Forum for Operational Oceanography

25-27 July, 2017
Esplanade Hotel, Fremantle WA

Forum for Operational Oceanography

Australian Forum for Operational Oceanography

FOO 2017

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CONFERENCE HANDBOOK

Sponsors

IMOS Integrated Marine Observing System

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Contents

FOO 2017 Program Overview

The inaugural Australian Forum for Operational Oceanography (FOO) conference was held in Fremantle, Western Australia in July 2015. The 125 participants from marine industries, service providers, government agencies, and R&D providers were unanimous in their support for FOO to become something that would endure. It was felt that a second conference in two years' time would be 'about right'. That time is now coming, and FOO 2017 will take place in Fremantle on 25-27 July.

FOO has endured in the intervening period, guided by a Steering Committee whose members have volunteered their time to keep the Forum running. The Steering Committee have taken responsibility for organising this second event, which will follow the same format of the successful FOO 2015.

FOO 2017 will start after lunch on Tuesday 25th July, with an afternoon program followed by a Cocktail Reception sponsored by **Austral Fisheries**. There will be a full day program on Wednesday 26th July, followed by a Conference Dinner. **CSIRO** is sponsoring the dinner. The conference will conclude at lunchtime on Thursday 27th July.

A brief outline of the program is as follows. There will be four thematic sessions:

1. The Australian Forum of Operational Oceanography
2. Assessing Present Capabilities and Future Needs
3. Users and Uses of Operational Oceanography
4. Marine Extremes

Theme 1 will provide an introduction and update on Forum activities, including the working groups on Surface Currents and Surface Waves. It will finish with a keynote from **John Gunn (Australian Institute of Marine Science)** as Co-Chair of the **Global Ocean Observing System (GOOS)** Steering Committee.

Theme 2 will assess present capabilities in Australian operational oceanography, as well as future needs. It will begin with **Professor Ian Young (University of Melbourne)** delivering the keynote on **satellite measured wave data**. This will be followed by nine high quality talks selected on the basis of submitted abstracts, and wrapped up with a facilitated Q&A segment. Topics include surface currents and waves, swell forecasting, temperature structure, consensus forecasting, and marine data and products.

Theme 3 will feature a series of invited talks from senior leaders representing users and uses of operational oceanography in Australia. Topics include marine hazards warnings and forecasts, offshore oil and gas, maritime defence, emergency response, fishing and aquaculture, and marine spatial planning. **Matthew Zed (Woodside Energy Ltd)** will deliver the keynote on **developing decision support tools for offshore and nearshore marine operations.** This session will conclude with a discussion segment focused on cross-sector synergies and opportunities.

Theme 4 will focus on marine extremes. It will have six high quality talks selected on the basis of submitted abstracts, a facilitated Q&A segment, and will feature a keynote on **tropical cyclone forecasting delivered by Dr Jeff Kepert (Bureau of Meteorology)**. Topics include tropical cyclone forecasting, extra-tropical storms, extreme storm surge, marine heatwaves, coral bleaching, and cold extremes.

In the Final Session we will look ahead, reflect on key points and issues raised at the conference, and set an agenda for FOO over the next two years. We look forward to your participation and engagement.

Jan Flynn (Shell Australia Pty Ltd)

Tim Moltmann (Integrated Marine Observing System)

Co-Chairs of the Australian Forum for Operational Oceanography (FOO) Steering Committee

Forum for Operational Oceanography

FOO 2017 Organising Committee

Co-Chair	Jan Flynn, Shell Australia Pty Ltd
Co-Chair	Tim Moltmann, Integrated Marine Observing System (IMOS)
Executive Support	Emma Sommerville, IMOS
RPS MetOcean	Steve Buchan
Fugro	Simon Foster
Austral Fisheries	Martin Exel
Department of Defence	Barbra Parker
Australian Maritime Safety Authority (AMSA)	Craig Longmuir
Australian Institute of Marine Science (AIMS)	Richard Brinkman
Bureau of Meteorology (BoM)	Louise Minty
CSIRO	Andreas Schiller

Acknowledgements

Thank you to Phoebe Thiessen from Conference Design Pty Ltd for helping to organise FOO 2017

FOO 2017 would not have been possible without the generous support of our sponsors:

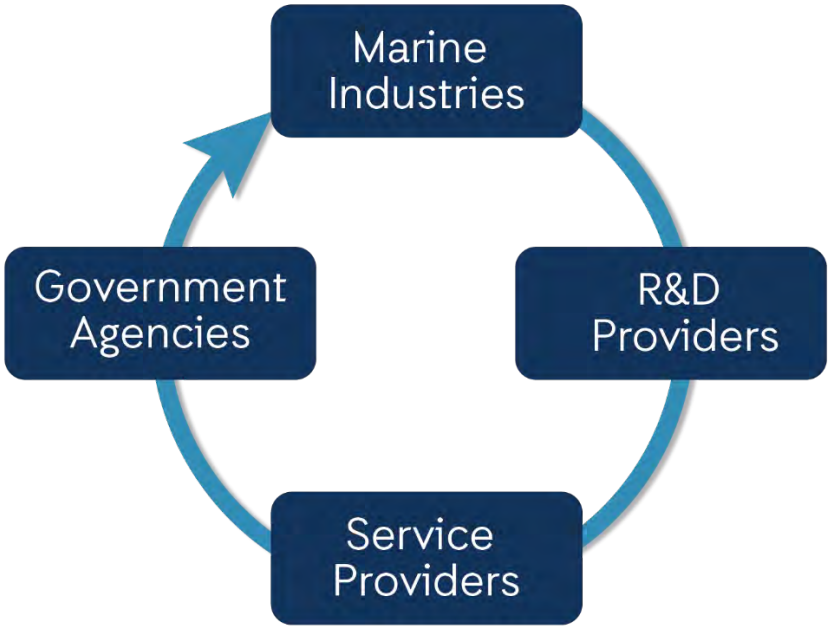
FOO 2017 at a Glance

Tuesday 25th July		
Time	Session	Room
1100 - 1300	Registration	Sirius/ Lobby
1200 - 1300	Lunch	Atrium Garden Restaurant
1300 - 1440	Theme 1 Presentations	Sirius Room
1440 - 1510	Afternoon tea	Sirius/ Lobby
1510 - 1800	Theme 2 Presentations	Sirius Room
1800 - 2000	Cocktail Reception	Sirius Room

Wednesday 26th July		
Time	Session	Room
0800 - 0830	Arrival tea and coffee	Sirius/ Lobby
0830 - 0940	Theme 2 Presentations	Sirius Room
0940 - 1030	Theme 3 Presentations	Sirius Room
1030 - 1100	Morning tea	Sirius/ Lobby
1100 - 1240	Theme 3 Presentations	Sirius Room
1240 - 1340	Lunch	Atrium Garden Restaurant
1340 - 1510	Theme 3 Presentations	Sirius Room
1510 - 1530	Afternoon tea	Sirius/ Lobby
1530 - 1800	Theme 4 Presentations	Sirius Room
1830 - 2130	FOO 2017 Dinner	Island Suite

Thursday 27th July		
Time	Session	Room
0800 - 0830	Arrival tea and coffee	Sirius/ Lobby
0830 - 0900	Theme 4 Presentations	Sirius Room
0900 - 1030	Looking Ahead Presentations	Sirius Room
1030 - 1100	Morning tea	Sirius/ Lobby
1100 - 1230	FOO 2017 Discussion	Sirius Room
1230 - 1330	Lunch	Atrium Garden Restaurant

The Four Pillars of Operational Oceanography



Operational Oceanography Value Chain

General Information

Conference Venue

Esplanade Hotel Fremantle – by Rydges, 46-54 Marine Terrace, Fremantle WA 6160

Telephone: +61 8 9432 4000

The conference will be held in the **Sirius Room**, which is located on the ground floor.

Registration Desk

The Registration Desk will be located in the Sirius Room and will be staffed between 11am - 1pm on Tuesday 25th July, and 8am – 8:30am on Wednesday 26 and Thursday 27 July.

Name Badges

Delegates are requested to wear their name badges at all times during the conference. Your name badge is also your ticket to the included functions.

Speaker Preparation

All speakers will need to refer to the Final Program in this Handbook to confirm their timeslot. Please ensure your presentation is loaded onto the laptop computer in the Sirius Room well in advance of your timeslot. A staff member from the audio-visual company (AV Partners) will be there to assist you. It is advised that you check your presentation is working in the break prior to your session if possible.

Social functions

- A Cocktail reception will be held following on from the session on **Tuesday 25 July, 6pm - 8pm in the Sirius Room**, where a selection of canapés and drinks will be served.
- The FOO 2017 Conference Dinner will be held on **Wednesday 26 July from 6:30pm onwards** in the Island Suite, which is located upstairs.

Parking, public transport, taxis, ATM and Banking

Please check with the Hotel Reception.

Internet access

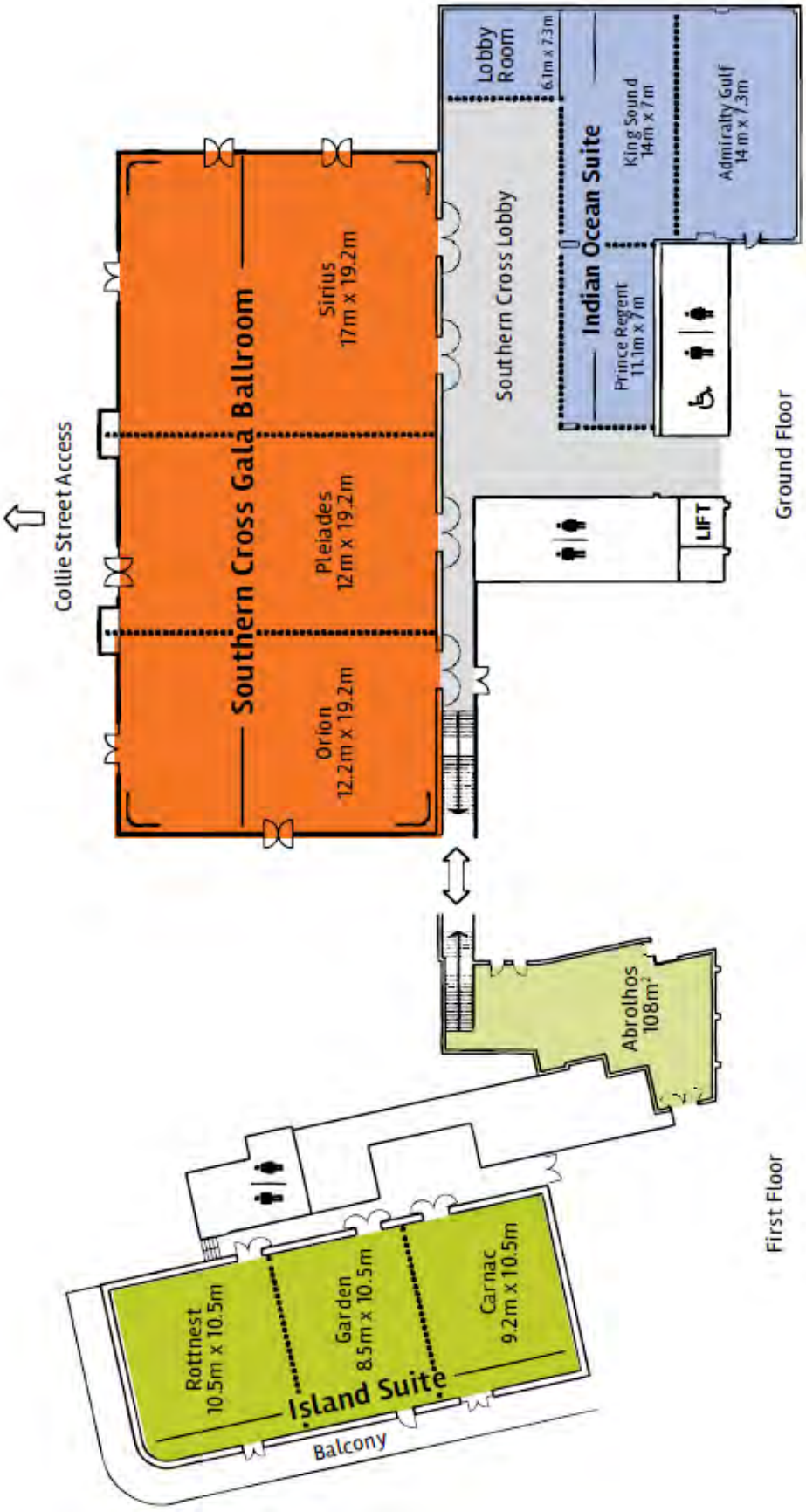
The Hotel offers complimentary Wi-Fi for all delegates throughout the Hotel. To access, connect to Rydges-EVENT, open a new browser and you will be re-directed to a login page, select Visitor, and then enter the Access Code: IMOS. Each user is required to enter the Access Code.

Meals and Refreshments

Tea and coffee will be served in the morning from 8am - 8:30am on Day 2 and Day 3. Morning and afternoon tea will be served in the Sirius Room/Lobby. Lunch will be a buffet served in the Atrium Garden Restaurant. Delegates who provided information regarding special dietary requirements will be catered for.

Esplanade Hotel Fremantle – by Rydges Floor Plan

Esplanade Hotel - by Rydges, 46-54 Marine Terrace, Fremantle WA 6160, Australia.



Keynote Speaker Biographies

John Gunn FTSE

John Gunn is the Chief Executive Officer of the Australian Institute of Marine Science (AIMS – www.aims.gov.au). John has significant experience in leading development of strategy, scientific research and capability, and stakeholder engagement across a research portfolio encompassing marine ecology, fisheries, coastal systems, physical and chemical oceanography, atmospheric chemistry and climate science. John joined AIMS from the position of Chief Scientist of the Australian Antarctic Program, where he played a key role in developing the Australian Antarctic Science Strategy Plan: 2011–2021. Prior to this, John was Deputy Chief of CSIRO's Marine and Atmospheric Research Division.

John has broad experience on high level advisory and policy development boards and Advisory Committees, including as Co-Chair of the UNESCO - IOC Global Ocean Observing System Steering (GOOS) Committee, Previous Chair of the National Marine Science Committee (NMSC), member of the Great Barrier Reef 2050 Advisory Committee (GBRAC), Board Member of the Reef & Rainforest Research Centre (RRRC) Board, and Australia's Integrated Marine Observing System (IMOS) Board.

Alongside his executive experience, John has an extensive academic record. He has authored over 150 peer-reviewed publications, papers and technical reports, and presented at more than 100 conferences and symposia, in many instances as the keynote speaker. He has an international reputation in pelagic fish ecology and in the development of marine biology observation technology and systems.

Ian Young

Ian Young has had a career that has spanned both senior Higher Education administration and scientific research. He is presently Kernot Professor of Engineering at the University of Melbourne. Prior to this appointment he held the administrative roles of Vice-Chancellor of the Australian National University and Vice-Chancellor of Swinburne University of Technology. During 2014 and 2015, he was Chair of the Group of Eight. When he retired from ANU in 2016, he was the second longest serving Vice-Chancellor in Australia. His researcher interests concern wind generated ocean waves. He has an extensive publication record in areas such as: the physics of air-sea interaction, the numerical modelling of waves, finite depth waves, satellite remote sensing and ocean wind and wave climate.

In recent years, his research has concentrated on the use of satellite measurements of the ocean to understand changes in wind and wave climates on a global scale over the last 30 years. This work has extended to applications such as the prediction of extreme wind speed and wave height on a global scale. He is author of more than 150 refereed papers and two major research monographs in the field. He is also a consultant to the offshore oil industry in Australia, the United States and Asia, as well as an advisor to the US Navy on ocean wave physics.

Matthew Zed

Matthew has spent the last three years acting as a senior metocean engineer at Woodside Energy, focusing on extreme and operational criteria for new developments, analytical systems for metocean data processing and swell forecasting support to marine operations in his capacity as the company's subject matter expert for waves.

Prior to this, Matthew spent eight years as a consulting coastal engineer, and later coastal engineering manager, specialising in wave and hydrodynamic numerical modelling, metocean field studies, data processing, effluent and dredge dispersion modelling.

Matthew's range of in-country roles across the Middle East, Canada, India, regional and urban Australia has provided him with global exposure and experience on numerous small and large-scale industrial developments.

Jeff Kepert

Jeff is Head of High Impact Weather Research for the Bureau of Meteorology, and leads a team responsible for improving our predictions and understanding of tropical cyclones, fire weather, severe thunderstorms and other forms of severe weather.

Jeff began his career with the Bureau as a forecaster, before moving into training and then research. As a researcher, Jeff has spent most of his career on tropical cyclone and bushfire meteorology, but also worked for a while on data assimilation. He is prominent nationally and internationally, having convened major conferences, edited journals and served on the Australian Standards Wind Loading committee.

Jeff particularly values working as a researcher for the Bureau, because it provides an environment to not just do high standard research on interesting weather, but also the opportunity and support to see that research used to improve our ability to manage severe weather, thereby saving lives, property and money.

FOO 2017 Program

DAY 1 – Tuesday 25th July 2017 (*Sirius Room*)		
11:00–13:00	Registration	
12:00–13:00	Lunch (Atrium Garden Restaurant)	
13:00–13:05	FOO 2017 Welcome and Introduction	Jan Flynn, Shell Australia Pty Ltd
Theme 1 – The Australian Forum for Operational Oceanography		
13:05–13:20	Update on Forum activities since FOO 2015	Tim Moltmann, Integrated Marine Observing System (IMOS)
13:20–13:35	FOO Surface Currents Working Group – Key discussions and benefits	Craig Longmuir, Australian Maritime Safety Authority (AMSA)
13:35–13:50	Perspectives from the FOO Surface Waves Working Group to support Australia's operational oceanography activities	Mark Hemer, CSIRO
13:50–14:20	**Keynote #1** **Solving many of the challenges facing our global oceans, while ensuring we can take advantage of the opportunities, requires a step change in collaboration and integration across the marine science community**	**John Gunn, Australian Institute of Marine Science (AIMS)**
14:20–14:40	The Australian Forum for Operational Oceanography - Q&A Session	
14:40–15:10	Afternoon Tea	
Theme 2 – Assessing Present Capabilities and Needs		
15:10–15:40	**Keynote #2** **An unprecedented era of satellite measured wave data – opportunities for Australia**	**Prof Ian Young, University of Melbourne**
15:40-16:00	Improved performance of operational wave models at Australian coast	Aihong Zhong, Bureau of Meteorology (BoM)
16:00-16:20	Collaborative approaches for swell affected operations on Australia's North West Shelf	Greg Williams, RPS MetOcean
16:20-16:40	Weather: ships sail safely – port decision making with operational oceanographic forecasts	Gregory Hibbert, OMC International
16:40-17:00	eSA-Marine – phase 1: the first step towards an operational now-cast/forecast ocean prediction system for Southern Australia	John Middleton, SARDI Aquatic Sciences
17:00-17:20	Near real-time atmosphere-ocean two-way nested system for west coast of Australia	Ivica Janekovic, University Of Western Australia (UWA)
17:20-17:40	Complex near-bed sedimentary dynamics in seasonally stratified waters control visibility for subsea engineering	Piers Larcombe, RPS MetOcean
17:40-18:00	Challenges and advances in predicting waves in the nearshore	Jeff Hansen, UWA
18:00	CLOSE DAY 1	
18:00–20:00	Cocktail Reception (Sirius Room) - SPONSORED BY AUSTRAL FISHERIES	

DAY 2 – Wednesday 26th July 2017 (*Sirius Room*)		
08:00–08:30	Arrival Tea and Coffee	
Theme 2 – Assessing Present Capabilities and Needs, CONTINUED		
8:30-8:50	…CONTINUED FROM DAY 1 The emergence of data-driven technologies for operational oceanographic applications	Simon Foster, Fugro
8:50-9:10	Maximising impact and value from marine observations - Modelling tools for network design	Boris Kelly-Gerreyn, BoM
9:10–9:40	Assessing present capabilities and needs - Q&A Session	
Theme 3 – Users and Uses of Operational Oceanography		
9:40-10:10	**Keynote #3** **Developing decision support tools for offshore and nearshore marine operations**	**Matthew Zed, Woodside Energy Ltd**
10:10-10:30	The business of fishing in a changing ocean	David Carter, Austral Fisheries Pty Ltd
10:30–11:00	Morning Tea	
11:00-11:20	National Energy Resources Australia (NERA) – technology and science activities	Jill Stajduhar, NERA
11:20-11:40	FLNG and the need for operational oceanography	Jan Flynn, Shell Australia Pty Ltd
11:40-12:00	AMSA's application of metocean models and awareness to support strategic and operational decision-making	Paul Irving, AMSA
12:00-12:20	Marine and Ocean Services in the Bureau of Meteorology – The importance of partnerships as we strengthen the value chain	Greg Stuart, BoM
12:20-12:40	Harmful algal bloom forecasting – can we do it?	Scott Condie, CSIRO
12:40–13:40	Lunch (Atrium Garden Restaurant)	
13:40-14:00	Spatial management of fisheries in a changing ocean - using operational oceanography	Claire Spillman, BoM
14:00-14:20	Introduction to Pilbara Ports Authority's metocean networks	Frans Schlack, Pilbara Ports Authority
14:20-14:40	SEA 2400 – next generation hydrographic capability for Australia	Barbra Parker, Department of Defence
14:40–15:10	Users and uses of operational oceanography, with a focus on cross-sector synergies - Q&A Session	
15:10–15:30	Afternoon Tea	
Theme 4 – Marine Extremes		
15:30-15:50	Responding to the 2016 and 2017 mass coral bleaching events on the Great Barrier Reef: from observations to modelling.	Craig Steinberg, AIMS
15:50-16:10	Sub-surface intensification of marine heatwaves off southeastern Australia: the role of stratification and local winds	Moninya Roughan, University of New South Wales

DAY 2 – Wednesday 26th July 2017 (*Sirius Room*)		
16:10-16:30	Deriving extreme metocean criteria for the Browse Basin using a 100,000 year synthetic tropical cyclone track database	Michael Garvey, Shell Australia Pty Ltd
16:30-16:50	Estimates of extreme water levels around Australia	Charitha Pattiaratchi, UWA
16:50-17:10	Severe Tropical Cyclone Debbie: sea surface response	Daryl Metters, QLD Department of Science, Information Technology and Innovation
17:10-17:30	Marine heatwaves in northern Australia and new observations to improve their predictions	Ming Feng, CSIRO
17:30-18:00	Marine Extremes - Q&A Session	
18:00	CLOSE DAY 2	
18:30–21:30	FOO 2017 Conference Dinner (*Island Suite*) - *SPONSORED BY CSIRO*	

DAY 3 – Thursday 27th July 2017 (*Sirius Room*)		
08:00–08:30	Arrival Tea and Coffee	
8:30–9:00	**Keynote #4** **Improved tropical cyclone predictions for northwest Australia**	**Dr Jeff Kepert, Bureau of Meteorology**
Final Session - Looking Ahead		
9:00-9:25	Operational ocean observing for offshore carbon capture and storage	Nick Hardman-Mountford, CSIRO
9:25-9:50	Australia has a national advantage in ocean monitoring, with huge requirements and world leading science. Can we add industry and commercialisation to create a virtuous circle?	Neil Hodges, BlueZone Group
9:50-10:15	The National Innovation and Science Agenda meets a growing blue economy – 'opportunity knocks'	Tim Moltmann, IMOS and National Marine Science Committee
10:15-10:30	Looking Ahead - Q&A Session	
10:30–11:00	Morning Tea	
11:00–11:30	What have we heard at FOO 2017? Key points from the presentations Key issues from the five x Q&A Sessions	Tim Moltmann and Jan Flynn as FOO Co-Chairs
11:30–12:15	Forward agenda for FOO Six candidate priorities were identified in 2015, and we have worked of two - surface currents and surface waves. What about thermal structure, consensus forecasting, new products (such as a shelf reanalysis), and data stewardship? Other priorities emerging here? Is the Working Group approach a good way to progress agreed priorities? If so, what Working Groups do we need going forward? Are there any new projects or programs that FOO should be catalysing? Do we continue to plan for a conference every two years? Should there be more regular events in the intervening period e.g. symposia, seminars, webinars? If there is to be a FOO 2019, where, and when?	
12:15–12:30	FOO 2017 conference wrap-up, next steps and feedback	
12:30-13:30	FOO 2017 CLOSE followed by Lunch	

FOO 2017 Abstracts

Theme 1 – The Australian Forum for Operational Oceanography

Update on Forum activities since FOO 2015

Moltmann, Tim*[1], Jan Flynn[2], Martin Exel[3], Craig Longmuir[4], Louise Minty[5], Andreas Schiller[6], Simon Foster[7], Barbra Parker[8], Steve Buchan[9] and Emma Sommerville[1]

[1] Integrated Marine Observing System (IMOS), IMAS Building, University of Tasmania, Hobart TAS 7001

[2] Shell Australia Pty Ltd, 562 Wellington St, Perth, Western Australia 6000

[3] Austral Fisheries, Level 4, 50 Oxford Close, West Leederville, WA, AUSTRALIA, 6007

[4] AMSA Response Centre (ARC) Chief, Australian Maritime Safety Authority, Canberra, ACT 2612

[5] Bureau of Meteorology, 700 Collins Street, Docklands, VIC 3008

[6] CSIRO Oceans and Atmosphere, Hobart, TAS 7001

[7] Fugro, 24 Geddes Street, Balcatta, WA 6021

[8] Department of Defence, Canberra, ACT 2600

[9] RPS MetOcean, Subiaco, WA 6014

Tim.Moltmann@imos.org.au

The inaugural Australian Forum for Operational Oceanography (FOO) conference was held in Fremantle, WA in July 2015. The official Meeting Report notes that there was overwhelming support for FOO to endure, and that participants did not want it to be a one-off event. There was a strong desire to build on the dialogue commenced at the meeting to establish effective, ongoing communication between Forum participants. Suggestions made included engaging additional stakeholders, and forming smaller expert teams focused on a short list of Forum-agreed priorities in order to make progress. Six candidate priority areas were identified at FOO 2015. In this presentation, made on behalf of the FOO Steering Committee, an update will be provided on Forum activities since FOO 2015. It will cover:

- the activities of the Steering Committee,
- development of the FOO website and communication through news items and email updates,
- establishment of working groups focused on two (of six) priority areas,
- progress on growing the stakeholder base,
- organisation of FOO 2017, and
- how FOO is influencing relevant aspects of the National Innovation System.

FOO Surface Current Working Group – Key discussions and benefits

Longmuir, Craig*[1], Ben Brushett[2], David Griffin[3], Peter Oke[3], Eric Schulz[4], Gary Brassington[4], Craig Steinberg[5], Simone Cosoli[6], Michael Garvey[7], Barbra Parker[8] and Ana Lara-Lopez[9]

[1] AMSA Response Centre (ARC) Chief, Australian Maritime Safety Authority, Canberra, ACT 2612

[2] RPS MetOcean, Subiaco, WA 6014

[3] CSIRO Oceans and Atmosphere, Hobart, TAS 7001

[4] Bureau of Meteorology, 700 Collins Street, Docklands, VIC 3008

[5] Australian Institute of Marine Science, Townsville, Qld 4810

[6] School of Civil, Environmental and Mining Engineering & UWA Oceans Institute, The University of Western Australia, Crawley, WA 6009

[7] Shell Australia Pty Ltd, 562 Wellington St, Perth, Western Australia 6000

[8] Department of Defence, Canberra, ACT 2600

[9] Integrated Marine Observing System (IMOS), IMAS Building, University of Tasmania, Hobart TAS 7001

craig.longmuir@amsa.gov.au

At the inaugural FOO meeting in July 2015, a number of priority areas emerged that would benefit from further dialogue to ensure effective, ongoing communications and cooperation. Of these the FOO Steering Committee identified two to be the highest priority and formed Working Groups on surface currents and surface waves. Since then the Surface Current working group has regularly convened via teleconference and this presentation will cover key discussions and work of the group and the benefits of a collaborative approach;

- Membership – numbers and make-up of group
- Key outputs for discussion – definition of what is a 'surface current'
- Position statement
- MH370 work – Stokes Drift
- Key data sets: Surface drifters and HF radar
- Sharing of data
- Networking benefits & future opportunities

Perspectives from the FOO Surface Waves Working Group to support Australia's operational oceanography activities

Hemer, Mark*[1], Alex Babanin[2], Paul Boswood[3], Diana Greenslade[4], Jess Kolbusz[5], Daryl Metters[3], Tim Moltmann[6], Roger Proctor[6], Emma Sommerville[6], Craig Steinberg[7], Greg Williams[8]

[1] CSIRO Oceans and Atmosphere, Hobart, TAS 7001

[2] Department of Infrastructure Engineering, University of Melbourne, Melbourne, VIC 3010

[3] Department of Science, Information Technology and Innovation, Queensland Govt, Deagon, Qld 4017

[4] Bureau of Meteorology, Melbourne, VIC 3001

[5] Formerly Carnegie Clean Energy Ltd, North Fremantle, WA 6159

[6] Integrated Marine Observing System (IMOS), IMAS Building, University of Tasmania, Hobart TAS 7001

[7] Australian Institute of Marine Science, Townsville, Qld 4810

[8] RPS MetOcean, Subiaco, WA 6014

Mark.Hemer@csiro.au

At the inaugural FOO meeting in 2015, surface waves were identified as one of two priority areas which could benefit from ongoing communication across Marine Industry, R&D and Service providers, and Government Agencies. A FOO surface waves working group was established in response, with a set of key initial discussion points derived from FOO 2015 outcomes. The working group has since met 4 times, and discussion has focussed largely on identifying existing public domain and commercially owned wave data (observations and model datasets) and their availability, whether these meet the FOO community needs, and how and where future investment be best placed to deliver valuable wave information to meet these needs. Discussions are ongoing, with efforts to identify priority knowledge and data gaps which need to be addressed underway. This presentation will provide an overview of the surface waves WG discussions and resolutions to date.

Solving many of the challenges facing our global oceans, while ensuring we can take advantage of the opportunities, requires a step change in collaboration and integration across the marine science community

Gunn, John

Australian Institute of Marine Science, Townsville, Qld 4810

j.gunn@aims.gov.au

In the Anthropocene, our global oceans are changing at an unprecedented rate, the consequence of CO2 emissions, pollution, over-exploitation of resources, and rapid population expansion in coastal zones. Over the last 30 years, developed and developing nations alike have increasingly focussed attention on growing their "blue economies", in many cases without building the architecture (evidence bases, regulatory frameworks, monitoring systems etc) required to ensure the sustainability of this growth. Recognising this, the United Nations undertook a first World Ocean Assessment in 2014 and in 2016 embraced a new sustainable development goal (SDG 14) focussed on the oceans (SDG 14). Inter-governmental bodies such as the G7 have also begun to emphasize the importance of ocean science, sustainable development and governance.

Over the last decade in Australia, as awareness and concerns increase in government and community sectors, we have seen the demand for ocean data, information, services and "decision support" tools increase significantly. The marine science community, regulatory bodies and increasingly industry have been asked to meet this demand, often without the required additional resources. The National Marine Science Committee responded to the demand and challenges in its 2015 decadal National Marine Science Plan in which we called for enhanced national efforts in: collecting the required baseline and observing/monitoring data, integrated (physics – biology – social – economic) modelling; and decision support tools. We noted that these national efforts would bring greater efficiency, but that to do the job properly required significant new investment.

NMSC remains hopeful that new investment – for IMOS, for Integrated Monitoring of the GBR and National Marine Reserve System, vessels and other initiatives – will be forthcoming. However, in the interim we must push forward in building the collaborations and systems that will provide the basis for improved decision making, by the private and public sectors. My thesis is that only by showing a willingness and capability to do this, will we get the support required to build and maintain sustained observing and modelling capability. With unprecedented technological advances in observing technologies (in situ and remote), modelling frameworks, computing power and data systems, the time is right to see all components of the marine science and engineering community to work together.

Theme 2 – Assessing Present Capabilities and Needs

An unprecedented era of satellite measured wave data – opportunities for Australia

Young, Ian

Department of Infrastructure Engineering, University of Melbourne, Melbourne VIC 3010

ian.young@unimelb.edu.au

Oceanographic satellites which provide global coverage of wind speed and wave conditions have now been in operation for approximately 30 years. Over this period more than 30 such missions have occurred and the composite dataset is extensive. In the next few years, a new generation of satellite systems will be launched. These new instruments have the capability of providing an order of magnitude more data. The spatial and temporal resolution of the instruments will significantly increase and the range of parameters which are measured will expand. This presentation will provide an overview of the exiting data set, its limitations and the potential applications of this data. In addition, the range of systems which will be available in the coming years will be described. In order to use such resources in an operational sense however, users need to develop new ways of analysing and presenting data. For instance, statistical techniques to analyse time series measured at a fixed point are now well developed. However, by its nature, satellite data is quite different. Data is measured over a large spatial domain but the temporal repeat time is less than for insitu instruments. This provides both advantages and disadvantages compared to insitu data and requires new analysis techniques. The presentation will consider altimeters, radiometers, synthetic aperture radars and scatterometers. Combined, and carefully calibrated against insitu buoys, they provide a rich resource for monitoring our oceans, both over extended periods, as well as in near real time. If Australia is to make the best use of this huge resource, we will need to plan and develop the analysis and archiving infrastructure to make best use of this data.

Improved performance of operational wave models at Australian coast

Zhong, Aihong,* Robert Greenwood, Neal Moodie, Stefan Zieger and Diana Greenslade

Bureau of Meteorology, Docklands, VIC 3008

Aihong.zhong@bom.gov.au

The Bureau of Meteorology is Australia's national agency responsible for warning mariners, industry and the community of dangerous or damaging waves affecting people and structures along the Australian coastline and high seas. The Bureau's warning services to the community rely on wave modelling capabilities that range in scale from the open ocean down to the coastal zone.

The Australian wave model (AUSWAVE), based on the third-generation wind wave modelling framework WAVEWATCH III® (WW3) model has been the operational sea-state model run by the Bureau National Operations Centre since August 2010. The AUSWAVE system is forced by the Australian Community Climate and Earth-System Simulator (ACCESS) Numerical Weather Prediction (NWP) system. The operational wave models run at two different domains: global model at 25km resolution and regional model at 10km resolution.

This presentation covers four ways to improve the wave model performance: increasing the global wave model resolution to match improvements in the resolution of the atmospheric forcing; improving wave model physics by using a new physical spectral source term package; introducing ensemble probabilistic forecasts and developing operational consensus forecasting system (OCF), which optimally combines the direct model outputs from a number of wave models and produces wave forecasts for the selected wave buoy sites around the Australian Coast. The wave OCF produces forecasts of significant wave height, peak wave period, wind direction and wind speed up to 5 days ahead. Wave OCF is simpler method that tends to outperform more expensive computational methods. The combined forecast is proved to be often the best forecasts for the Australian coast.

Collaborative Approaches for Swell Affected Operations on Australia's North West Shelf

Williams, Greg

31 Bishop Street, Subiaco, WA, Australia 6014

Greg.williams@rpsgroup.com.au

Almost a ***trillion*** dollars of coastal installations, LNG terminals, ports exporting iron ore, and oil and gas production facilities line the North West coast of Australia. Together, the mining and oil and gas industries provide the bulk of Western Australia's revenue and contribute to a large proportion of Australia's wealth. This region is already the largest producer and shipper of iron ore in the world, and by 2018, the total LNG export capacity is expected to reach 87 million tonnes per annum, the largest of any country.

Further offshore along the continental shelf, an array of oil and gas fields, wells, subsea infrastructure, pipelines, and associated production platforms and floating facilities are operated in one of the most exposed and extreme environments anywhere in the world.

The relatively warmer waters between Australia and Indonesia host the formation zone for tropical cyclones – some of the strongest in the world. More generally, the region is open to some of the longest fetches in the world, such that severe storms in the Southern Ocean can generate very long period swells travelling thousands of kilometres before arriving on the North West Shelf.

Despite its economic importance, the number of industry types and operating companies, the value of the offshore and coastal assets supporting them, and the risks associated with working in such a harsh environment - no single operator or government agency has the coverage to offer a full view of swell arrival or cyclone impacts in this region. Only collaboration and data-sharing offer a reasonable solution to supporting these industries – with all available information used and presented in a single system, to provide a clear understanding to all.

RPS MetOcean has developed a sophisticated swell prediction system comprised of automated cyclone track assimilation and advanced cyclone wind blending, highly tuneable wind-forcings and physics, and a calibration system based on remote-sensing and near-realtime measurement feeds from private and public networks.

In this presentation we describe case studies and areas of collaborative application, and discuss the applicability of the swell prediction system across industry boundaries.

Weather: ships sail safely – port decision making with operational oceanographic forecasts

Hibbert, Gregory*[1], Peter McComb[2], Eric Schulz[3] and Sebastien Boulay[2]

[1] OMC International, 126 Trenerry Crescent, VIC 3067, Australia.

[2] MetOcean Solutions Ltd., PO Box 441, New Plymouth, New Zealand

[3] Australian Bureau of Meteorology, Melbourne, Australia

g.hibbert@omcinternational.com

Shipping cargo through a port is a multi-factored exercise in logistics and optimisation. Like many ventures, the weather often has a major influence on the efficiency and safety of the import and export of cargoes, and thus the Australian economy. The personnel overseeing operations at a port continually monitor the weather and decision support systems must do the same to be effective. Operational oceanography can be used to inform users and automated systems alike of immediate threats to safety, while also detecting opportunities to optimise cargo throughput efficiency. From an under keel clearance (UKC) perspective, key inputs to optimise decision making for loading and sailing ships rely on the operational provision of water level (anomaly) estimation and (spectral) predictions for swell exposed channels. The decision support systems rely on several quality aspects of the predictions, which include accuracy and precision, and also timeliness, robustness and stability over time. The challenges in balancing and maximizing these qualities, while incorporating the skill of numerically-produced forecasts and near real-time observations, are explored along with some of the consequences to port operations when these qualities are degraded. While site-specific, short term (2 to 7

days) forecasts are routinely available for swells, there is an increased availability of water level forecasts, with great potential for improving decision making with improved accuracy and reduced uncertainty. One such approach is the use of consensus forecasting techniques. Present capabilities in the provision and use of ensemble forecasts for port UKC-related decision making are explored, along with foreseeable possibilities.

eSA-Marine – phase 1: the first step towards an operational now-cast/forecast ocean prediction system for Southern Australia

Middleton*[1], John. F., Paul Sandery[2] and Charles James[1]

[1] SARDI Aquatic Sciences, 2 Hamra Ave, West Beach, S.A. 5022

[2] Bureau of Meteorology, 700 Collins Street, Docklands VIC 3008

John.middleton@sa.gov.au

In this project the first phase of an operational model has been developed for Australia's southern shelves by nesting SARDI's high resolution (2.5 km grid) ocean model SAROM inside the BoM's global 10 km grid operational now-cast/forecast model - Ocean MAPS. SAROM is a data assimilating model. In turn, a very high resolution model (< 600 m grid) of Spencer and Gulf St Vincent has been developed (The Two Gulfs Model; TGM) and is embedded inside SAROM. All domains reflect significant regions for fisheries and aquaculture and provide now-casts/forecast of ocean currents, temperature *etc* in plan view as well as at selected station sites. The project will provide demonstrations of the system capability through the eSA-Marine web site including pages on now-cast/forecasts and animations as well as methodology, system validation and highlights including the now-cast/forecast of the S.A. September 2016 extreme storm event at Port Pirie. Examples of optimal ship routing and pollutant/toxin dispersal are given.

Near real-time atmosphere-ocean two-way nested system for west coast of Australia

Ivica Janekovic*, Charitha Pattiaratchi, Yasha Hetzel, Badema Grcic

School of Civil, Environmental, and Mining Engineering / UWA Oceans Institute, The University of Western Australia, Crawley, Australia

ivica.janekovic@uwa.edu.au

The UWA nowcast-forecast ocean/atmosphere system is based on the latest WRF-ARW atmospheric model configured as a 2-way nested constellation consisting of 2 km resolution in the Perth region within a 10 km resolution covering the west coast. This system provides forcing needed for the ocean counterpart, based on the latest ROMS 3D model, having curvilinear/stretched ~2.5 km (wide parent) and 500 m (nested Perth region) domain resolution, along with real-time forecast fields from Mercator and Hycom global models at the boundaries. These models have been running daily on the linux server at UWA, in a near real-time mode for more than a year, providing stable 5-day 3D atmosphere/ocean forecasts with detailed outputs for major regions and ports in WA. Acquisition and preparation of model inputs are automated, using a shell and python environment developed in-house. Comparison of model results with the available sea level observations at major ports in WA confirms that this system is capable of predicting even meteo-tsunami events that occur during winter frontal storms. Data from the system are freely served to the community using an openDAP/thredds server and plotted graphically on the web site (http://coastaloceanography.org).

Complex near-bed sedimentary dynamics in seasonally stratified waters control visibility for subsea engineering

Larcombe, Piers*[1], Garvey, Michael[2]

[1] RPS MetOcean Pty Ltd, 31 Bishop St, Jolimont, Perth, Western Australia 6014

[2] Shell Australia Pty Ltd, 562 Wellington St, Perth, Western Australia 6000

piers.larcombe@rpsgroup.com.au

Many aspects of subsea installation and inspection operations involving Remotely Operated Vehicles (ROVs) rely on a human pilot viewing live video feeds. Poor underwater visibility has been a leading cause of downtime for some projects in the Browse Basin, Western Australia. At one project site, careful measurements of the oceanography, vertical structure and particle characteristics (nature, concentration, particle size distribution) and dynamics have been combined with ROV visibility logs to produce an understanding of the variety of factors controlling visibility at different heights above the bed. Visibility conditions vary with seasonal stratification, tidal currents and other more complex near-bed sedimentary processes. The science has allowed the development of predictions of ROV visibility within 50 m above the bed, validated over a period of 12 months and used for a further ~18 months to plan field operations. The predictions present daily, weekly and monthly contours of the maximum likely visibility range in the basal 50 m of the water column. The predictions have significantly reduced downtime during the subsea construction phase, and will contribute to operational and later decommissioning phases.

Challenges and advances in predicting waves in the nearshore

Hansen, Jeff*[1], Ryan Lowe[1], Tom Baldock[2], Ian Turner[3], Alexander Babanin[4], Mark Hemer[5] and Diana Greenslade[6]

[1] UWA Oceans Institute and School of Earth Sciences, The University of Western Australia, Crawley, WA 6009.

[2] School of Civil Engineering, The University of Queensland, St Lucia, QLD 4072

[3] Water Research Laboratory, School of Civil & Environmental Engineering, University of New South Wales, Sydney, NSW 2052

[4] Department of Infrastructure Engineering, The University of Melbourne, Parkville, VIC, 3010

[5] CSIRO Oceans and Atmosphere, GPO Box 1538, Hobart, TAS 7001

[6] Bureau of Meteorology, GPO Box 1289, Melbourne, VIC 3001

jeff.hansen@uwa.edu.au

Understanding of waves in the nearshore, nominally depths less than 25 m, is critical for accurate prediction of a range of coastal hazards including beach erosion, coastal flooding, beach safety, and port operations. Waves in intermediate and shallow water behave differently than in deep water as they become increasingly influenced by interaction with the sea bottom. The transformation of waves in shallow water results in a range of processes including nonlinear energy transfers, depth induced breaking, setup and setdown, and ultimately wave driven currents with each of these ultimately influencing, for example, the degree of coastal flooding resulting from a storm. Improved computing capacity and numerics has allowed for the application of wave-resolving models (e.g. non-hydrostatic/Boussinesq) to be applied over increasingly large (coastal scale) spatial areas. Despite their computational expense, wave-resolving models offer considerable advantages compared to phase-averaged models. For example, they intrinsically include nonlinear energy transfers that are important in the generation of infragravity waves which often dominate the wave (and run-up) spectrum at the shoreline, thereby resulting in improved prediction of total water levels compared to phase-averaged models. Results will be presented from a series of field and laboratory experiments that highlight recent advances in the understanding and modelling of waves in the nearshore and how these can be used to improve forecasts of coastal hazards. This will include comparisons of both phase-averaged and resolving models with high-resolution data sets and a discussion of the need for accurate input bathymetry and boundary-conditions for both classes of models.

The emergence of data-driven technologies for operational oceanographic applications

Foster, Simon

Fugro, 24 Geddes Street, Balcatta, WA

s.foster@fugro.com

Metocean data inform decision making processes designed to reduce cost, mitigate risk and underpin safety. There are two distinct phases where operational oceanographic data add value: firstly in the planning phase and secondly during operations themselves. Traditionally, oceanographic data has been presented to users in the form of operational statistics derived from historical data, real-time observations and forecasts. However, often the data provider has had limited prior knowledge of the operational constraints and therefore the data products delivered have tended to be a quantitative description of the operationally relevant oceanographic parameters and processes. Rapid advances in connectivity, processing power and data storage have facilitated the innovation of new data-driven technologies across a range of industrial sectors that deliver customised information and insights specific to the end-users needs and objectives. Innovations are now reaching the offshore industry in the form of technologies designed to extract the previously untapped inherent value within the data through assimilation, integration and optimisation. Vessel routing is one example of how data-driven technologies, through the integration of vessel performance and Metocean data, can help manage risk while minimising costs and reducing harmful emissions; all of which align with global industrial and societal needs. This presentation show cases some novel data-driven technologies emerging within the arena of operational oceanography. The aim is to highlight the benefits that effective data management and innovative analytics can yield; not only in terms of existing industry needs but also as a means to help identify and understand complex oceanographic and environmental interdependencies.

Maximising impact and value from marine observations – Modelling tools for network design

Kelly-Gerreyn*, Boris, Chris Tingwell, Sergei Soldatenko, Peter Steinle, Robert De Maid and Agnes Lane

Bureau of Meteorology, 700 Collins St, Docklands, VIC 3008

b.kelly-gerreyn@bom.gov.au

One of the major challenges that the ocean observing community faces is the ability to provide data which maximises impact and value to users. Building on innovative work at the UK Meteorological Office, and in partnership with other international organisations, the Bureau of Meteorology has started to address this challenge by developing efficient modelling tools to assist with observing network design. The focus of this work, called Forecast Sensitivity to Observations (FSO), is on quantifying the impact of observation systems when they are assimilated in Numerical Weather Prediction systems. The FSO approach has the key advantage of being far more efficient than the resource-intensive data denial approaches to understanding observational impacts. As such, FSO lends itself to both operational and analysis usage.

This presentation will provide the progress we have made over the last couple of years and demonstrate the usefulness of the approach through results achieved so far.

Theme 3 – Uses and Users of Operational Oceanography

Developing Decision Support Tools for Offshore and Nearshore Marine Operations

Zed, Matthew

Woodside Energy Limited, Perth, WA 6000

Matthew.zed@woodside.com.au

Woodside, along with all other offshore oil and gas operators, rely on accurate and reliable decision support systems for safe and efficient operations. In the metocean context, this includes access to reliable weather forecasts and tailored tools to ingest these projections and convert them into operation-specific guidance at relatively long forecast horizons. Over the past three decades of operation on the North West Shelf Woodside has utilised a number of marine weather forecasting systems. This has included the Remote Offshore Warning System (ROWS) established in the late 80's for the short term forecasting of Tropical Cyclone swells, ongoing site and regional forecasts from the Australian Bureau of Meteorology and operation-specific forecasts from consultants.

As operational decisions within the oil and gas industry are risk-based, there is an increasing demand for weather forecasts that utilise both deterministic (i.e. best estimate) and probability based strategies to enable direct risk quantification against critical weather thresholds.

A brief summary of the marine weather forecast products currently employed within Woodside will be presented, along with the current decision support tools that are used for typical offshore and nearshore marine operations. Updates to ROWS and methods for metocean risk quantification at offshore sites will also be presented as part of recent improvements to decision support systems for Woodside's marine operations.

The business of fishing in a changing ocean

Carter, David

Austral Fisheries Pty Ltd, Mt Hawthorn, WA 6915

dcarter@australfisheries.com.au

The next 30 years promises change on a scale, and at a speed, as yet unimagined by most of the 7 billion humans on this planet. For us to contain global warming to just 2 degrees by 2050, we will need unprecedented performance from our political leadership and governments, businesses, the science community, conservation groups, and individuals. We have seen fish move, mangroves and seagrasses die, corals bleach, and recruitment impacts on fisheries. "Unusual events" are becoming more common; changes in weather more extreme. Our boats are exposed to weather conditions including the highest wave ever recorded in NZ at 19.4 metres. Fisheries are the 'canary in the coalmine' and the fishing industry has an opportunity, indeed responsibility to lead a discussion with the broader community and raise awareness of the overall challenge by connecting the food we eat to the actions that are required to prevent a catastrophe. In 2016, Austral Fisheries took a World first step to fully offset our carbon emissions and to begin a conversation and to offer our customers a climate friendly protein choice. As we gallop toward our uncertain future it will be science that guides our decisions, assesses our risks and looks to find answers to the many unanswered questions. For practitioners of Operational Oceanography, the fishing industry stands ready to provide real time insights informed by long and intimate experience of our oceans and to collaborate in data collection as ships of opportunity.

National Energy Resources Australia (NERA) technology and science activities

Stajduhar, Jill

General Manager Industry Research and Innovation, National Energy Resources Australia, 26 Dick Perry Avenue, Kensington WA 6151

jill.stajduhar@nera.org.au

While many of the actions required by the energy resources sector to address the challenges and opportunities ahead are relatively well known and understood, there are other issues which are not well defined or there are gaps in knowledge. This presentation will focus on the outcomes of NERA's (National Energy Resources Australia) initial extensive industry stakeholder engagement and benchmarking using nine knowledge priority areas.

NERA is committed to working openly with stakeholders to identify and pursue strategic initiatives and projects that will assist the Australian energy resources sector to adapt to current and future challenges and disruption.

Key to this future success will be increased collaboration amongst operators, contractors, service providers, the government and research organisations; a willingness to explore challenging and, at times uncomfortable new issues and opportunities; and a willingness to take considered risks on novel disruptive solutions to tomorrow's pressing questions.

The presenter will provide examples of current NERA technology and science initiatives and how future collaborative consortia can access funding.

FLNG and the need for operational oceanography

Flynn, Jan

Lead Metocean Engineer, Shell Australia Pty Ltd, Shell House, 562 Wellington Street, Perth WA 6000, Australia.

Jan.flynn@shell.com

Prelude Floating Liquefied Natural Gas (FLNG) facility is the largest offshore floating facility ever built and as such presents unique challenges both for engineering design and operation during its 25-year lifespan. Prelude is on its way to the Prelude field, where the hook-up and commissioning of the facility to the pre-installed infrastructure will take place. Its location in the Browse Basin presents a challenging metocean environment. This paper will address some of the specific oceanographic challenges Shell has encountered in engineering design and planning the operation of the facility. We will also discuss the development of operational tools to support the offloading of LNG, LPG and oil condensate from the Prelude FLNG to carriers in the open ocean to export product direct to market. We will conclude by considering how further developments in operational oceanography could support the development of stranded gas reserves for Australia's future economic growth.

AMSA's application of metocean models and awareness to support strategic and operational decision-making

Prosser, Gary

Australian Maritime Safety Authority, 82 Northbourne Ave, Braddon, ACT 2612

Gary.Prosser@amsa.gov.au

AMSA makes strategic (investment), operational (planning) and tactical (action) decisions every day. AMSA is a risk management agency, and this is most clearly reflected in the business model that underpins its latest evolution – Standards, Operations and Response. In a world increasingly able to harness the power of big data and better information, AMSA has committed to improving outcomes for its clients and stakeholders by better understanding what contributes to risk and how best to mitigate it. Foremost among recent development is a growing capability by AMSA to understand and predict the influence of metrological and oceanographic conditions on maritime activities. AMSA has long been a recipient and user of metocean modelling for search and rescue, and oil spill trajectory prediction. But more recently, we have been engaging much more directly with the technical experts in the research and delivery sectors to better understand and apply that knowledge to a wider range of applications. Managing dynamic under keel clearance in the busy, complex and depth constrained Torres Strait is a matter of centimetres. Being able to confidently predict how a drifting bulk carrier will react to winds, tides, currents and waves is a recent operational reality. And using dynamic ambient oceanic conditions to identify areas of greater risk for types of vessels or types of voyages (or other maritime activities) means more astute and evidence-based planning and investment in risk mitigation is now possible. AMSA now sees its understanding of metocean conditions as fundamental to its business needs.

Marine and Ocean Services in the Bureau of Meteorology – The importance of partnerships as we strengthen the value chain

Webb, Rob

Bureau of Meteorology, Hazards, Warnings and Forecasts Division, Docklands, Vic 3008

rob.webb@bom.gov.au

The Bureau of Meteorology's capability has been greatly enhanced through large increases in supercomputing power to support the delivery of robust services to Australian and international customers. With leaps forward in technology, so to have customers rapidly developed capability and enhanced requirements. Such advances require a sharpened focus on understanding customer needs and delivering services and research focussed on solving real problems and supporting effective decision-making. Modern weather, marine and ocean service providers point to a value chain that contributes to effective service delivery with the strongest delivery of resilient, client-focussed services revolving around deep focus on observations, high-performance computing, modelling, post processing and dissemination. The presentation will examine the value chain in the context of the Bureau's marine and ocean services and the importance of partnerships to strengthen the chain. The Bureau's refreshed strategy and evolving service suite will also be discussed, highlighting the importance of placing customers at the centre of the successful operational delivery of services.

Harmful algal bloom forecasting – can we do it?

Condie, Scott*[1] and Gustaaf Hallegraeff[2]

[1] CSIRO Oceans and Atmosphere, GPO Box 1538, Hobart, Tasmania 7001

[2] Institute for Marine and Antarctic Studies, University of Tasmania, Private Bag 55, Hobart, Tasmania 7001

scott.condie@csiro.au

Harmful algal blooms (HABs) cause severe economic losses to aquaculture, fisheries and tourism throughout the world, and can have major environmental and human health impacts. Forecasting HAB events poses many challenges, particularly in relation to the complexity of the marine environment across a broad range of temporal and spatial scales. However, environmental conditions are key drivers for the development of HABs and may provide a basis for forecasting bloom events. We investigated the influences of environmental conditions on the development of blooms off eastern Tasmania of the highly toxic dinoflagellate species, *Alexandrium tamarense*, impacting on mussel, oyster, scallop, abalone and rock lobster industries. Analyses of bloom events starting in 2011 suggest that rainfall and air-sea temperature differences can create conditions conducive to blooms by enhancing coastal stratification. We propose a risk forecasting framework for *A. tamarense* blooms utilising operational meteorological and oceanographic data streams.

Spatial management of fisheries in a changing ocean – using operational oceanography

Spillman, Claire*[1], Alistair Hobday[2], Jason Hartog[2], Paige Eveson[2], Stephanie Brodie[3]

[1] Bureau of Meteorology, Melbourne, VIC 3001, Australia.

[2] CSIRO Oceans and Atmosphere, Hobart, TAS 7000, Australia.

[3] University of New South Wales, Sydney, NSW 2052, Australia.

claire.spillman@bom.gov.au

Seasonal forecasting has great scope for use in marine applications, particularly those with a management focus. Seasonal forecasts from dynamical ocean-atmosphere models of high risk conditions in marine ecosystems can be very useful tools for managers, allowing for proactive management responses. The Australian Bureau of Meteorology's seasonal forecast model POAMA currently produces operational real-time global forecasts of sea surface temperatures, with tailored outlooks produced for aquaculture and wild fisheries management in Australian waters. In marine farming and fishing operations in Australia, seasonal forecasting is being used to reduce uncertainty and manage business risks. Further, habitat distribution forecasts can be generated by combining these environmental forecasts with biological habitat preference data, providing industry with species-specific information. POAMA will be upgraded to the new higher resolution ACCESS-S seasonal prediction system in 2017, in collaboration with the UK Met Office. Dynamical forecasts potentially offer improved performance relative to statistical forecasts, particularly given baseline shifts in the environment due to climate change. Seasonal forecasts are most useful when management options are available for implementation in response to the forecasts. Improved management of marine resources, with the assistance of such forecast tools, is likely to enhance future planning, industry resilience and adaptive capacity under climate change.

Introduction to Pilbara Ports Authority's Metocean Networks

Schlack, Frans

Dredging & Survey Department, Pilbara Ports Authority. 2 The Esplanade Port Hedland, WA 6721.

Frans.Schlack@pilbaraports.com.au

Since 2013, the Pilbara Ports Authority (PPA) has made significant investments in the establishment of Meteorological and Oceanographic (Metocean) Networks in its ports it is responsible for; the ports of Port Hedland, Dampier and Ashburton. These Networks provide metocean data to these ports' marine operation teams to base their operational decisions on. Additionally, the PPA metocean data is made available to the PPA's stakeholders and contractors who conduct their operations in these ports. The PPA is actively involved looking for ways to share metocean data with organisations to improve forecasting of wave and swell data that can have a significant impact on its ports operations. PPA will present an introduction of its Metocean Networks, the metocean data that is gathered and the importance of metocean data to the safety of its ports operations.

SEA 2400 – next generation Hydrographic capability for Australia

Dunne, Stewart and Barbra Parker*

Hydrographic, Meteorological and Oceanographic Branch, Australian Hydrographic Office, Department of Defence, Wollongong, NSW 2500

barbra.parker@defence.gov.au

Defence has commenced Project SEA 2400 *Hydrographic Data Collection Capability* which seeks to replace and expand the existing Hydrographic Survey Capabilities and introduce a Strategic Military Survey Capability (SMSC). It aims to do so through two components. The first is a commercial strategy, to be known as the Hydroscheme Industry Partnership Program (HIPP), to meet the legislated requirements of the National Survey Function, with an anticipated endstate of a more efficient, effective and sustainable hydrographic and oceanographic data collection program. The second will introduce into service a SMSC to meet the Military Survey Function.

Theme 4 – Marine Extremes

Responding to the 2016 and 2017 Mass Coral Bleaching events on the Great Barrier Reef: from Observations to Modelling

Steinberg, Craig*[1], Claire Spillman[2], Neal Cantin[1], Jessica Benthuysen[1], Hemerson Tonin[1], Scott Bainbridge[1], Felicity McAllister[1], Neal Cantin[1], Richard Brinkman[1], Mike Herzfeld[3], Mark Baird[3], Chaojiao Sun[3], William Skirving[4], Rachel Pears[5], Tristan Simpson[6], Chari Pattiaratchi[7] and Eduardo Klein[8]

[1] Australian Institute of Marine Science, Townsville, Qld

[2] Bureau of Meteorology. Melbourne, Vic

[3] CSIRO CMAR, Castray Esplanade, Hobart, Tas

[4] Coral Reef Watch, NOAA/NESDIS, Maryland, USA

[5] Great Barrier Reef Marine Park Authority, Townsville, Qld

[6] Torres Strait Regional Authority, Thursday Island, QLD

[7] University of Western Australia, Perth, WA

[8] Universidad Simón Bolívar, Caracas, Venezuela

c.steinberg@aims.gov.au

The Great Barrier Reef has suffered extensive coral bleaching and mortality following record breaking exposure to heat stress in 2016 and now experiencing the first ever repetitive bleaching event for the region in 2017. The distribution of severe bleaching in 2017 has extended further south to the central GBR, increasing the spatial impacts of ocean warming on live coral cover. The severe levels of bleaching and mortality in 2016 coincided with extreme heat exposures in excess of 2°C. In contrast, the onset of severe bleaching in 2017 has occurred at much lower maximum temperatures that do not exceed the expected NOAA 4 Degree Heating Week threshold. Seasonal outlook models by NOAA and BoM predicted the warming for 2016 but in contrast considered 2017 to be a lower risk. IMOS, BoM and AIMS contributed a wide range of observations from satellite observations feeding into ReefTemp to reef based weather and oceanographic sensor networks that provided real time observations as events unfolded. A glider was also deployed at short notice in 2017 after the 13 glider missions in the previous year to help understand how deep the thermal stress extended to. The combination of the extended summer time observations throughout the water column by multiple observing platforms and the application of the operational eReefs model is allowing the 2016 and 2017 bleaching event to be analysed in ways unprecedented since the last major event in 2002.

Sub-surface intensification of marine heatwaves off southeastern Australia: the role of stratification and local winds

Roughan, Moninya*[1,2] and Amandine Schaeffer [1]

[1] Coastal and Regional Oceanography Lab, UNSW Australia, Sydney NSW 2052.

[2] MetOcean Solutions Ltd, Ragland NZ.

mroughan@unsw.edu.au

Marine heatwaves (MHWs) are becoming more common with record events occurring around the world, and unprecedented biological impacts including mass mortality and habitat shifts. However, little is known about the statistical characteristics of MHWs due to the lack of long term in situ observations. Using two historical datasets spanning 1953 (and 1992) to 2016 we use a seasonally-varying climatology and temperature anomalies to identify and characterize MHW events down to 100 m depth in coastal waters off southeastern Australia. We show that MHWs regularly extend the full depth of the water column, with a maximum intensity below the surface. Extreme temperatures at depth are driven by local downwelling favorable winds that mix the water column and reduce the stratification. These results show the importance of considering sub-surface hydrography, and that sea surface temperature is insufficient to fully understand MHWs which are having disastrous ecological consequences in coastal regions globally.

Deriving extreme metocean criteria for the Browse Basin using a 100,000 year synthetic tropical cyclone track database

Garvey, Michael *[1] and Emma Foster[2]

[1] Shell Australia Pty Ltd, 562 Wellington St, Perth, Western Australia 6000

[2] RPS Australia West Pty Ltd, 31 Bishop St, Jolimont, Perth, Western Australia 6014

michael.garvey@shell.com

It is standard in the oil and gas industry to design some offshore infrastructure to metocean criteria to the 0.01% risk per annum level (a probability of 10^{-4}, or a 1 in 10,000 year return period). Traditionally, metocean survivability criteria in tropical regions have been derived from the extreme analysis of hindcast databases which are based on historical records of cyclone tracks. These tracks are used to drive parametric wind and pressure models and these fields can then be used to model the associated waves and currents, yielding a coherent metocean database. Statistically extrapolating these historical databases from the reliable post-satellite era storms (1970 onwards) to derive extreme criteria with return periods in well in excess of 100 years is tenuous, let alone 10,000 year return periods. Some methods, such as track-shifting, to artificially increase the base data time to periods of hundreds of years, can be employed to increase confidence in the return period criteria in the order of 100 to 1,000 years. An emerging method is to use statistical methods to create long databases of "synthetic" tropical cyclone tracks. The underpinning assumption is that very rare metocean extremes result from a random combination of less extreme parameters sampled from the statistical distributions of historical track parameters. A synthetic cyclone database representing 100,000 years was created. Subsets of the full database of ~$5x10^5$ cyclone tracks were selected to be used to drive a 3rd generation wave model WAVEWATCH III™ and a hydrodynamic model SHOC. The resulting coherent metocean database has been used to derive 10,000 year return period metocean criteria for sites in the Browse Basin.

Estimates of extreme water levels around Australia

Pattiaratchi*[1,2], Charitha, Ivica Janekovic[1,2], Yasha Hetzel[1,2]

[1] School of Civil, Environmental and Mining Engineering & The UWA Oceans Institute, The University of Western Australia, Perth WA 6009, Australia

[2] Bushfire and Natural Hazards Cooperative Research Centre, Melbourne

chari.pattiaratchi@uwa.edu.au

The occurrence of extreme water level events along low-lying, highly populated and/or developed coastlines can lead to devastating impacts on coastal infrastructure with much of the damage caused by coastal flooding. The aim of this paper is to provide estimates of present day extreme total water level exceedance probabilities around the whole coastline of Australia, arising from combination of mean sea level, astronomical tides and storm surges generated by both extra-tropical and tropical storms. Simulations were undertaken over a 60 year period using an unstructured grid for the whole Australian coastline. Estimates of storm surge included the action of surface gravity waves including wave setup. Recent computational advances were utilised to investigate storm surge dynamics, including the effects of waves, using a new unstructured fully coupled numerical modelling system (3D SCHISM sigma-z hydrodynamic model coupled with the WWM-III wave model). Despite the large domain, the finite element model grid was capable of resolving coastal regions at order of 100 m. Model simulations for the whole of Australia have been conducted and validated with observations. Extreme water level annual recurrence intervals have been calculated will be presented including the development of a web based tool to access the results. We also highlight some current modelling challenges as well as the improvements gained when 2-way coupled waves were included particularly for forecasting extreme water levels. Results indicated that including the effects of waves in the model can often account for between 15-35% of simulated storm surge heights during an extreme event.

Severe Tropical Cyclone Debbie, sea surface response

Metters, Daryl

Coastal Impacts Unit, Department of Science, Information Technology and Innovation, Deagon, QLD, Australia

daryl.metters@dsiti.qld.gov.au

Severe tropical cyclone (STC) Debbie made landfall on the central Queensland coast at Airlie Beach on March 28 2017. The slow moving system was one of the largest tropical cyclones to make landfall on the east coast of Australia in recorded history. The passage of Debbie began over the Coral Sea as a tropical low pressure system, it moved towards the Queensland coast and developed in size and strength as it approached. Just before making landfall the system was classified as a category 4 Severe Tropical Cyclone. After crossing the coast from the east, STC Debbie deteriorated back to an intense low pressure system and turned toward the south east. Ex-TC Debbie then crossed back over the east coast just south of Gladstone and continued south easterly finally passing south of New Zealand. The passage of STC Debbie generated extreme wave heights and sea levels on the central Queensland coast. Maximum wave heights south of the crossing of 8.7 m at Mackay and storm surge of 2.66 m at Laguna Quay were recorded by the Queensland Government wave and storm-tide monitoring network. North of landfall the wind direction was off-shore, so the measured wave height and surge were considerably smaller with a 3.67 m maximum wave height and a negative surge at Townsville. The continued passage of Ex-TC Debbie along the Queensland and NSW coasts generated severe wave heights and storm surges with a maximum wave height of 9.55 m off Brisbane and a 0.9 m surge in Hervey Bay.

Marine heatwaves in northern Australia and new observations to improve their predictions

Feng, Ming

CSIRO Oceans and Atmosphere, IOMRC, 35 Stirling Highway, Crawley, WA 6009

Ming.Feng@csiro.au

Episodic anomalously warm sea surface temperature (SST) extremes, or marine heatwaves, amplify ocean warming effects and may lead to severe impacts on marine ecosystems. Coral bleaching events induced by extreme warming events have been observed frequently in recent decades in Indonesian-Australian Basin (IAB) the southeast Indian Ocean, a region traditionally regarded to have resilience to global warming. In this study, we assess the contribution of modes of climate variability, such as El Niño-Southern Oscillation (ENSO), Indian Ocean Dipole, Australian Monsoon, and Madden-Julian Oscillations, to the extreme warming events across the IAB. We find that in extended summer months, the extreme warming events are more likely to occur at the tropical reefs during eastern Pacific El Niño, driven by enhanced solar radiation and weaker Australian Monsoon. The magnitude of warming is also modulated by the Indian Ocean Dipole and Madden-Julian Oscillations (MJO) activities. In the presentations, a planned upper ocean observation program using state-of-art robotic technology in the IAB will be introduced, which will shed light on the air-sea coupling during the evolution of the MJO in the southeast Indian Ocean and help improve the predictions of the drivers of the marine heatwaves in the region, the MJO and the onset of Australian monsoon.

Improved tropical cyclone predictions for northwest Australia

Kepert, Jeff*[1]; Aijaz, Saima[1]; Burton, Andrew[2]; Davidson, Noel[1]; Greenslade, Diana[1]; Hawksford, Alister[1]; Wang, Xingbao[1]; Ye, Harvey[1]; and Zieger, Stefan[1]

[1] Bureau of Meteorology Research and Development, 700 Collins St, Melbourne, Vic, Australia

[2] Bureau of Meteorology WA Regional Office, 1 Ord St, Perth, WA, Australia

Jeff.Kepert@bom.gov.au

Tropical cyclones present a major risk to safe, economic and efficient operation of offshore industries in north-western Australia and elsewhere. Recently, a major research and development project has produced new tools to help improve forecasts of tropical cyclones in this region, thereby mitigating the impact on the industry. The new tools are a (i) bias-correction technique for tropical cyclones in global ensemble prediction systems, (ii) an ensemble wave model driven by component (i), (iii) a new high-resolution tropical cyclone forecast model, with (iv) an accompanying wave model. The two ensemble components (I and ii) of this research have been running operationally for the past tropical cyclone season, with the remaining components (iii and iv) to follow for next season. This research has delivered improved probabilistic wind guidance, more reliable probabilistic wave guidance, substantial improvements to tropical cyclone intensity forecasts, a new capability for wave forecasts from the tropical cyclone model, and new data for assessing the occurrence and timing of cyclone formation. Verification of the new systems has demonstrated the clear performance gains over existing forecast guidance. The research was conducted in close dialogue with, and supported by, four industry partners: Shell, Woodside, INPEX and Chevron. This collaboration ensured that the resulting knowledge was relevant and directly addressed the problems that are of most concern to the industry.

Final Session – Looking Ahead

Operational ocean observing for offshore carbon capture and storage

Hardman-Mountford, Nick*[1], Jim Greenwood[1], Rudy Kloser[2], Bronte Tilbrook[2] and Charles Jenkins[3]

[1] CSIRO Oceans & Atmosphere, Indian Ocean marine Research Centre, Crawley, WA 6009, Australia

[2] CSIRO Oceans & Atmosphere, Castray Esplanade, Hobart, TAS 7004, Australia

[3] CSIRO Energy, Black Mountain, Canberra, ACT 2601, Australia

nick.hardman-mountford@csiro.au

Understanding the possible environmental impact of subsea CO_2 storage is a challenging task globally, with off-the-shelf monitoring solutions still several years away. The CarbonNet project aims to inject up to 125 Mt of CO_2 into near-shore reservoirs of the Gippsland Basin, which are located under a shallow coastal shelf-sea with significant ecological status, complex oceanography and multiple active stakeholders, making it a unique global case study for coastal CCS demonstration. To develop a risk-based environmental monitoring program that can address public assurance as well as regulatory requirements, it will be important to understand and quantify both the likelihood of detection and the potential for environmental impact from putative release. Recent developments in research and technology have opened the door to improved methodologies, with lower false alarm rates and better understanding of underlying processes. Maximising the benefits of these technologies requires new understanding to assess the extent they can be used to improve robustness and cost-effectiveness of marine monitoring and verification in specific real-world contexts. We present initial results on detectability of CCS releases in coastal environments using new monitoring technologies such as seabed bubble detection systems and autonomous vehicles. We explore how understanding monitoring target signals within the context of background environmental variability can reduce false alarm rates and improve cost effectiveness of environmental monitoring programs.

Australia has a national advantage in ocean monitoring, with huge requirements and world leading science. Can we add industry and commercialisation to create a virtuous circle?

Hodges, Neil* and Darren Burrowes

BlueZone Group, 21 Huntingdale Drive, Thornton NSW 2322

Darren.Burrowes@bluezonegroup.com.au

Australia's performance in science research is well-known and demonstrated to be world-leading. Science and research in the ocean is no different where we lead the world in many ways, developing techniques and technologies to support monitoring, management and measurement of our vast ocean resources. How can we leverage this science to move inventions from the marine laboratories of the nation to commercialise them into products to assist global science? Can we develop a marine science industry that contributes to creating high-tech employment opportunities and leads to the development of a 'blue economy'? Eventually the business generated from the blue economy can support further science creating a virtuous circle. This paper discusses the experience of an Australian-based SME, BlueZone Group Pty Ltd, and shows some examples of collaboration with marine customers from multiple markets leading to 'win-win' outcomes. Pointers for the way forward are discussed to support development of a continuing conversation between science, commercialisation partners and industry.

The National Innovation and Science Agenda meets a growing blue economy – 'opportunity knocks'

Moltmann, Tim*

Integrated Marine Observing System (IMOS), IMAS Building, University of Tasmania, Hobart TAS 7001

Tim.Moltmann@imos.org.au

Australia has the third largest ocean territory on the planet, and marine industries already make a significant contribution to the nation's prosperity. The Australian Institute of Marine Science (AIMS) recently released its biennial industry update showing Australia's marine industries contributed $74.2 billion to the national economy in 2013-14. Significantly, the blue economy is increasingly recognised around the world as a high value, high potential growth sector. Development of Australia's blue economy could therefore deliver a disproportionately large and positive impact on the future prosperity of our nation – or not. The Australian Government's National Innovation and Science Agenda (NISA) is looking to embrace new ideas in innovation and science, and harness new sources of growth to deliver the next age of economic prosperity in Australia. It recognises the role of government support for innovation through investment in enablers such as education, science and research, and infrastructure; incentivising business investment; and removing regulatory obstacles. FOO is ideally placed to make a distinctive contribution at the nexus of the National Innovation and Science Agenda and the growing blue economy. It has a focus on improving the safety and efficiency of marine industries through a 'value chain' approach from R&D to operational decision. This presentation will review the landscape of opportunities presented by the National Innovation and Science Agenda, in the context of current and emerging FOO priorities. It aims to stimulate discussion about the potential for FOO to influence future investment that will catalyse enhanced collaboration across R&D, government, services, and industries within Australia's blue economy. 'Opportunity knocks'? Let's discuss.

NOTES

FOO 2017

25–27 July, 2017

Esplanade Hotel, Fremantle WA

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