewart	2	Haddon, Malcolm	1		
Gardner, Caleb	3	Hardesty, Denise	1		
Hartmann, Klaas	4	Hemer, Mark	1		
Hill, Nicole	1	Hobday, Alistair	3		
Hindell, Mark	2	Legresy, Benoit	1		
Hobbs, Will	3	Lenton, Andrew	1		
Holbrook, Neil	3	Little, Rich	2		
Johnson, Craig	1	Martin, Tara	1		
Klocker, Andreas	2	Matear, Richard	4		
Llort Jordi, Joan	1	Nichols, Peter	1		
Lucieer, Vanessa	1	O'Kane, Terence	2		
Meyer, Amelie	1	Patterson, Toby	1		
Michael, Kelvin	2	Pena-Molina, Beatriz	2		
Moore, Brad	3	Richards, Shane	1		

Moreno, David	1	Rintoul, Stephen	4
Nash, Kirsty	1	Sloyan, Bernadette	3
Nikurashin, Max	5	Trull, Thomas	1
Oliver, Eric	1	Tuck, Geoff	1
Pecl, Gretta	3	Wilcox, Chris	1
Phillips, Helen	6	Zhang, Xeubin	1
Phipps, Steven	1	Ziegler, Philippe	1
Semmens, Jayson	3		
Strutton, Peter	3		
Stuart-Smith, Rick	1		
Swadling, Kerrie	1		
Tracey, Sean	4		
Virtue, Patti	1		
Watson, Reg	2		
Whittaker, Jo	1		
Wotherspoon, Simon	3		

Summary of QMS teaching (unit breakdown)

Unit	Teaching Staff UTAS	Other Teaching Staff
QMS511 Physical Oceanography	Maxim Nikurashin Jo Whittaker	Bernadette Sloyan
QMS512 Marine Biogeochemistry	Zanna Chase Pete Strutton Delphine Lannuzel Hakase Hayashida Bernadette Proemse	Eric Mortensen Monika Wozniak Kristen Karsh
QMS517 Data Analysis Methods	Simon Wotherspoon	
QMS510 Introduction to Quantitative Marine Science	Simon Wotherspoon	
QMS513 Fisheries Science	Caleb Gardener Klaas Hartmann Craig Munday Sean Tracey Emily Ogier Jayson Semmens Rafael Leon	

QMS student publications – 2019-2020

QMS student authors are indicated in bold. Publications have been included until one year after graduation to allow for delays in the publication process.

Alexander, K. A., A. J. Hobday, C. Cvitanovic, E. Ogier, K. L. Nash, **R. S. Cottrell**, A. Fleming, et al. 2019. "Progress in Integrating Natural and Social Science in Marine Ecosystem-Based Management Research." *Marine and Freshwater Research* 70 (1): 71–83. https://doi.org/10.1071/MF17248.

Audzijonyte, Asta, Heidi Pethybridge, **Javier Porobic**, Rebecca Gorton, Isaac Kaplan, and Elizabeth A. Fulton. 2019. "Atlantis: A Spatially Explicit End-to-End Marine Ecosystem Model with Dynamically Integrated Physics, Ecology and Socio-Economic Modules." *Methods in Ecology and Evolution* 10 (10): 1814–19. https://doi.org/10.1111/2041-210X.13272.

Briton, Florence, Claire Macher, Mathieu Merzeréaud, Christelle Le Grand, Spyros Fifas, and Olivier Thébaud. 2020. "Providing Integrated Total Catch Advice for the Management of Mixed Fisheries with an Eco-Viability Approach." *Environmental Modeling & Assessment* 25 (3): 307–25. https://doi.org/10.1007/s10666-019-09685-7.

Briton, Florence, Lynne Shannon, Nicolas Barrier, Philippe Verley, and Yunne-Jai Shin. 2019. "Reference Levels of Ecosystem Indicators at Multispecies Maximum Sustainable Yield." *ICES Journal of Marine Science* 76 (7): 2070–81. https://doi.org/10.1093/icesjms/fsz104.

Buchanan, Pearse J., Richard J. Matear, Zanna Chase, Steven J. Phipps, and Nathan L. Bindoff. 2019. "Ocean Carbon and Nitrogen Isotopes in CSIRO Mk3L-COAL Version 1.0: A Tool for Palaeoceanographic Research." *Geoscientific Model Development* 12 (4): 1491–1523. https://doi.org/10.5194/gmd-12-1491-2019.

Clavel-Henry, Morane, Jordi Solé, Miguel-Ángel Ahumada-Sempoal, Nixon Bahamon, **Florence Briton**, Guiomar Rotllant, and Joan B. Company. 2019. "Influence of the Summer Deep-Sea Circulations on Passive Drifts among the Submarine Canyons in the Northwestern Mediterranean Sea." *Ocean Science* 15 (6): 1745–59. https://doi.org/10.5194/os-15-1745-2019.

Cottrell, Richard S., Kirsty L. Nash, Benjamin S. Halpern, Tomas A. Remenyi, Stuart P. Corney, Aysha Fleming, Elizabeth A. Fulton, et al. 2019. "Food Production Shocks across Land and Sea." *Nature Sustainability*, January, 1. https://doi.org/10.1038/s41893-018-0210-1.

Devloo-Delva, Floriaan, Roger Huerlimann, Gladys Chua, Jordan K. Matley, Michelle R. Heupel, Colin A. Simpfendorfer, and Gregory E. Maes. 2019a. "How Does Marker Choice Affect Your Diet Analysis: Comparing Genetic Markers and Digestion Levels for Diet Metabarcoding of Tropical-Reef Piscivores." *Marine and Freshwater Research* 70 (1): 8–18. https://doi.org/10.1071/MF17209.

———. 2019b. "How Does Marker Choice Affect Your Diet Analysis: Comparing Genetic Markers and Digestion Levels for Diet Metabarcoding of Tropical-Reef Piscivores." *Marine and Freshwater Research* 70 (1): 8–18. https://doi.org/10.1071/MF17209.

Echevarria, E. R., M. A. Hemer, and N. J. Holbrook. 2019. "Seasonal Variability of the Global Spectral Wind Wave Climate." *Journal of Geophysical Research: Oceans* 124 (4): 2924–39. https://doi.org/10.1029/2018JC014620.

Ekawaty, R., J. Lynham, and P. Mous. 2020. "Can Demand-Side Management Replicate a Size Limit in a Small-Scale Fishery?" *Fisheries Research* 223. https://doi.org/10.1016/j.fishres.2019.105436.

Ericson, Jessica A., Nicole Hellessey, So Kawaguchi, Peter D. Nichols, Stephen Nicol, Nils Hoem, and Patti Virtue. 2019. "Near-Future Ocean Acidification Does Not Alter the Lipid Content and Fatty Acid Composition of Adult Antarctic Krill." *Scientific Reports* 9 (1): 1–10. https://doi.org/10.1038/s41598-019-48665-5.

Ericson, Jessica A., Nicole Hellessey, Peter D. Nichols, Stephen Nicol, So Kawaguchi, Nils Hoem, and Patti Virtue. 2019. "New Insights into the Seasonal Diet of Antarctic Krill Using Triacylglycerol and Phospholipid Fatty Acids, and Sterol Composition." *Polar Biology* 42 (11): 1985–96. https://doi.org/10.1007/s00300-019-02573-6.

Focardi, Amaranta, Martin Ostrowski, **Kirianne Goossen**, Mark V. Brown, and Ian Paulsen. 2020. "Investigating the Diversity of Marine Bacteriophage in Contrasting Water Masses Associated with the East Australian Current (EAC) System." *Viruses* 12 (3): 317. https://doi.org/10.3390/v12030317.

Green, M. E., S. A. Appleyard, W. White, S. Tracey, **F. Devloo-Delva**, and J. R. Ovenden. 2019. "Novel Multimarker Comparisons Address the Genetic Population Structure of Silvertip Sharks (Carcharhinus Albimarginatus)." *Marine and Freshwater Research* 70 (7): 1007–19. https://doi.org/10.1071/MF18296.

Healy, Teleah Joy, **Nicholas James Hill**, Adam Barnett, and Andrew Chin. 2020. "A Global Review of Elasmobranch Tourism Activities, Management and Risk." *Marine Policy* 118 (August): 103964. https://doi.org/10.1016/j.marpol.2020.103964.

Hill, Nicholas J., Caleb Gardner, Malcolm Haddon, Klaas Hartmann, L. Richard Little, Jeremy M. Lyle, and Bradley R. Moore. 2020. "Assessing the Status of Australia's Fish Stocks Relative to Target Objectives." *Marine Policy* 112 (February): 103741. https://doi.org/10.1016/j.marpol.2019.103741.

Kiss, Andrew E., Andrew Hogg, Nicholas Hannah, **Fabio Boeira Dias**, Gary B. Brassington, Matthew A. Chamberlain, Christopher Chapman, et al. 2020. "ACCESS-OM2 v1.0: A Global Ocean–Sea Ice Model at Three Resolutions." *Geoscientific Model Development* 13 (2): 401–42. https://doi.org/10.5194/gmd-13-401-2020.

Li, Zeya, Neil J. Holbrook, Xuebin Zhang, Eric C. J. Oliver, and Eva A. Cougnon. 2020. "Remote Forcing of Tasman Sea Marine Heatwaves." *Journal of Climate* 33 (12): 5337–54. https://doi.org/10.1175/JCLI-D-19-0641.1.

Lou, Jiale, Terence J. O'Kane, and Neil J. Holbrook. 2020. "A Linear Inverse Model of Tropical and South Pacific Seasonal Predictability." *Journal of Climate* 33 (11): 4537–54. https://doi.org/10.1175/JCLI-D-19-0548.1.

Lou, Jiale, Neil J. Holbrook, and Terence J. O'Kane. 2019. "South Pacific Decadal Climate Variability and Potential Predictability." *Journal of Climate* 32 (18): 6051–69. https://doi.org/10.1175/JCLI-D-18-0249.1.

Murphy, K. J., D. Sephton, K. Klein, C. D. Bishop, and R. C. Wyeth. 2019. "Abiotic Conditions Are Not Sufficient to Predict Spatial and Interannual Variation in Abundance of Ciona Intestinalis in Nova Scotia, Canada." *Marine Ecology Progress Series* 628 (October): 105–23. https://doi.org/10.3354/meps13076.

Ni, Ping, **Kieran J. Murphy**, Russell C. Wyeth, Cory D. Bishop, Shiguo Li, and Aibin Zhan. 2019. “Significant Population Methylation Divergence and Local Environmental Influence in an Invasive Ascidian Ciona Intestinalis at Fine Geographical Scales.” *Marine Biology* 166 (11): 143. https://doi.org/10.1007/s00227-019-3592-3.

O’Hara, Timothy D., Alan Williams, Skipton N. C. Woolley, **Amy W. Nau**, and Nicholas J. Bax. 2020. “Deep-Sea Temperate-Tropical Faunal Transition across Uniform Environmental Gradients.” *Deep Sea Research Part I: Oceanographic Research Papers* 161 (July): 103283. https://doi.org/10.1016/j.dsr.2020.103283.

Patel, Ramkrushnbhai S., Helen E. Phillips, Peter G. Strutton, Andrew Lenton, and Joan Llort. 2019. “Meridional Heat and Salt Transport across the Subantarctic Front by Cold-Core Eddies.” *Journal of Geophysical Research: Oceans* 124 (2): 981–1004. https://doi.org/10.1029/2018JC014655.

Peel, Samantha L., Nicole A. Hill, Scott D. Foster, Simon J. Wotherspoon, Claudio Ghiglione, and Stefano Schiaparelli. 2019. “Reliable Species Distributions Are Obtainable with Sparse, Patchy and Biased Data by Leveraging over Species and Data Types.” Edited by Nick Isaac. *Methods in Ecology and Evolution*, June, 2041-210X.13196. https://doi.org/10.1111/2041-210X.13196.

Pittman, N.A., P.G. Strutton, R. Johnson, and R.J. Matear. 2019. “An Assessment and Improvement of Satellite Ocean Color Algorithms for the Tropical Pacific Ocean.” *Journal of Geophysical Research: Oceans* 124 (12): 9020–39. https://doi.org/10.1029/2019JC015498.

Porobic, Javier, Elizabeth A. Fulton, Carolina Parada, Stewart Frusher, Billy Ernst, and Pablo Manríquez. 2019. “The Impact of Fishing on a Highly Vulnerable Ecosystem, the Case of Juan Fernández Ridge Ecosystem.” Edited by Andrea Belgrano. *PLOS ONE* 14 (2): e0212485. https://doi.org/10.1371/journal.pone.0212485.

Rathore, Saurabh, Nathaniel L. Bindoff, Helen E. Phillips, and Ming Feng. 2020. “Recent Hemispheric Asymmetry in Global Ocean Warming Induced by Climate Change and Internal Variability.” *Nature Communications* 11 (1): 2008. https://doi.org/10.1038/s41467-020-15754-3.

Roman, Lauren, Elizabeth Bell, Chris Wilcox, Britta Denise Hardesty, and Mark Hindell. 2019. “Ecological Drivers of Marine Debris Ingestion in Procellariiform Seabirds.” *Scientific Reports* 9 (1): 916. https://doi.org/10.1038/s41598-018-37324-w.

Roman, Lauren, Britta Denise Hardesty, Mark A. Hindell, and Chris Wilcox. 2019. “A Quantitative Analysis Linking Seabird Mortality and Marine Debris Ingestion.” *Scientific Reports* 9 (1): 3202. https://doi.org/10.1038/s41598-018-36585-9.

Roman, Lauren, Linda Lowenstine, Laura Maeve Parsley, Chris Wilcox, Britta Denise Hardesty, Kirsten Gilardi, and Mark Hindell. 2019. “Is Plastic Ingestion in Birds as Toxic as We Think? Insights from a Plastic Feeding Experiment.” *Science of The Total Environment* 665 (May): 660–67. https://doi.org/10.1016/j.scitotenv.2019.02.184.

Rousseau, Yannick, Reg A. Watson, Julia L. Blanchard, and Elizabeth A. Fulton. 2019. “Evolution of Global Marine Fishing Fleets and the Response of Fished Resources.” *Proceedings of the National Academy of Sciences*, May, 201820344. https://doi.org/10.1073/pnas.1820344116.

Twiname, Samantha, Quinn P. Fitzgibbon, Alistair J. Hobday, Chris G. Carter, and Gretta T. Pecl. 2019. “Multiple Measures of Thermal Performance of Early Stage Eastern Rock Lobster in a Fast-Warming Ocean Region.” *Marine Ecology Progress Series* 624 (August): 1–11. https://doi.org/10.3354/meps13054.

QMS review and links to national strategy

As mentioned in the introduction, the QMS program was reviewed in 2020. The major findings of that review were:

- The QMS program offers an existing engagement structure for staff and students, pre-opened doors, between CSIRO and UTAS and progresses the objectives of both organisations in the training and co-supervision of PhD students.
- It represents efficiency, as an established and overarching program, in facilitating the co-supervision and training intentions of both organisations.
- It carries a reputational standard for students that both attracts quality candidates and enhances the employability of graduates.
- It brings together UTAS and CSIRO staff around the supervision and training of students which creates and develops connections that facilitate collaboration.
- The coursework in the program is recognised as a distinct competitive advantage, however this view is not held consistently by all staff and students involved.
- The program has developed in parallel to the rise of IMAS/UTAS in the marine science area, as reflected in University Ranking and Performance assessments, and contributed to the world class ranking of CSIRO Oceans and Atmosphere in its external reviews.

The recommendations were:

- For continued success, QMS supervisory teams are encouraged to be consciously selected across the scientific career range (early, mid and senior science levels). This will support succession planning, increase involvement of staff and career advancement opportunities of early and mid-career scientists and student mentor diversity. (TOR 3)
- Continue to support distinct CSIRO contribution to the QMS & Centre for Marine Socioecology (CMS) programs. At the end of the next 5-year period, if the QMS program and CMS programs are to be continued, CSIRO and UTAS to consider if synergy between them has grown such that new arrangements might be suitable. (TOR 4)
- (1) UTAS and CSIRO should reiterate the value of coursework to supervisors, incoming and existing students (TOR 5) (2) A review of QMS course structure and content should be undertaken within the next twelve months, led by the QMS director. (TOR 5)
- CSIRO and UTAS explore options to stimulate domestic demand towards the UTAS future direction of less than 30% international students, by for example establishing a register of all enquiries towards creating a pool of potential applicants. (TOR 6)
- The success of graduates be captured to allow post-PhD stories to be used in promotion of the program and refreshed on the QMS website to attract domestic recruits. (TOR 7)
- (1) Seek to ensure that competitive scholarships and top-ups are attractive to students in the current market. (TOR 8) (2) CSIRO is introducing a new minimum $10K policy for top-up scholarships. CSIRO will need to comply with the new CSIRO top-up policy for any QMS student who does receive a QMS top-up, as they will be considered as being co-funded, and the policy will apply. (TOR 8)
- Mostly maintain the status quo going forward. There are opportunities for additional CSIRO staff engagement in teaching, which may be motivated with formal organisational recognition of the benefits and workloads. (TOR 9)

The QMS program considers the review outcomes extremely helpful and constructive and will be working to implement the recommendations this coming year. We would like to thank the review panel members for their hard work during a challenging time: Alistair Hobday, Bernadette Sloyan and Nigel Foster (CSIRO) and Simon Wotherspoon, Neil Holbrook and Anya Reading (UTAS).
The full QMS review report is available from Christine Fury or Pete Strutton on request.

In 2019, the QMS program was highlighted as a national success story in quantitative marine science education by the National Marine Science Committee, in their report into training for the blue economy. The NMSC web site hosts the summary and full reports.