



High-precision, low-cost animal positioning in passive acoustic telemetry

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41st Australian Society for Fish Biology (ASFB) Annual Conference & 5th International Symposium on Stock Enhancement and Sea Ranching (ISSESR)

11-14 October 2015 | Sydney Australia



ASFB & ISSESR 2015
SYDNEY-AUSTRALIA 11-14 OCT

program & abstracts book



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- Artificial reefs
- Fishcare Volunteers
- Gamefish tagging
- Kids fishing workshops
- *Get Hooked... it's fun to fish*, primary schools education



Recreational
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Welcome

Welcome to the 5th International Symposium on Stock Enhancement and Sea Ranching (ISSESR) and the 41st Australian Society for Fish Biology (ASFB) Annual Conference. This is the first time the ISSESR has partnered with the ASFB. This offers an excellent opportunity to international delegates, to be exposed to the breadth of world-class fish and fisheries research and management that is currently being undertaken in Australia. It also brings progressive international science and knowledge about the effects and effectiveness of stock enhancement, restocking and sea ranching, under the theme of Fisheries enhancement and restoration in a changing world, to ASFB members and delegates.

The conference will showcase contemporary research, management and governance for all of us interested in understanding, sustaining and restoring fish populations, and will encompass three days of presentations. Each morning will commence with a series of keynote plenary presentations from national and international experts in their field, before we break into concurrent subject-specific sessions for the remainder of each day. The 5th ISSESR will run as a single session throughout the conference in the Wattle room on Monday and Wednesday, and on Tuesday in the Harris Room. Also on Tuesday, the conference will host the 2015 Murray Darling Basin Native Fish Forum (MDB-NFF). Delegates are free to move between the ISSESR, ASFB, and MDB-NFF sessions.

In addition to the scientific program, the conference includes an exciting social program commencing with the Welcome Reception (sponsored by Sea-Life Trust) at the Sydney SEA-LIFE Aquarium on Sunday evening. This is followed by the Student Mixer (sponsored by University of Technology, Sydney) on Monday, and the Conference Dinner (sponsored by Subcon) on Wednesday, cruising aboard the John Cadman 2 on Sydney Harbour. In addition, the ISSESR Catch-up (for ISSESR delegates only, sponsored by Mote Marine Labs) and the MDB-NFF Meet-the-Boffins (for NDW-NFF delegates only) will both be held on the Tuesday night.

We would like to take this opportunity to thank and acknowledge the contributions of our sponsors. Their support has been essential to the success of this event. We encourage you to visit the trade booths in the venue foyer, introduce yourselves to the representatives of the various organisations who are present at the conference and take advantage of the opportunities they provide to support your research or business.

We trust you will enjoy the conference, enjoy Sydney, and use this opportunity to foster existing and establish new relationships among all of our national and international delegates.



Dr. Matt Taylor
Chair, Local Organising Committee



Dr. Gary Jackson
President, Australian Society for Fish Biology

We would like to acknowledge the Gadigal people of the Eora Nation who are the traditional custodians of the land where we gather for our conference. We would like to pay our respects to the elders, past and present, of the Eora nation; and extend that respect to all Indigenous people present. We recognise the lasting contribution that Indigenous people worldwide have made, and continue to make, to the understanding and management of our fish and fisheries.



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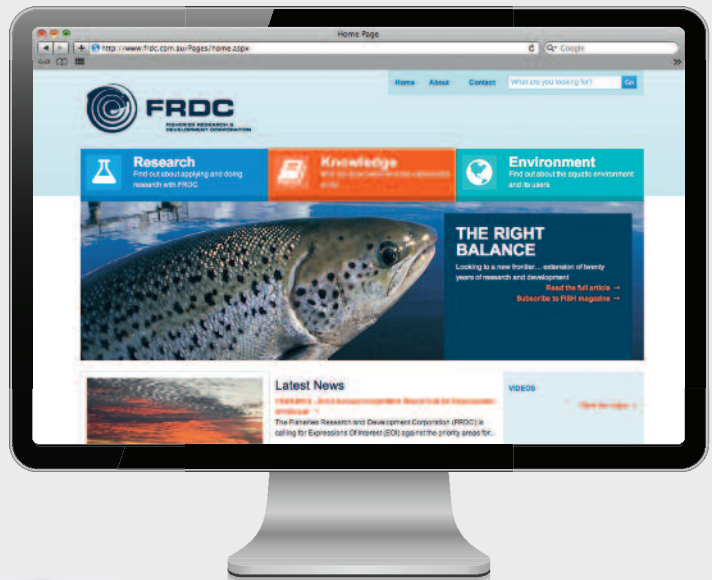
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About the Australian Society for Fish Biology

The Australian Society for Fish Biology (ASFB) is an Australasian-based scientific society focussed on the study of fish (including invertebrates) and their habitats. The ASFB was founded in 1971 to promote fish studies and the exchange of information between fish biologists. The Society has around 400 members mostly based in the Australian states and territories and New Zealand. The membership includes scientists and resource managers working in government agencies, tertiary institutions and the private sector.

The ASFB has held annual conferences since 1975 many of which also included workshops on specific topics of interest. The Society has a number of standing sub-committees that focus on specific areas of interest (e.g. threatened species, education, recreational fishing). The ASFB has always had a strong focus on fostering the scientific and intellectual development of tertiary students and early career researchers. The ASFB today supports a wide range of post-graduate research awards, international travel awards for post-graduate and early career researchers, and an early career excellence award. The Society's most prestigious award, the Kay Radway Allen, is only occasionally presented for "an outstanding contribution to fish or fisheries science".

The ASFB is a member of Science and Technology Australia, and was one of four founding member societies of the World Council of Fisheries Societies, the organisation responsible for the World Fisheries Congress (WFC) that is held every 4 years. The ASFB co-hosted the 2nd WFC in Brisbane and is currently involved with planning for the 7th WFC in 2016. The ASFB publishes a newsletter twice a year, which contains information and notices of interest to the membership, articles, state-by-state reports on activities of the membership and a bibliography of members' publications.

The roles of ASFB are:

- To promote research, education and the management of fish, fish habitat and fisheries
- To provide a forum for the exchange of information that encompasses the professional interests of all members
- To promote discussion on topics of relevance and interest to enhance excellence in fish studies
- To encourage participation by all members, particularly tertiary students
- To facilitate professional networks and career development
- To promote the use of fish research in sustainable natural resource management
- To provide access to expertise on fish and fisheries and provide independent advice and information on relevant issues as required.

Contact

For more information go to the ASFB website at www.asfb.org.au

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About the International Symposium on Stock Enhancement and Sea Ranching

Many of the world's marine fisheries no longer yield the benefits they once did, due to over fishing and/or the degradation of supporting ecosystems. Governments are typically responding to these reductions in yield and declining fish populations by reducing fishing effort and protecting fisheries habitats. However, fisheries management agencies and co-management entities are being progressive and asking how advances in fisheries science and aquaculture, which enable juveniles of many species to be produced en masse, can be responsibly applied to speed up recovery of some stocks, or increase the production of others.

The International Symposium on Stock Enhancement and Sea Ranching (ISSESR) series began in Norway in 1997. The series was stimulated by continuing concern over the decline of fisheries, coupled with emerging technologies in marine aquaculture and new efforts to quantify the effects of stocking cultured organisms into the sea. These symposia, which are held every 4 to 5 years, have connected scientists and others interested in the efficacy of using fisheries science and aquaculture to help sustain, replenish, enhance or investigate exploited fish and invertebrate populations. Previous symposia have been hosted by Norway (1997, 1st ISSESR), Japan (2002, 2nd ISSESR), the USA (2006, 3rd ISSESR) and China (2011, 4th ISSESR).

Previous ISSESR have been published as either a stand-alone publication (the Stock Enhancement and Sea Ranching book series), or as a Special Issue of an international journal (Reviews in Fisheries Science). These publications serve both as a proceedings document for the ISSESR series, and as a contemporary synthesis of progress in the field. Manuscripts appearing in these publications represent some of the most highly-cited works in the field.

More information on the ISSESR Series, including publications from the series and information on previous symposia, can be found at www.searanching.org.

About the Murray-Darling Basin Native Fish Forum

The Murray-Darling Basin Native Fish Forum will showcase the latest developments in the science and management of



native fish in the Murray-Darling Basin. The one day forum will include plenary and short talks from leading experts on native fish in the Murray-Darling Basin. Topics will encompass environmental flow management, 'fish-friendly' infrastructure, habitat rehabilitation, stocking, carp control and the role of recreational fishers in citizen science and fish habitat management. Q & A sessions will provide everyone with a chance to contribute ideas and the day will wrap up with a 'Meet the Boffins' mixer and an opportunity to chat to the various speakers and other experts.

Speakers

Mr Brad Adams Ocean Grown Abalone



Brad Adams is a third generation fisherman who has been involved in the abalone industry all his life. His father, Terry, founded the Western Australian commercial abalone diving industry in Augusta in the 1960's. For 12 years Brad worked as commercial abalone diver along Western Australia's south coast. In addition to his significant knowledge about wild abalone Brad has extensive abalone aquaculture experience. He worked in Tasmania after completing a post graduate degree in Aquaculture in 1992 where he conducted early research on culturing abalone in cages on long-lines.

Since 2000, he has been focused on abalone research & development in WA involving both shore-based and sea-based culture systems. In 2009 he and partners founded Ocean Grown Abalone Pty Ltd (OGA), a commercial aquaculture business working on the development of greenlip abalone ranching technology in Flinders Bay near Augusta. OGA have successfully developed artificial abalone reef modules that can be used to build suitable habitat in locations where hard natural structure is limited. These artificial reefs are then seeded with juvenile abalone that are then grown to maturity. The success of extensive trials has led to OGA commercializing the ranching technology. Reef modules have been deployed on a commercial basis since May 2014 with the first abalone harvest due to commence in early 2016. Brad's practical abalone fishing and aquaculture background and formal science training was complemented with formal business training via completion of an MBA in 2010. Brad was a Director of the Western Australian Fishing Industry Council (WAFIC), 2009-2011 and Chairman from 2011-2013.

A/Prof Kate Barclay University of Technology, Sydney



Kate Barclay researches the social aspects of fisheries. Since the late 1990s she has researched the sustainable development of tuna resources in the island Pacific in the context of changing governance systems and globalization. Current projects include multidisciplinary work to evaluate the social and economic contributions fisheries make to coastal communities in New South Wales, and a governance analysis of the supply chain of beche de mer from Papua New Guinea to markets around Asia. Kate has done work for the WWF, Greenpeace, the United Nations Development Program, the European Parliament, and the Pacific Islands Forum Fisheries Agency, the World Bank, and the David and Lucile Packard Foundation. Kate is a member of the Scientific and Technical Advisory Committee of the International Pole and Line Foundation, which promotes the development of socially and ecologically responsible tuna fisheries. She is also a member of the International Advisory Board of the BESTTuna project on Benefiting from Innovations in Sustainable and Equitable Tuna Management in the Coral Triangle and Western Pacific, based at the University of Wageningen in the Netherlands.

Dr Marissa Baskett University of California



Dr. Marissa L. Baskett is an Associate Professor in the Department of Environmental Science and Policy at the University of California, Davis. Dr. Baskett was a postdoctoral scholar at the National Center for Ecological Analysis and Synthesis (Santa Barbara, CA), before arriving at UC Davis in 2008. Her research focuses on applying mathematical modeling to questions in natural resource and

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conservation management, primarily in marine systems. She emphasizes cases where either rapid evolution or shifts in community composition affect management decision-making, which also informs an understanding of the feedback between ecological and evolutionary dynamics and the drivers of community structure. Specific topics include evaluating management approaches to reduce unintended fitness consequences of hatcheries and aquaculture, quantifying factors that determine the adaptive capacity of coral reefs to climate change, and exploring how ecological and evolutionary processes affect the design and monitoring of marine reserves. She was elected as an Early Career Fellow of the Ecological Society of America in 2013.

A/Prof Caleb Gardner Institute for Marine and Antarctic Studies



A/Prof. Caleb Gardner is a fisheries scientist and resource economist. He is the Director of the partnership between UTAS and the Tasmanian State Government at the Institute of Marine and Antarctic Research in Hobart. Caleb conducts applied research across a broad spectrum of topics with the core aim of improving the management of marine resources. Most research has been on high value, coastal invertebrate fisheries.

Australia's high value fisheries tend to be described as "fully exploited" which is commonly interpreted as meaning they are at their peak of both production and economic yield. This can be misleading as there are often substantial opportunities to improve both yield and value of fisheries through changes in management systems. These opportunities include simple tuning of regulations such as size limit controls, using bioeconomic modelling to improve harvest strategies, and enhancing productivity of stock.

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Prof Dean Jerry James Cook University



Prof. Dean Jerry is Head of Aquaculture and Fisheries at James Cook University (JCU) and has conducted research into the genetics of Australian aquatic fauna for 20 years. His research group at JCU is active in the development of translational genetic technologies to the aquaculture industry and that are applicable to aquatic biodiversity management. Recently his group has developed and successfully tested environmental DNA (eDNA) technology in the detection of invasive aquatic pests, threatened species like sawfish and disease causing pathogens. In his presentation he will highlight the power of eDNA to detect aquatic organisms in a variety of environments, along with some of the pitfalls that need to be considered when conducting eDNA surveys.

Mr Paul Lumley Columbia River Inter-Tribal Fish Commission



Baptist "Paul" Lumley is Executive Director of the Columbia River Inter-Tribal Fish Commission (CRITFC), and has an extensive history working with Northwest US tribes on salmon issues, particularly in the Columbia River Basin. He previously spent 17 years with CRITFC working on biological issues associated with power stations, and has also assisted in fund raising and establishing a grant program for the four Columbia River treaty tribes. Mr. Lumley has a wide-ranging background on issues that directly impact American Indians, Alaska Natives, and Native Hawaiians. He has worked directly with tribal governments, tribal consortia, virtually all US federal agencies impacting Indian Country, and Native American national and regional organizations throughout his professional career. CRITFC as an organization is dedicated to restoring the salmon runs to their historical range and

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Speakers

protecting the tribes' treaty-reserved fishing rights. This entails efforts, co-management, and coordination throughout the Columbia River basin, a basin that is approximately the size of France and spans five states and one Canadian province. Numerous dams were constructed in the Columbia River basin, which has severely impacted salmon runs and devastated tribal villages.

Dr Martin Mallen-Cooper Fishway Consulting Services



Dr Mallen-Cooper has 30 years' experience in fish ecology through research and management, with 10 years in government and 20 years as a consultant. His research on the ecology of fish migration, fish behaviour and swimming ability led to the first successful fishways for native fish in Australia. Much of his work is aimed at fish passage and flow management projects where conceptual models of fish populations and fish migration are used to form ecological objectives, which are then used to develop practical management guidelines.

Dr Mallen-Cooper has worked on over 210 fish ecology and fish passage projects. Clients have included state and federal government agencies, water authorities, engineering firms, local councils, and community groups; mainly in Australia, but also sites in Laos, Cambodia, Bangladesh, China, and New Zealand. Dr Mallen-Cooper has published widely in national and international journals, workshops, and symposia, as well as in more popular publications such as in *New Scientist* and *Australasian Science*.

Mr Les Perkins Farmers Conservation Alliance (FCA), USA



Les is the Business Development Director and a co-founder of the Farmers Conservation Alliance (FCA), a non-profit organization based in Hood River, Oregon. FCA's mission is to develop resource solutions for rural communities, specifically focused on water and energy. For the past 10 years, Les and FCA have taken a patented fish screen technology (The Farmers Screen TM) to market, received Federal approval for the technology, and developed 35 fish screening and passage projects in 5 states. FCA works to develop projects that benefit both the agricultural community and fish populations. Balancing the needs of both agriculture and the environment is at the core of FCA's mission to ensure a healthy future for irrigated agriculture and fish populations through drought resiliency and adaptive management. Les also chaired a Basin Study Work Group in the basin where he lives which recently produced a comprehensive Basin Study which outlines the conservation potential and future water needs for both in and out of stream uses in the Hood River Basin. Les also is a member of the Fish Screening Taskforce for the State of Oregon and is a member of the Oregon Hatchery Research Center Board representing the agricultural community. In addition, Les has served as a Hood River County Commissioner for the past 15 years, focusing primarily on water and other natural resource concerns.

Sunday 11 October – Welcome Reception

Venue: Sydney Aquarium
6 – 8 pm



Monday 12 October – Student Mixer

Venue: Penny Lane,
Building 11 – Level 1, 81-117 Broadway, Ultimo



Included with registration

Tuesday 13 October – Meet the Boffins Mixer

Venue: UTS, Aerial Function Centre



For MDB NFF delegates only

Tuesday 13 October – ISSSR 2015 Catch Up

Venue: Bar Broadway



6.30 – 9.30pm

Ticket: \$20

Wednesday 14 October – Conference Dinner Cruise

Venue: Captain Cook Cruise

7 – 11pm

Delegates: \$100 incl GST

Additional tickets: \$121 incl GST



Aerial UTS Function Centre is located within UTS Building 10 on Level 7, 235 Jones Street, Ultimo. The centre plays host to spectacular views of the city and provides large sweeping balconies and a fully equipped bar.

Directions:

Location, level 7, UTS Building 10. Enter at 235 Jones St Ultimo Foyer, take the lift to level 7 and proceed to the Function Centre.

Car park entrance is accessed from Thomas St (travelling West), with lift access to level 7.

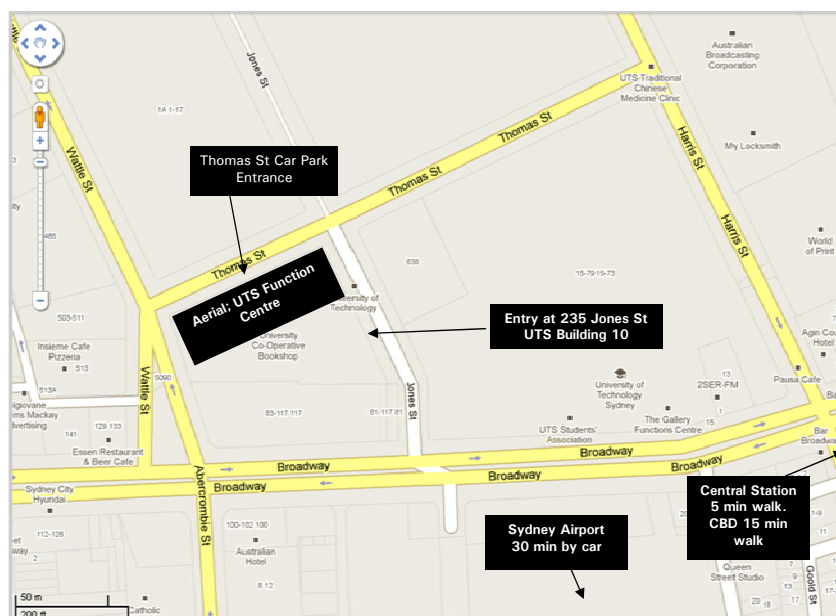
Metered street parking is available in Thomas Street but limited.

Aerial is located 5 minutes walk from Central Railway Station and 15 minutes to Sydney CBD.

Airport is 30 minutes drive (allow for traffic)

Public buses run regularly to the City from Broadway

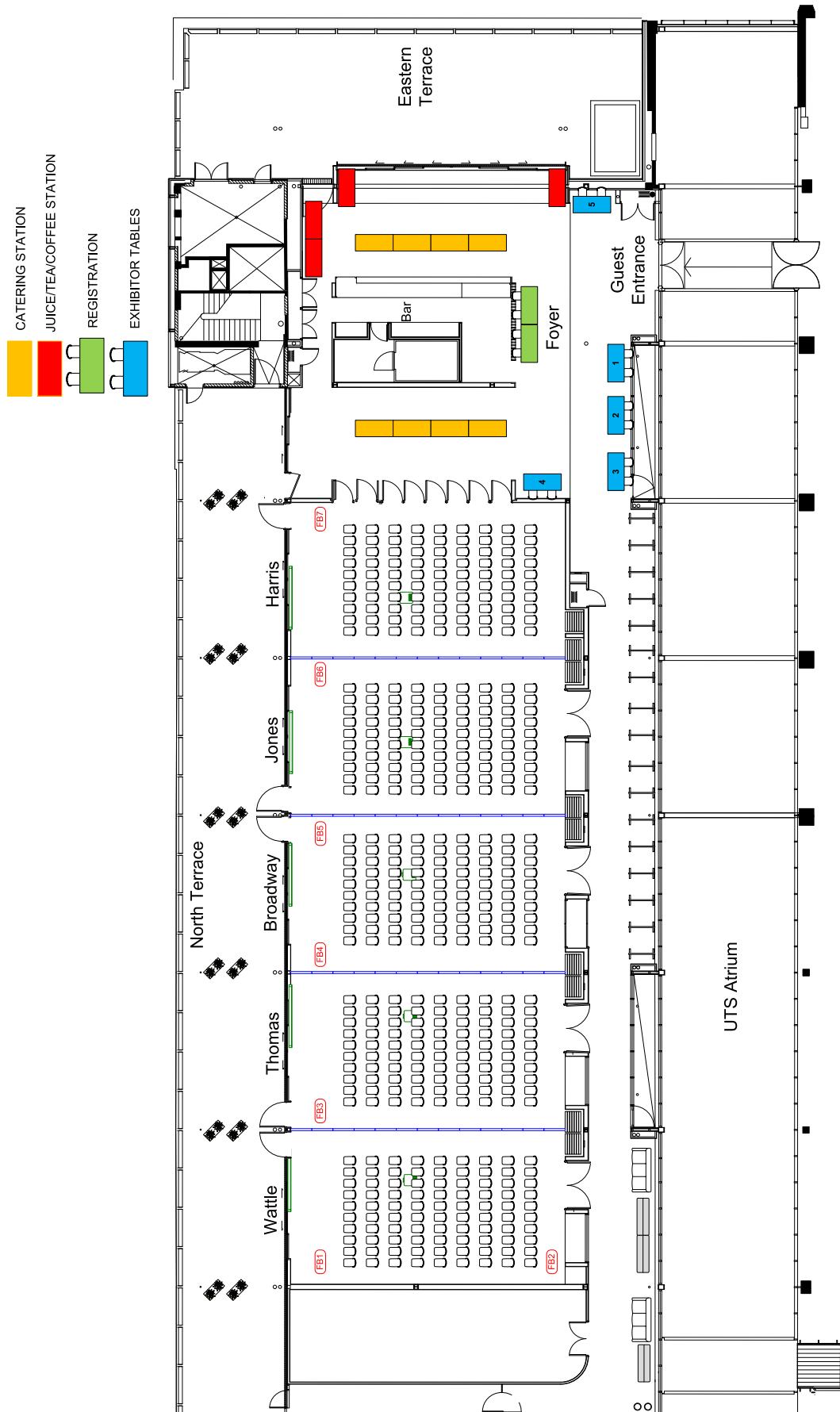
Broadway Shopping Centre is 5 minutes walk along Broadway to the West.



Location Map Sydney CBD



Floorplan



General Information

Catering times

Catering will be available during the Conference and is included in the registration fee. Catering will be served in the Aerial Function Centre. Please refer to the table below for the times.

	Monday 12 October	Tuesday 13 October	Wednesday 14 October
Morning Tea	1015 – 1045	1020 – 1045	1015 – 1045
Lunch	1230 – 1315	1230 – 1315	1230 – 1315
Afternoon Tea	1515 – 1545	1500 – 1530	1500 – 1530

Registration Desk

The registration desk is located when you enter the Aerial Function Centre on level 7 within Building 10. The registration desk will be open at the following times:

Sunday 11 October:
1730 – 2000 at Sydney Aquarium

Monday 12 October:
0700 – 1700 at Aerial Function Centre

Tuesday 13 October:
0800 – 1700 at Aerial Function Centre

Wednesday 14 October:
0830 – 1700 at Aerial Function Centre

Internet Access

Free Wifi Access is available in the Aerial Function Centre – WiFi instructions as per below:

1 Connect to the wireless network: UTS Function Centre

2 Enter credentials:

– Username: aerial

– Password: 2015oct8

Conference Delegate Materials

Please pick up your satchel and program book when collecting your delegate materials at the registration desk from Monday onwards.

Speakers' Preparation Room

The Speakers' Preparation Room is located in the Short Course Venue, Computer Lab - adjoined to the Aerial Function Centre.

The room will be open on:

Monday 12 October 0700 – 1700

Tuesday 13 October 0800 – 1700

Wednesday 14 October 0800 – 1600

Please make sure you have uploaded your presentation at least 3 hours before your allocated time slot.

Weather in Sydney

<http://www.bom.gov.au/nsw/forecasts/sydney.shtml>

Banks

Monday – Friday: 0930 – 1600/1700

Most branches have 24 hour automatic teller machines (ATM)

Climate

Sydney enjoys a temperate climate with a mild winter, and has more than 340 sunny days a year.

Currency

Decimal currency is used in Australia - units are dollars and cents. Current exchange rates can be obtained from your bank. All major credit cards are widely accepted in Australia.

Electricity

The electrical supply is 240 volts, 50Hz. The connection for appliances is a flat, 3-pin plug of unique design. Most hotels provide 110 volt outlets for shavers.

Language

English is spoken throughout Australia and is the official language for the Conference.

Mobile Phones

Australia operates on a digital network, therefore analogue mobile or cell phones cannot be used. Mobile phones can be readily hired at Sydney Airport or telecommunication outlets.

Shopping

Sydney retail shopping hours:
Monday – Friday: 0900 – 1730
Saturday & Sunday: 1000 – 1600
Hours vary at smaller shopping centres.

Taxes

A Goods and Services Tax (GST) of 10% applies to all consumer goods, and is included in retail prices.

Tipping

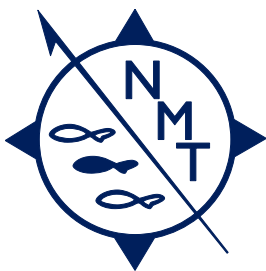
Service charges are not added to accounts by hotels and restaurants. You may tip hotel porters and restaurant wait-staff (up to 10% of the bill) if you wish to acknowledge exceptional service. At any time, tipping is your choice.

Public Transport

Public transport is the easiest way to get around Sydney. Call the transport line on 131 500 or go to www.transportnsw.com.au for timetable information. To travel on Sydney's public transport you will need an Opal Card. You can buy your Opal card at most news agencies, convenience shops and train stations.

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General Information

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Once you've arrived at Sydney Airport, travel into the city centre with Sydney Trains. A free shuttle bus operates in the city centre (Route 555) while Sydney buses will take you to all the major tourist attractions around the city including Bondi Beach, Manly, The Rocks and Sydney Opera House. If you are travelling late at night, be sure to plan your trip using the 131500 trip planner.

The best way to really appreciate the natural beauty of Sydney is on board a ferry or a leisurely cruise across the sparkling harbour. Water taxis can deliver you to prime harbour locations or take to the air in a seaplane. Other ways to get around Sydney are by hiring a bike, going for a coastal walk or hiring a car and using the inner toll roads for speedy cross-city travel. Use the Tripview app to plan your journey.

Travel and Health Insurance

We strongly recommend that you take out insurance policies to cover medical and travel expenses. If necessary, consult your travel agent.



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The Australian Centre for International Agricultural Research (ACIAR) is a statutory authority that operates as part of the Australian Aid Program. The Centre encourages Australia's agricultural scientists to use their skills for the benefit of developing countries and Australia.

ACIAR funds research projects that are developed within a framework reflecting the priorities of Australia's aid program and national research strengths, together with the agricultural research and development priorities of partner countries.



Department of Fisheries, Government of Western Australia

Session Sponsor



Government of Western Australia
Department of Fisheries

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The Department of Fisheries' primary responsibility is to conserve, sustainably develop and share the use of Western Australia's aquatic resources and their ecosystems for the benefit of present and future generations.

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The FRDC invests in science to create knowledge for the benefit of the Australian community so that Australia's marine and freshwater resources can be managed and used for fishing and aquaculture sustainably. It is a statutory corporation within the Australian Government's Agriculture portfolio and leads, partners and collaborates on establishing strategic national approach to fishing and aquaculture that aims to share knowledge, build cohesion and common goals between sectors.

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Mote Marine Laboratory is an independent, non-profit marine research institution comprised of world-class marine scientists committed to the belief that the conservation and sustainable use of our oceans begins with research and education.

Northwest Marine Technology, Inc.



Exhibitor

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Murray-Darling Basin Authority

Sponsor



Contact:
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Email: engagement@mdba.gov.au
Website: www.mdba.gov.au

The Murray-Darling Basin Authority is responsible for achieving the equitable and sustainable use of Basin water resources through the development and implementation of a Basin Plan, operation of the River Murray system, shared natural resource management programs, research, information and advice. This is achieved in collaboration with other Australian Government, Basin state and territory government and local agencies; industry groups; scientists and research organisations.

NSW Department of Primary Industries – Fisheries



Department of Primary Industries

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Contact: Director, Fisheries Research
Port Stephens Fisheries Institute, Taylors Beach Road
Taylors Beach NSW 2316
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Website: www.dpi.nsw.gov.au

The NSW Department of Primary Industries (NSW DPI) strives to increase the capacity of primary industries and communities and drive economic growth across NSW. DPI-Fisheries is a division of NSW DPI, with the responsibility for developing and maintaining healthy aquatic ecosystems, productive fisheries and aquaculture. The key goal of DPI-Fisheries is the provision of effective, science-based management to meet the NSW Government's goals and to deliver on community expectations relating to both economic growth and careful stewardship of NSW aquatic resources.

NSW DPI Recreational Fishing Trusts

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**Contact: Executive Officer
PO Box 4291
Coffs Harbour Jetty NSW 2450
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Phone: +61 2 6691 9681
Email:
recreational.fishingtrust@dpi.nsw.gov.au
Website: www.dpi.nsw.gov.au**

All money raised by the NSW Recreational Fishing Fee is placed into the Recreational Fishing Trusts and spent on improving recreational fishing in NSW. Anyone can apply for funding from the Recreational Fishing Trusts, including fishing clubs and organisations, universities, councils, community groups, individuals and so on. A wide variety of programs are implemented using funds from the Recreational Fishing Trusts, including recreational fishing enhancement programs, education, fishing access and facilities, research on fish and recreational fishing, aquatic habitat protection and rehabilitation etc.

SEA LIFE Trust

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**Contact: Claudette Rechterik
1 - 5 Wheat Rd
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Australia
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The SEA LIFE Trust ANZ is a non-profit Registered Environmental Organisation working globally with the SEA LIFE Trust UK, regionally and locally, to drive positive behaviour change to conserve aquatic habitats and protect the amazing wild life that lives within them.

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an end to over-exploitation of marine life.

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<http://www.uts.edu.au/about/faculty-science/school-life-sciences/about-us>

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WA Fish Foundation (Inc)

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Australia
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Website: www.waff.com.au

Established in 2004 the West Australian Fish Foundation is on the Federal Register of Environmental Organisations and was established to carry out fish stocking and associated research and monitoring across a range of species in Western Australia. By co-ordinating the current expertise available, from both around Australia and overseas, the Foundation is able to undertake conservation restocking and stock enhancement for a range of fresh and saltwater species.



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Program at a Glance

Wednesday 14 October

Tuesday 13 October

Monday 12 October

0820- 0845	Official Opening	MDB NFF Opening		
0845-0930	Keynote Session	Keynote Session	Keynote Session	Keynote Session
0930-1015	Keynote Session	Oral Session	Keynote Session	Oral Session
1015-1045	Morning Tea	Morning Tea	Morning Tea	Morning Tea
1045-1230	Oral Session	Oral Session	Oral Session	Oral Session
1230-1315	Lunch	Lunch	Lunch	Lunch
1315-1515	Oral Sessions	Keynote and Oral Session	Oral Session	Oral Session
1515-1545	Afternoon Tea	Afternoon Tea	Afternoon Tea	Afternoon Tea
1545-1630	Oral Session & ASFB Award Talks	Oral Session	Oral Session	Oral Session
1630-1830	ISSESR International Scientific Meeting & ASFB AGM			
Evening	Student Mixer 	Meet the Boffins Mixer	ISSESR 2015 Catch Up 	Conference Dinner Cruise 

Program Monday 12 October 2015

Room	Wattle	Thomas	Broadway	Jones	Harris	SC 1 and 2
Theme	ISSESR	ASFB	ASFB	ASFB	ASFB	ASFB
0700 - 0820	Registration - Aerial Function Centre					
0820 - 0825	Opening Words by Matt Taylor, Chair ASFB 2015 and 5th ISSESR					
0825 - 0830	Official Opening by Geoff Allen, Deputy Director General, NSW DPI-Fisheries					
0830 - 0845	Gary Jackson (President, ASFB) and Ron Essig (President, AFS)					
0845 - 0930	Keynote - Paul Lumley SPONSORED BY FISHERIES RESEARCH AND DEVELOPMENT CORPORATION					
0930 - 1015	Keynote - Marissa Baskett SPONSORED BY UNIVERSITY OF FLORIDA					
Morning Tea						
1015 - 1045	ISSESR - Integrating Demo & Gen. Pers. On Stock Mgt. & Socio. Ec. And Gov. Cons.	Threatened Species	Rec. Fisheries	Climate Change	Videos, Fish Behav.	Fish Bio., Ecol., Mgt.
1045 - 1230	<ol style="list-style-type: none"> 1. Michael Tringali (30 mins) 2. Enrique Blanco Gonzalez 3. Taylor Hunt 4. Ben Doolan 5. Graeme Bowley 6. Sarah Boyd 	<ol style="list-style-type: none"> 1. Mark Lintermans 2. Scott Raymond 3. Luke Pearce 4. Michael Hutchison 5. Rhys Coleman 6. William Gladstone 7. Lauren Veale 	<ol style="list-style-type: none"> 1. Lee Georgeson 2. Bruce Hartill 3. Nicola Rush 4. Jane Zhao 5. Jeremy Lyle 6. Marcus Lincoln-Smith 	<ol style="list-style-type: none"> 1. Julian Hughes 2. Jane Williamson 3. Stephen Mayfield 4. Tullio Rossi 5. Giverny Rodgers 6. Michael Tropiano 7. Paloma Matis 	<ol style="list-style-type: none"> 1. Evan Byrnes 2. Jordan Goetze 3. Dianne McLean 4. Dianne McLean 5. Matt Rees 6. Miles Parsons 	<ol style="list-style-type: none"> 1. Charles Todd 2. Matthew Gordos 3. Ben Broadhurst 4. Peter Unmack 5. Ashley Fowler 6. Ken McColl 7. Peter Unmack
Lunch						
1230 - 1315	ISSESR - Stock Enh. as a Comp. Fish. Mgmt. Tool	Threatened Species	Rec. Fisheries	Climate Change SPONSORED BY DEPARTMENT OF FISHERIES, WESTERN AUSTRALIA	Videos, Fish Behav.	Rep. ELH, Recruit.
1315 - 1515	<ol style="list-style-type: none"> 1. Kai Lorenzen (30 mins) 2. Takaaki Kayaba 3. Shinji Uehara 4. Tom McCowan 5. Grant Leeworthy 6. Lachie Jess 	<ol style="list-style-type: none"> 1. Nick Whiterod 2. Mae Noble 3. Stewart Fallon 4. Lara Suitor 5. Qifeng Ye 6. Jonas Bylemans 7. Brendan Ebner 	<ol style="list-style-type: none"> 1. Jamin Forbes 2. Faith Ochwada-Doyle 3. Stephen Taylor 4. Stephen Taylor 5. Krystle Keller 6. Jeff Murphy 	<ol style="list-style-type: none"> 1. Graeme Poleweski 2. Will Figueira 3. Chris Hallett 4. Katherine Cure 5. Gary Jackson 6. Nathan Waltham 7. Laura Lopez 	<ol style="list-style-type: none"> 1. Derrick Cruz 2. James Donaldson 3. Tim Langlois 4. Alistair Becker 	<ol style="list-style-type: none"> 1. Dan Warren 2. Luke McPhan 3. Danswell Starrs 4. Brett Pfulgrath 5. Tara Hicks 6. Caitlin Young 7. Anne-Marie Hegarty
Afternoon Tea						
1500 - 1530	ASFB AWARD TALKS					
1545 - 1630	ISSESR - Stock Enh. as a Comp. Fish. Mgmt. Tool	<ol style="list-style-type: none"> 1. Christopher Izzo 2. John Morrongiello 				
1630 - 1830	ISSESR International Scientific Committee Meeting	ASFB AGM				
1900 - 2100	Student Mixer - Penny Lane, Ultimo (sponsored by University of Technology, Sydney) - Incl with registration, but must book ticket SPONSORED BY UNIVERSITY OF TECHNOLOGY SYDNEY					

Program Monday 12 October 2015

- 820 - 825 Opening by Chair Matt Taylor
- 825 - 830 Official Opening by Geoff Allen, Deputy Director General, NSW DPI-Fisheries
- 830 - 845 Opening by Gary Jackson, President ASFB and Ron Essig, President AFS

845 - 930 **Keynote** *Room: Wattle, Thomas, Broadway*

- 845 - 930 **Paul Lumley**
Using Indigenous Fishing Rights to Stimulate Restoration of Fish Populations



930 - 1015 **Keynote** *Room: Wattle, Thomas, Broadway*

- 930 - 1015 **Marissa Baskett**
The role of rapid evolution in responses to stock enhancement and environmental change



1015 - 1045

Morning Tea

1045 - 1230 **Integrating demo & gen pers on stock mgt & socio ec and gov cons** *Room: Wattle*

- 1045 - 1115 **Michael Tringali**
Utilizing managed releases to maintain and, where necessary, restore genetic security in demographically challenged populations

- 1115 - 1130 **Enrique Blanco Gonzalez**
Genetic and phenotypic characterization of local and translocated corkwing wrasse (*Symphodus melops*) populations

- 1130 - 1145 **Taylor Hunt**
Economic cost-effectiveness of a fish stocking program for enhancing recreational fishing

- 1145 - 1200 **Ben Doolan**
Environmental and Social Benefits of Engaged Governance of Fish Stocking Activities

- 1200 - 1215 **Graeme Bowley**
New South Wales (NSW) Hatchery Quality Assurance Scheme

- 1215 - 1230 **Sarah Boyd**
Marine stocking in NSW.... moving ahead responsibly

1045 - 1230 **Threatened Species I** *Room: Thomas*

- 1045 - 1100 **Mark Lintermans**
Comparing Sampling Methods For Detecting An Endangered Freshwater Fish

- 1100 - 1115 **Scott Raymond**
Ovens River Demonstration Reach

- 1115 - 1130 **Luke Pearce**
Patterns in abundance of southern pygmy perch and alien species in four New South Wales creeks

- 1130 - 1145 **Michael Hutchison**
Bringing back jungle perch


1145 - 1200	Rhys Coleman Recovery Of Threatened Dwarf Galaxias In The Dandenong Valley, Melbourne	
1200 - 1215	William Gladstone Aerial surveys of juvenile white sharks in the Port Stephens nursery area: a step towards a baseline estimate of abundance	
1215 - 1230	Lauren Veale Restoration of coastal wetlands assisting in the recovery of threatened native fish	
<hr/>		
1045 - 1230	Recreational Fisheries I	<i>Room: Broadway</i>
1045 - 1100	Lee Georgeson A Framework for Regular National Recreational Fishing Surveys	
1100 - 1115	Bruce Hartill Comparison of recreational harvest estimates provided concurrently by two independent large scale surveys in New Zealand	
1115 - 1130	Nicola Rush Use of web cameras to monitor long term trends in dynamic recreational fisheries	
1130 - 1145	Jane Zhao Development of Computer Vision Algorithms to Automate Web Camera Monitoring of Recreational Traffic at Boat Ramps	
1145 - 1200	Jeremy Lyle Key developments in the Tasmanian recreational fishery: Teasing out the impacts of the major drivers for change	
1200 - 1215	Marcus Lincoln-Smith Recreational Fishing and Dredging In Darwin Harbour	
<hr/>		
1045 - 1230	Climate Change I	<i>Room: Jones</i>
1045 - 1100	Julian Hughes Top-down pressure on small pelagic fish by eastern Australian salmon <i>Arripis trutta</i> in a changing coastal pelagic ecosystem	
1100 - 1115	Jane Williamson Impacts of ocean acidification on eggs and larvae of Yellowfin Tuna, <i>Thunnus albacares</i>	
1115 - 1130	Stephen Mayfield Climate change challenge: predicting the influence of a changed physical environment on the Australian abalone fisheries	
1130 - 1145	Tullio Rossi Ocean acidification leaves dispersing fish larvae lost at sea	
1145 - 1200	Giverny Rodgers Damsels in distress: the effects of climate change on low-latitude coral reef fish and their potential for developmental acclimation.	
1200 - 1215	Michael Tropiano Tropicalisation Of The Reef Fish Community At Rottneest Island	

Program Monday 12 October 2015

1215 - 1230	Paloma Matis Habitat specialisation and the influence of temperature: investigating behavioural plasticity in coral reef fishes	
1045 - 1230	Videos, Fish Behaviour I	<i>Room: Harris</i>
1045 - 1100	Evan Byrnes Individual Personality Differences in Port Jackson sharks (<i>Heterodontus portusjacksoni</i>)	
1100 - 1115	Tim Langlois Rapidly collected behavioral data predicts the effectiveness of periodically harvested closures in Fiji	
1115 - 1130	Dianne McLean BRUVS as a tool for assessing marine fisheries and ecosystems: hurdles and potential	
1130 - 1145	Dianne McLean Biogeographical patterns in fish assemblages of the remote Pilbara region, northwest Australia	
1145 - 1200	Matt Rees Rules Of Attraction: Enticing Pelagic Fish To Mid-water Video Systems	
1200 - 1215	Miles Parsons Some fish-chanting evenings: The contribution of fish choruses to soundscapes in Australian coastal waters and implications of sampling duration.	
1045 - 1230	Fish Biology, Ecology and Management	<i>Room: SC 1 and 2</i>
1045 - 1100	Charles Todd Murray Crayfish Management Model: Development And Utility	
1100 - 1115	Matthew Gordos Carp Separation Cage effectiveness in remote Australian lowland rivers: assessing ecological benefit and commercial viability.	
1115 - 1130	Ben Broadhurst Early response of Macquarie perch to enlargement of an upland reservoir	
1130 - 1145	Peter Unmack Comparative phylogenomics of four Murray-Darling Basin aquatic species	
1145 - 1200	Ashley Fowler Demography of the eastern blackspot pigfish <i>Bodianus unimaculatus</i> , a long-lived labrid inhabiting deep temperate reefs	
1200 - 1215	Ken McColl Cyprinid herpesvirus 3: a potential biological control agent for carp in Australia	
1215 - 1230	Peter Unmack The Ecology of <i>Gambusia holbrooki</i> in Edgbaston Springs	
1230 - 1315	Lunch	
1315 - 1515	Stock enh as a comp fish mgment tool	<i>Room: Wattle</i>
1315 - 1345	Kai Lorenzen Quantitative assessment of fisheries enhancements: a critical review	

1345 - 1400	Takaaki Kayaba An approach to restore the stock condition of a depleted species of flounder in Northern Japan: Elucidating the spawning ecology of stocked barfin flounder <i>Verasper moseri</i> for better fishery management	
1400 - 1415	Shinji Uehara Evaluation of the Effectiveness of Stocking Japanese Flounder	
1415 - 1430	Tom McCowan PauaMAX' - Holistic Enhancement of New Zealand's Blackfoot Abalone (Paua) Resource	
1430 - 1445	Grant Leeworthy Potential for marine stock enhancement and spatial fisheries management in Victoria. Concepts, practice, policy needs, economics and sustainability.	
1445 - 1500	Lachie Jess Re-introduction of Trout cod in NSW - One million fish later	
<hr/>		
1315 - 1515	Threatened Species II	<i>Room: Thomas</i>
1315 - 1330	Nick Whiterod Exploring the capacity of Murray crayfish (<i>Euastacus armatus</i>) to recover from significant population loss associated with a severe hypoxic blackwater event	
1330 - 1345	Mae Noble Habitat Specialisation In Threatened Murray Crayfish Occupying Upland Streams	
1345 - 1400	Stewart Fallon How to non-destructively age a protected fish with no otoliths, spines, or discernible scale annuli? With an atomic bomb!	
1400 - 1415	Lara Suitor Cross-border cooperation to streamline recovery actions for the endangered Murray hardyhead (<i>Craterocephalus fluviatilis</i>) in the southern Murray-Darling Basin	
1415 - 1430	Qifeng Ye Population dynamics and status of freshwater catfish (<i>Tandanus tandanus</i>) in the lower River Murray, South Australia	
1445 - 1500	Jonas Bylemans Combining traditional and environmental DNA (eDNA) based monitoring to improve the management of native and invasive fish species.	
1500 - 1515	Brendan Ebner Proposing the use of an ecoart platform to conserve Australian fishes	
<hr/>		
1315 - 1515	Recreational Fisheries II	<i>Room: Broadway</i>
1315 - 1330	Jamin Forbes Murray Cod Creel Surveys - Finding Out What Really Goes On	
1330 - 1345	Faith Ochwada-Doyle Patterns of exploitation within Recreational Fishing Havens: implications for zonal management in NSW estuaries.	
1400 - 1415	Stephen Taylor Camera Surveys of Recreational Fishing in Western Australia	

Program Monday 12 October 2015

- 1415 - 1430 **Krystle Keller**
Estimating Fishing Catch and Effort from a Designed Artificial Reef
- 1430 - 1445 **Jeff Murphy**
Development of a flexible system for reporting recreational fishing data at fine spatial scales for Telephone/Diary surveys.
-
- 1315 - 1515 **Climate Change II** *Room: Jones*
- 1315 - 1330 **Graeme Poleweski**
Plasticity of tropical reef fish to future Sydney winters
- 
- 1330 - 1345 **Will Figueira**
Evaluating thermal performance reactions norms as a predictor of vagrant tropical fish success in temperate waters
- 1345 - 1400 **Chris Hallett**
Effects of climate change on estuarine fish communities of southwestern Australia
- 1400 - 1415 **Katherine Cure**
Evidence for poleward range shift in WA endemic *Choerodon rubescens*
- 1415 - 1430 **Gary Jackson**
The 2011 Marine Heatwave And Tropical Fish Off SW Australia
- 1430 - 1445 **Nathan Waltham**
Climate change increases thermal exposure of freshwater fishes occupying tropical seasonal rivers
- 1445 - 1500 **Laura Lopez**
Climate Change alters competition between Australian Bass and Mosquito fish
-
- 1315 - 1515 **Videos, Fish behaviour II** *Room: Harris*
- 1315 - 1330 **Derrick Cruz**
Behavioural interactions between the threatened Australian native fish, *Bidyanus bidyanus* and the non-native, *Gambusia holbrooki*
- 1330 - 1345 **James Donaldson**
Video Monitoring of a Fish Assemblage in a Turbid Tropical Estuary
- 1345 - 1400 **Tim Langlois**
A Novel Stereo-Video Method to Investigate Fish-Habitat Relationships
- 1400 - 1415 **Alistair Becker**
Monitoring fish movements and behaviour through estuary mouths using high resolution acoustic cameras. Effects of tides, light and urban modification
-
- 1315 - 1515 **Reproduction, Early Life History And Recruitment I** *Room: SC 1 and 2*
- 1315 - 1330 **Dan Warren**
Sexual ontogeny, sperm competition, and sperm performance in the bluehead wrasse
- 1330 - 1345 **Luke McPhan**
Temporal Growth Rates Of Murray Cod Larvae (*Maccullochella peelii*) In Relation To Prey Availability

- 1345 - 1400 **Danswell Starrs**
Can computed X-ray tomography reveal otolith growth increments?
- 1400 - 1415 **Brett Pflugrath**
Quantify Hydraulic Conditions Fish Encounter Passing Downstream Through River Infrastructure
- 1415 - 1430 **Tara Hicks**
The influence of maternal body size on fecundity and egg quality in Dusky flathead (*Platycephalus fuscus*).
- 1430 - 1445 **Caitlin Young**
Don't Blame It On The Moonlight: Abiotic Drivers Of Reproductive Development In Greentail Prawns, *Metapenaeus bennettiae*
- 1445 - 1500 **Anne-Marie Hegarty**
Reproductive Characteristics Of Teraglin, *Atractoscion aequidens*, Off The Coast Of NSW

1515 - 1545

Afternoon Tea

-
- 1545 - 1630 **Stock enh as a comp fish mgment tool II** *Room: Wattle*
- 1545 - 1600 **Caleb Gardner**
The pathway from research on lobster translocation into a commercial enhancement enterprise
-
- 1545 - 1630 **ASFB Award talks** *Room: Broadway, Jones, Harris*
- 1545 - 1605 **Christopher Izzo**
Seasonally Resolved Environmental Reconstructions Using Fish Otoliths
- 1605 - 1625 **John Morrongiello**
Otoliths: From Individuals to Assemblages in a Changing World

Program Tuesday 13 October 2015

Room	Wattle	Thomas	Broadway	Jones	Harris
Theme	MDB NFF SPONSORED BY RECREATIONAL FISHING TRUSTS		ASFB	ASFB	ISSESR
0845 - 0915	Opening MDB NFF Craig Copeland		Keynote – Kate Barclay		
0915 - 1000	Keynote – Martin Mallen Cooper		Keynote– Caleb Gardener SPONSORED BY WA FISH FOUNDATION (INC)		
0930 - 1015	1. John Koehn 2. Brenton Zampatti		SUBCON - Art. Reefs Pres		
1015 - 1020					
1020 - 1045	Morning Tea				
MDB NFF	Prod. & Prof. Fish SPONSORED BY NSW DEPARTMENT OF PRIMARY INDUSTRIES - FISHERIES	Climate Change & Rep. ELH, recruit	ISSESR - Evaluating Outcomes		
1045 - 1230	Environmental Flow Q&A 1. Greg Ringwood 2. Michael Hutchison 3. Zeb Tonkin 4. Matt Hansen Habitat Rehabilitation Q&A	1. Malcolm Hadden 2. Juan Carlos Quiroz 3. Jennifer Ovenden 4. Annabel Jones 5. Tim Ward 6. Crystal Beckmann 7. Emily Fisher	1. Matthew Le Feuvre 2. Garry Ogston 3. Jennifer Donelson 4. Natalie Moltischnawskyj Discussion 5. Joel Williams 6. Steven Hawes	1. Ken Leber (30 mins) 2. Shigenori Suzuki 3. Yoshitaka Sakakura 4. Ann-Lisbeth Agnalt 5. Craig Blount 6. Ellen Sofie Grefsrud	
1230 - 1315	Lunch - Formal Poster Session				
MDB NFF	Prod. & Prof. Fish SPONSORED BY NSW DEPARTMENT OF PRIMARY INDUSTRIES - FISHERIES	MPAs, Marine Estate SPONSORED BY NSW DEPARTMENT OF PRIMARY INDUSTRIES - FISHERIES	ISSESR - Evaluating Outcomes & Adv. in Aquacult Tech		
1315 - 1500	1. Craig Boys Keynote – Les Perkins 2. Lee Baumgartner 3. Matt Gordos Fish-friendly river infrastructure Q&A	1. Tyson Martin 2. Osman Samsun 3. Neil Loneragan 4. Craig Mundy 5. Anthony Fowler 6. John Stewart	1. Bob Creese 2. Michelle Voyer 3. John Ford 4. Nick Yabsley 5. Hamish Malcolm 6. Renata Ferrari Legorreta 7. Lynnath Beckley	1. Neil Loneragan 2. Christopher Setio 3. Peggy O'Donnell 4. Cathy Hair 5. Reg Blaylock 6. Gavin Partridge	
1500 - 1530	Afternoon Tea				
MDB NFF	Prod. & Prof. Fish SPONSORED BY NSW DEPARTMENT OF PRIMARY INDUSTRIES - FISHERIES	Tech. Ecol. Telemetry	ISSESR - Advances in Aquacult Tech.		
1530 - 1700	1. Keller Kopf 2. Matt Barwick 3. Jamin Forbes Invasives, stocking and citizen Q&A 4. Craig Copeland	1. Emily Fisher 2. Samantha Sherman 3. Stuart Sexton Discussion	1. Anthony Fowler 2. Nathan Knott 3. Jan-Olaf Meynecke	1. Fletcher Warren-Myers 2. Ryo Kawabe 3. Nathan Brennan	
1700 - 1830	Meet the Boffins - Aerial Function Centre - for MDB NFF delegates only				
1830 - 2130	ISSESR Catch Up - Bar Broadway (Sponsored by Mote Marine Labs) - Ticket required SPONSORED BY MOTE MARINE LABORATORY				

845 - 915	Opening Murray Darling Basin Native Fish Forum: Craig Copeland	
915 - 1000	Keynote MDB NFF	<i>Room: Wattle, Thomas</i>
915 - 1000	Martin Mallen-Cooper Does the natural flow paradigm need a rethink?	
930 - 1015	Murray Darling Basin Native Fish Forum	<i>Room: Wattle, Thomas</i>
930 - 945	John Koehn Environment flows and fish: Setting targets and making predictions.	
945 - 1000	Brenton Zampatti Disparate Responses of Invasive and Native Fishes to Engineered Floodplain Inundation and Natural Flooding	
845 - 930	Keynote	<i>Room: Broadway, Jones, Harris</i>
845 - 930	Kate Barclay How Can We evaluate the Social Contribution of Fisheries?	
930 - 1015	Keynote	<i>Room: Broadway, Jones, Harris</i>
930 - 1015	Caleb Gardner Increasing production in fully exploited fisheries	
1020 - 1045	Morning Tea	
1045 - 1230	Murray Darling Basin Native Fish Forum I	<i>Room: Wattle, Thomas</i>
1110 - 1125	Greg Ringwood Queensland Flood Recovery - rough and bumpy rivers	
1125 - 1140	Michael Hutchison Fish And Strips: A Case Where Less Is More	
1140 - 1155	Zeb Tonkin Prioritising instream woody habitat restoration for fish across Victoria: Case studies, knowledge gaps and future direction	
1155 - 1210	Matt Hansen Recreational fishers leading fish habitat rehabilitation	
1045 - 1230	Productivity & Profitability in Fisheries I	<i>Room: Broadway</i>
1045 - 1100	Malcolm Haddon Formal Harvest Strategies and Fishery Status Reporting	 Department of Primary Industries
1100 - 1115	Juan Carlos Quiroz Simulating harvest control under the new management framework of Patagonian Toothfish in Chile	
1115 - 1130	Jennifer Ovenden The spatial extent of western gemfish stocks	
1130 - 1145	Annabel Jones Testing new boundaries: Efficient assessment of a complex harvest strategy for a MSC accredited prawn fishery	

Program Tuesday 13 October 2015

- 1145 - 1200 **Tim Ward**
Empowering industry to maximise fish size and quality in the South Australian Sardine Fishery
- 1200 - 1215 **Crystal Beckmann**
Inter-annual Variability In Blue Swimmer Crab (*Portunus armatus*) Distribution In South Australia: Implications For Monitoring
- 1215 - 1230 **Emily Fisher**
Applying EBFM in Western Australia: developing resource management strategies and harvest control rules that incorporate social, economic and sectoral allocation objectives
-
- 1045 - 1230 **Climate Change III & Reproduction, Early Life History and Recruitment II**
Room: Jones
- 1045 - 1100 **Matthew Le Feuvre**
Thermal Limits of Northern Australian Freshwater Fishes
- 1100 - 1115 **Garry Ogston**
Implications Of Climate Change On Aestivating Fishes
- 1115 - 1130 **Jennifer Donelson**
Reproductive Performance Is Influenced By The Thermal Environment Experienced In Present And Previous Generations
- 1130 - 1145 **Natalie Moltschaniwskyj**
Using Redmap data as an early warning system for changes occurring in the marine environment: the value of community engagement through citizen science
- 1200 - 1215 **Joel Williams**
Fine-scale vertical distribution of black bream *Acanthopagrus butcheri* larvae explains poor recruitment in the Blackwood River Estuary
- 1215 - 1230 **Steven Hawes**
Vertical distribution of temperate reef fish larvae off NSW
-
- 1045 - 1230 **Evaluating Outcomes**
Room: Harris
- 1045 - 1115 **Ken Leber**
Evolution of marine stock enhancement in Florida, USA
- 1115 - 1130 **Shigenori Suzuki**
Stock enhancement of Tiger puffer (*Takifugu rubripes*) in the Tokai region of Japan assessed using a new method for the detection of released-fish
- 1130 - 1145 **Yoshitaka Sakakura**
Evaluation of fish quality and microhabitat for release in the hatchery-reared tiger puffer juveniles
- 1145 - 1200 **Ann-Lisbeth Agnalt**
Enriched environment promotes shelter-seeking and survival of hatchery-produced juvenile European lobster (*Homarus gammarus*)
- 1200 - 1215 **Craig Blount**
Increasing Production from an Under-exploited Fishery - Enhancing the Yield and Colour of the Roe of the Urchin, *Centrostephanus rodgersii*, by Reducing Density or Transplanting Individuals

1215 - 1230 **Ellen Sofie Grefsrud**
Exposure to predator odors enhances shelter seeking and competitive behaviour in hatchery reared juvenile European lobster (*Homarus gammarus*)

1230 - 1315

Lunch

1315 - 1500 **Murray Darling Basin Native Fish Forum II** *Room: Wattle, Thomas*

1315 - 1330 **Craig Boys**
Fish Under the Pump: The case for screening water diversions in the Murray-Darling Basin

1330 - 1415 **Keynote – Les Perkins**
Collaborative Fish Screening Pilot Projects for the MDB: What Lessons can be Learned from the Pacific Northwest United States

1415 - 1430 **Lee Baumgartner**
Rehabilitating an Australian Icon: The Sea to Hume Fish Passage Program

1430 - 1445 **Matthew Gordos**
Fishways - Cheaper or not at all?

1315 - 1500 **Productivity & Profitability in Fisheries II** *Room: Broadway*

1315 - 1330 **Osman Samsun**
Pelagic fish catching efficiency in Marmara Sea, Turkey



1330 - 1345 **Tyson Martin**
Subsistence fishing on Pacific atolls can maintain near-pristine fish communities

1345 - 1400 **Neil Loneragan**
What's The Catch? Shark Fisheries In Eastern Indonesia

1400 - 1415 **Craig Mundy**
Expression of fishery trends at different spatial scales: at what scale does the crystal ball become cloudy?

1415 - 1430 **Anthony Fowler**
Understanding changes in spatial-structure of snapper fisheries in southern Australia

1430 - 1445 **John Stewart**
Cool, Windswept and Interesting – The New South Wales Sea Mullet Spawn Run Fishery

1315 - 1500 **MPAs & Marine Estate research & management** *Room: Jones*

1315 - 1330 **Bob Creese**
Enhancing marine biodiversity conservation in the Hawkesbury Shelf marine bioregion



1330 - 1345 **Michelle Voyer**
Embracing complexity in Marine Protected Area governance

1345 - 1400 **John Ford**
Using Fishermens Local Knowledge to Guide Collaborative Management of Seagrass Habitat

Program Tuesday 13 October 2015

1400 - 1415	Nick Yabsley Resource type modifies the effects of reserves and connectivity on ecological functions	
1415 - 1430	Hamish Malcolm Planning guidelines for spatial management synthesised from three long-term (>10 yr) reef-fish studies in the Solitary Islands Marine Park	
1430 - 1445	Renata Ferrari Legorreta Predicting fish distributions for marine spatial planning in MARXAN	
1445 - 1500	Lynnath Beckley Benchmarking human use of Eighty Mile Beach Marine Park prior to implementation of the management plan	
1315 - 1500	Evaluating Outcomes & Adv in aquacult tech	<i>Room: Harris</i>
1315 - 1330	Neil Loneragan Understanding the ecology of the Western School Prawn to maximize restocking success	
1330 - 1345	Christopher Setio A responsible stocking program for Eastern king prawns (<i>Penaeus plebejus</i>) in Australia	
1345 - 1400	Peggy O'Donnell Maximising Benefits and Minimising Adverse Impacts from Marine Stocking: A Case Study from Australia	
1400 - 1415	Cathy Hair Optimising Methods for Community-based sea cucumber Ranching: Experimental releases of cultured Juvenile <i>Holothuria Scabra</i> into PNG Seagrass Meadows	
1415 - 1430	Reg Blaylock Hatchery Related Effects on Post-Release Survival of Spotted Seatrout <i>Cynoscion nebulosus</i>	
1430 - 1445	Gavin Partridge The development of techniques for the collection of fertilised snapper <i>Chrysophrys auratus</i> eggs from Cockburn Sound spawning aggregations and their culture for enhancement purposes.	
1500 - 1530	Afternoon Tea	
1530 - 1700	Murray Darling Basin Native Fish Forum III	<i>Room: Wattle, Thomas</i>
1530 - 1545	Keller Kopf Invasive species and river regulation turn Murray-Darling Basin fish assemblage structure upside down	
1545 - 1600	Matt Barwick The countdown to Carp control: progress with implementation of a biological control program for Common carp in Australia	
1600 - 1615	Jamin Forbes Effectiveness of Murray cod and golden perch stocking in MDB waterways: contrasting systems, targets and life-history	

1530 - 1700	Productivity & Profitability in Fisheries III	<i>Room: Broadway</i>
1530 - 1545	Emily Fisher MSC certification with limited data: to B or not to B?	 Department of Primary Industries
1545 - 1600	Samantha Sherman How effective is Australia's management of sharks in commercial fisheries?	
1600 - 1615	Stuart Sexton Characterising the spawning patterns of jack mackerel (<i>Trachurus declivis</i>) off eastern Australia to optimise future survey design	
1530 - 1700	Technology & ecology - telemetry & connectivity I	
1530 - 1545	Anthony Fowler Movement Of Snapper (<i>Chrysophrys auratus</i>) In South Australia From Acoustic Telemetry	
1545 - 1600	Nathan Knott Movement of fishes among reefs and over soft sediments within a temperate embayment: the necessity and implication of movement data for spatial management.	
1600 - 1615	Jan-Olaf Meynecke PIT-tagged: Investigating the movement of estuarine fish and crustaceans	
1530 - 1700	Advances in aquacult tech	<i>Room: Harris</i>
1530 - 1545	Fletcher Warren-Myers Enriched Stable Isotope Mass Marking Techniques For Aquaculture And Restocking	
1545 - 1600	Ryo Kawabe Thermal regimes during the spawning migration of the barfin flounder (<i>Verasper moseri</i>) and its link to final oocyte maturation and ovulation	
1600 - 1615	Nathan Brennan Stage-specific vulnerability of juvenile common snook to spinal deformity: morphological responses to water velocity and rearing environment	

Room	Wattle	Thomas	Broadway	Jones	Harris
Theme	ISSESR/ ASFB	ASFB	ASFB	ASFB	ASFB
0845 - 0930	Keynote – Dean Jerry				
0930 - 1015	Keynote – Brad Adams				
1015 - 1045 Morning Tea					
	ISSESR - Adapting To a Changing Env. & Artificial Habitat	Environmental Flows	Tech. Ecol. Telemetry SPONSORED BY VEMCO	Est. Coast Con. Hab.	Rec. Fisheries
1045 - 1230	<ol style="list-style-type: none"> Jay R Gorospe Jon Altamirano Marie Juinio-Menez Jon Altamirano Lachlan Strain Discussion Michael Lowry 	<ol style="list-style-type: none"> Jonathan Marshall Peter Negus Wayne Koster Doug Harding David Crook Frank Amstaetter Ryan Woods 	<ol style="list-style-type: none"> Lachlan Fetterplace Christopher Henderson Leanne Currey Russ Babcock Gwenael Cadiou Jordan Matley Daniel Yeoh 	<ol style="list-style-type: none"> Ronald Baker Hayden Schilling Christopher Fulton Alexia Dubuc Carlo Mattone Michael Bradley Martha Brians 	<ol style="list-style-type: none"> Claudia Trave Sean Tracey Sam Williams Discussion
1230 - 1315 Lunch					
	Artificial Habitat SPONSORED BY NSW DEPARTMENT OF PRIMARY INDUSTRIES - FISHERIES	Environmental Flows	Tech. Ecol. Telemetry SPONSORED BY VEMCO	Est. Coast Con. Hab.	Fish Energ. Behav.
1315 - 1500	<ol style="list-style-type: none"> Kate Reeds Molly Scott Shinjiro Ushima Curtis Champion Aaron Davis Brendan Lanham Heath Folpp 	<ol style="list-style-type: none"> Daniel Stoessel Heleena Bamford Fiona Small Andrew McDougall John Morrongiello John Koehn Zeb Tonkin 	<ol style="list-style-type: none"> Andre Steckenreuter Elodie Ledee Fernando Cagua Maria Espinoza Samanta Munroe Dylan Van Der Meulen Culum Brown 	<ol style="list-style-type: none"> Jakob Fries Joshua van Lier Michael Corry Geoffrey Collins Russell McWilliam Lachlan McLeay 	<ol style="list-style-type: none"> Timothy Clark (30 mins) Teresa Iglesias Nastasaran Mazloumi Stephanie Brodie Kyle Tyler Heide Pethybridge
1500 - 1530 Afternoon Tea					
	Artificial Habitat SPONSORED BY NSW DEPARTMENT OF PRIMARY INDUSTRIES - FISHERIES	Environmental Flows	Tech. Ecol. Telemetry SPONSORED BY VEMCO	Est. Coast Con. Hab.	Fish Energ. Behav.
1530 - 1715	<ol style="list-style-type: none"> David Booth David Booth Ryan Paik James Smith Iain Suthers Paul Lewis Discussion 	<ol style="list-style-type: none"> David Roberts Dale McNeil Andrew McDougall Discussion 	<ol style="list-style-type: none"> Barry Bruce Jason Lieschke Wayne Koster Stephen Beatty David Crook Discussion 	<ol style="list-style-type: none"> Jason Everett Stephen Beatty Discussion 	<ol style="list-style-type: none"> Darcie Hunt Jason Thiem Nick Whiterod Adrian Gleiss Discussion
1900 - 2300 Conference Dinner Cruise - ticket required SPONSORED BY SUBCON					

845 - 930	Keynote	<i>Room: Wattle, Thomas, Broadway</i>
845 - 930	Dean Jerry Spyglass into aquatic biological diversity - use of environmental DNA (eDNA) to detect rare and invasive species	
930 - 1015	Keynote	<i>Room: Wattle, Thomas, Broadway</i>
930 - 1015	Brad Adams Sea Ranching Of Abalone - Flinders Bay, Western Australia	


1015 - 1045

Morning Tea

1045 - 1230	Adapting to a changing env & Artificial Habitat I	<i>Room: Wattle</i>
1045 - 1100	Jay R Gorospe Growth And Survival Of Holothuria scabra Juveniles In Bottom-set Trays	
1100 - 1115	Jon Altamirano Challenges in Tiger Shrimp Stock Enhancement in the Philippines	
1115 - 1130	Marie Antonette Juinio-Menez Adaptive And Integrated Culture Production Systems For Holothuria scabra	
1130 - 1145	Jon Altamirano Substrate Preference of Sandfish Holothuria scabra juveniles: Implications for Grow-out and Sea Ranching	
1145 - 1200	Lachlan Strain Stock Recovery Initiative For A Commercial Roes Abalone Fishery Decimated By An Environmental Event.	
1215 - 1230	Michael Lowry Role of research in the development of NSW Artificial Reef Program.	

1045 - 1230	Environmental Flows I	<i>Room: Thomas</i>
1045 - 1100	Jonathan Marshall The Queensland approach to assessing environmental flows	
1100 - 1115	Peter Negus Q-catchments: an adaptive monitoring program using fish as an indicator of riverine condition	
1115 - 1130	Wayne Koster Links Between Riverine Flow Regimes And Movement And Reproduction Of Golden Perch	
1130 - 1145	Doug Harding Catadromous Fish Migration: Can Dam Releases Match Natural Flow Cues?	
1145 - 1200	David Crook 'Life history pressure points' as a basis for environmental flow development	
1200 - 1215	Frank Amtstaetter Environmental flow releases trigger spawning migrations by Australian grayling Prototroctes maraena, a threatened, diadromous fish	
1215 - 1230	Ryan Woods Molecular measures of population viability in response to altered flow regimes	

Program Wednesday 14 October 2015

1045 - 1230	Technology & ecology - telemetry & connectivity II	<i>Room: Broadway</i>
1045 - 1100	Lachlan Fetterplace Are Soft Sediment Fishes Always Highly Mobile? An Assessment Of The Movement Patterns Of The Bluespotted Flathead	
1100 - 1115	Christopher Henderson The relationship of home range and marine protected area size for the Giant Shovelnose Ray (<i>Glaucostegus typus</i>).	
1115 - 1130	Leanne Currey Assessing Fine-Scale Diel Movement Patterns Of An Exploited Reef Fish	
1130 - 1145	Russ Babcock Environmental influences on the behaviour of <i>Lethrinus nebulosus</i> at Ningaloo reef	
1145 - 1200	Gwenael Cadiou Drivers of temporal and spatial movement patterns in <i>Girella tricuspidata</i>	
1200 - 1215	Jordan Matley Sympatric Coral Trout Niche Partitioning Indicated By Movement And Diet	
1215 - 1230	Daniel Yeoh Divergent use of a south-western Australian estuary by four key recreational fish species: evidence from acoustic telemetry	
<hr/>		
1045 - 1230	Estuarine & coastal connectivity I	<i>Room: Jones</i>
1045 - 1100	Ronald Baker Life-History Movements Of The World's Toughest Sport Fish	
1100 - 1115	Hayden Schilling The Role of Fish Predation in Estuarine Zooplankton Biomass Variation	
1115 - 1130	Christopher Fulton Habitat Quality Drives Seasonal Hotspots In Seaweed-Associated Fishes	
1130 - 1145	Alexia Dubuc Dissolved Oxygen In Mangrove Ecosystems And Impacts As Productive Habitat	
1145 - 1200	Carlo Mattone The Value of Mangrove Forests as Fish Feeding Ground.	
1200 - 1215	Michael Bradley Re-writing the link between mangroves and fish	
1215 - 1230	Martha Brians Identifying important fish habitats through archived catch data, a tropical Australia case study	
<hr/>		
1045 - 1230	Recreational Fisheries III	<i>Room: Harris</i>
1045 - 1100	Claudia Trave Survivorship And Recovery Of Fish Species Subjected To Catch-and-release Practices	
1100 - 1115	Sean Tracey Capture stress and post-release survival of Southern Bluefin Tuna from recreational fishing	

1115 - 1130 **Sam Williams**
Sustainable sampling: the non-lethal tissue sampling of recreational species by citizen scientists

1230 - 1315

Lunch

1315 - 1500 **Artificial Habitat II** *Room: Wattle*

1315 - 1330 **Kate Reeds**
Sydney Offshore Artificial Reef: Benthos and Demersal Fish Gradient Study



1330 - 1345 **Molly Scott**
The Influence Of An Offshore Artificial Reef On The Abundance Of Fish In The Surrounding Pelagic Environment

1345 - 1400 **Shinjiro Ushiyama**
Artificial reef materials, orientation and predation on the epibenthic community

1400 - 1415 **Curtis Champion**
Zooplanktivory a key process for fish production on a coastal artificial reef

1415 - 1430 **Aaron Davis**
Conservation potential of anthropogenic waterbodies on a heavily modified agricultural floodplain

1430 - 1445 **Brendan Lanham**
Do boat moorings alter fish community composition in an urban estuary?

1445 - 1500 **Heath Folpp**
A best practice guide to development and evaluation of designed reef programs. Lessons learnt from a NSW perspective

1315 - 1500 **Environmental Flows II** *Room: Thomas*

1315 - 1330 **Daniel Stoessel**
The rise and fall of the Snowy River: consequence of altered flow regime on Australian bass

1330 - 1345 **Heleena Bamford**
Basin-wide Environmental Watering Strategy For The Murray-Darling Basin

1345 - 1400 **Fiona Small**
No Flow, No Go! Diadromous Fish Movement In Central Queensland.

1345 - 1415 **Andrew McDougall**
Ecological Risk Assessment Of The Burnett Basin Water Resource Plan

1415 - 1430 **John Morrongiello**
Quantifying the Freshwater Flow Requirements of Estuarine Fish

1430 - 1445 **John Koehn**
Using a Population model to manage flows and carp

1445 - 1500 **Zeb Tonkin**
Recruitment dynamics through time and space: A multi-population investigation of Macquarie perch recruitment across Victoria

Program Wednesday 14 October 2015

1315 - 1500 **Technology & ecology - telemetry & connectivity III** *Room: Broadway*

1315 - 1330 **Andre Steckenreuter**

Optimising the Integrity of a National Network of Acoustic Telemetry Research Infrastructure in Australia



1330 - 1345

Elodie Ledee

Identifying Movement Patterns Of Reef Predators: A Network Modelling Approach

1345 - 1400

Fernando Cagua

High-precision, Low-cost Animal Positioning in Passive Acoustic Telemetry

1400 - 1415

Mario Espinoza

Partial Migration Of Marine Predators: Is Habitat The Key?

1415 - 1430

Samantha Munroe

Individual variation in juvenile blacktip shark movement patterns in a tropical coastal nursery

1430 - 1445

Dylan Van Der Meulen

Temperature-mediated spawning migrations of an estuarine dependent sillaginid

1445 - 1500

Culum Brown

Where are my PJs? Movement of Port Jackson sharks at breeding aggregation sites

1315 - 1500 **Estuarine & coastal connectivity II**

Room: Jones

1315 - 1330

Jakob Fries

Detecting impacts of nutrient pollution in tropical Australian estuaries

1330 - 1345

Joshua Van Lier

Habitat Condition Underpins Fish Biodiversity Within Estuarine Sponge Gardens.

1345 - 1400

Michael Corry

The Functional Role of Soft Coral in Temperate Estuaries

1400 - 1415

Geoffrey Collins

Physiological plasticity versus inter-population variability: understanding drivers of hypoxia tolerance in a tropical estuarine fish

1415 - 1430

Russell McWilliam

Genetic patchiness among recruits of *Girella elevata*: spatial and temporal variation in genetic composition

1430 - 1445

Lachlan McLeay

A Biophysical Model To Assess Trade-offs In Larval Recruitment and Catch in Southern Australia's Largest Prawn Fishery

1315 - 1500 **Fish energetics and behaviour I**

Room: Harris

1315 - 1345

Timothy Clark

Fish energetics from the lab to the field: respirometry, tagging technologies, and understanding the impacts of climate change

1345 - 1400

Teresa Iglesias

The Unthinking Depths: Energetic Constraints On Encephalization In Marine Fishes

- 1400 - 1415 **Nastaran Mazloumi**
Swimming speed and oxygen consumption of adult King George whiting: influence of temperature
- 1415 - 1430 **Stephanie Brodie**
Improving consumption rate estimates by incorporating wild activity into bioenergetics models
- 1430 - 1445 **Kyle Tyler**
The response of juvenile Eastern King Prawns (*Melicertus plebejus*) to rapid changes in salinity associated with flooding of estuarine nurseries.
- 1445 - 1500 **Heidi Pethybridge**
Bioenergetics modelling of the fish and shark population dynamics to environmental fluctuations in SE Australia.

1500 - 1530

Afternoon Tea

-
- 1530 - 1715 **Artificial Habitat III** *Room: Wattle*
- 1530 - 1545 **David Booth**
UTS Decommissioning Ecology group: filling science gaps in evaluating oil and gas infrastructure options
- 1545 - 1600 **David Booth**
Righting the wrong: fish habitat enhancement of Harbour pontoons
- 1600 - 1615 **Ryan Paik**
Multi-purpose Marine Farm
- 1615 - 1630 **James Smith**
Estimating fish production on an artificial reef using Ecopath with Ecosim
- 1630 - 1645 **Iain Suthers**
Considerations of Tidal Flow for Enhancing Coastal and Estuarine Fisheries
- 1645 - 1700 **Paul Lewis**
Southwest Habitat Enhancement Structure Trial: A work in progress.
-
- 1530 - 1715 **Environmental Flows III** *Room: Thomas*
- 1530 - 1545 **David Roberts**
eFlows And Physical Barriers To Catadromous Downstream Spawning Migration
- 1545 - 1600 **Dale McNeil**
The Ecology of Lake Eyre Basin Fishes: Hydro-climatic drivers and fish assemblage dynamics in Australia's Desert River basin.
- 1600 - 1615 **Andrew McDougall**
Monitoring Environmental Flows In Queensland: The Next Generation
-
- 1530 - 1715 **Technology & ecology - telemetry & connectivity IIII** *Room: Broadway*
- 1530 - 1545 **Barry Bruce**
Multi-year movements of juvenile white sharks in eastern Australia
- 1545 - 1600 **Jason Lieschke**
Where do the fish go? Acoustic tracking of brown trout in relation to increased summer water temperatures



Program Wednesday 14 October 2015

- 1600 - 1615 **Wayne Koster**
Movement and Habitat Use Of The Threatened Australian Grayling
- 1615 - 1630 **Stephen Beatty**
Movement of Introduced Goldfish *Carassius auratus*: implications for control
- 1630 - 1645 **David Crook**
Integrating telemetric and biochronological data to elucidate movement patterns of riverine fish
-
- 1530 - 1715 **Estuarine & coastal connectivity III** *Room: Jones*
- 1530 - 1545 **Jason Everett**
Eastern king prawn dispersal in eastern Australia: new information from particle tracking
- 1545 - 1600 **Stephen Beatty**
The Fish Faunas Of An Intermittently-Open, Seasonally Inverse Estuary
-
- 1530 - 1715 **Fish energetics and behaviour II** *Room: Harris*
- 1530 - 1545 **Darcie Hunt**
Maximum swimming speeds of five finfish bycatch species from north-eastern Tasmania
- 1545 - 1600 **Jason Thiem**
Swimming Activity And Energetic Costs Of Adult Lake Sturgeon During Fishway Passage
- 1600 - 1615 **Nick Whiterod**
It eats, sits and that's about it: the bioenergetics of iconic sit-and-wait predator, the Murray cod
- 1615 - 1630 **Adrian Gleiss**
Seasonally Contrasting Physiological and Ecological performance question the "Warmer-is-Better" hypothesis for Juvenile fish

Keynote – 0845 - 0930

Using Indigenous fishing rights to stimulate restoration of fish populations

Paul Lumley¹

1 Columbia River Inter-Tribal Fish Commission, Oregon, USA

Since time immemorial, the health, spirit, and cultures of the Columbia River tribes have been sustained by the water, salmon, game, roots, and berries of our homeland—our sacred 'First Foods.' When the Yakama, Umatilla, Warm Springs and Nez Perce tribes entered into treaties with the United States in 1855, they specifically reserved their rights to fish, hunt, and gather at all usual and accustomed areas. The treaties have not only protected these rights, they have provided crucial legal leverage helping drive current salmon recovery efforts. Since the signing of the treaties, the Columbia Basin has been dramatically altered. Increased human population, dam construction, unregulated harvest, and substantial habitat modifications drastically reduced salmon populations. The significant decline drove the four tribes to form the Columbia River Inter-Tribal Fish Commission (CRITFC) in 1977. Since then, these tribes have become leaders in 'putting fish back in the rivers and protecting the watersheds where fish live.' The tribes participate in interstate agreements and international treaties controlling salmon harvest and water management. The tribes are also successfully rebuilding naturally spawning salmon populations, and they are restoring habitat and protecting the water flowing in the rivers. Despite many daunting challenges, the tribes never strayed from their mission to protect salmon. Remarkably, the salmon decline has been reversed, in large part to the legal leverage of the treaty-reserved fishing right and the value of partnership. Our work has only begun, but the success of our efforts will benefit future generations, tribal and non-tribal alike.

Keynote – 0930 - 1015

The role of rapid evolution in responses to stock enhancement and environmental change

Marissa Baskett¹

1 Department of Environmental Science and Policy, University of California, Davis, USA

Human activities and global environmental change can alter selection pressure to drive rapid evolutionary changes that affect population dynamics and management decision-making. For example, genetic adaptation can influence persistence under climate change, and artificial selection in stock enhancement can affect the fitness of wild populations. I will discuss how alternative management strategies affect each of the adaptive capacity to changing environments and the unintended fitness consequences of stock enhancement. In addition, I will discuss how evolution affects the interaction between environmental change and stock enhancement, from how stock enhancement approaches can affect diversity across populations and therefore response to environmental change, to how enhancement and restoration approaches might account for future change by protecting adaptive

capacity.

Oral Session 1 – ISSESER - 1045 – 1230

Integrating demo & gen pers on stock management & socio ec and gov cons

Utilizing managed releases to maintain and, where necessary, restore genetic security in demographically challenged populations

Michael D. Tringali¹

1 Florida Fish and Wildlife Research Institute, St. Petersburg, USA

As the science of enhancement and restoration develops and adapts to meet the 21st century challenges of sustaining and improving the world's fisheries, responsible genetic management remains a critical component of these endeavors. Without effective genetic management, demographic gains could be offset to a degree by future reductions in fitness (survival and reproductive potential). The inbreeding effective number, N_e , has long been a parameter of interest to genetic managers of fishery enhancement and conservation aquaculture programs. It is well known that tokogenetic dynamics within target stocks and species differ markedly, as do latent levels of coancestry and inbreeding. Unfortunately, due to mathematical limitations, the 'ancestral backgrounds' of hatchery brood fish as well as those of the wild breeders in recipient populations are often ignored during enhancement and restocking, which could lead to overly optimistic temporal projections of N_e in admixed cohorts. In this presentation, the basic model for estimating N_e is reconstructed using Wright's method of path analysis, and then extended to the more general case in which P_1 parents are inbred and/or related. The extended model yields a discretized expression that can be used to more accurately forecast the dynamics of coancestry and N_e over time in population admixtures (i.e., those having hatchery + wild components). Using the model and exemplar genetic metrics from empirically studied populations, conditions are illustrated under which (1) managed releases can threaten the genetic security of stocked populations, and (2) managed releases can maintain or improve these circumstances.

Genetic and phenotypic characterization of local and translocated corkwing wrasse (*Symphodus melops*) populations

Enrique Blanco Gonzalez^{1,2}, Halvor Knutsen^{1,2,3}, Per Erik Jorde^{2,3}

1 University of Agder, Kristiansand, Norway

2 Institute of Marine Research, Flådevigen, Norway

3 CEES, University of Oslo, Oslo, Norway

The demand of cleaner fish for the biological control of salmon lice infestation has increased dramatically in recent years. Corkwing wrasse (*Symphodus melops*) is one of the main species used by the salmon industry in the Northeast Atlantic. This small benthic fish inhabits the rocky shore

substrate and its abundance appears correlated to the increase in sea temperatures. Thus, the wrasse fishery in the Skagerrak has boosted in response to the high price and demand of the species by the salmon industry. However, as the salmon farms are located in colder areas, further north, the wrasses are translocated from one temperature regime to another. In this study, we characterized the genetic and phenotypic profiles of translocated (southern) and native (northern) corkwing wrasse populations. We discuss our findings in relation to the potential for local adaptation and evolutionary response of native and translocated fish to global warming and human translocations. Keywords: genetic structure, growth, translocations, corkwing wrasse, *Symphodus melops*

Economic cost-effectiveness of a fish stocking program for enhancing recreational fishing

Taylor Hunt^{1,2}, John Douglas¹, Paul Jones², Helen Scarborough³, Khageswor Giri

1 Fisheries Management, Fisheries Victoria, DEDJTR, Queenscliff, Australia

2 Faculty of Science, E.B.E, Deakin University, Warrnambool, Australia

3 Department of Economics, Deakin University, Warrnambool, Australia

4 Biometrics Unit, Agriculture Research Division, Department of Economic Development, Jobs Transport and Resources, Werribee, Victoria, Australia

Fish stocking is commonly used to enhance, create and maintain recreational fisheries that are recognised as generating significant economic activity. As fish stocking is often a large economic investment of public funds, it should be evaluated to ensure it provides adequate economic return and is an effective use of funding to meet recreational fishing objectives. Accepted responsible approaches to fish stocking highlight that economic evaluations are required, and government policies often stipulate that fish stocking programs must be economically feasible. Despite these requirements, economic evaluations of fish stocking are rare in the literature and such knowledge could validate whether fish stocking is an economically effective fisheries management tool. In this study we evaluated the economic cost-effectiveness of a put-grow-and-take lake fishery stocking program for brown trout, rainbow trout and Chinook salmon located in Lake Purrumbete, south-western Victoria, Australia. The cost of the stocking program was estimated taking into account aquaculture production and transport of fish to release. The economic return of the stocking program was determined by conducting a fully stratified angler creel survey and extrapolating creel survey responses and angler trip estimates to determine the total expenditure generated from the fishery. The additional willingness to pay, and perceived social value of the fishery, was also calculated using a combination of both the travel cost and contingent valuation methods. This unique study will be of use to fisheries managers and fishers in informing effective use of funds to enhance recreational fishing, particularly when fiscal budgets are tight.

New South Wales (NSW) Hatchery Quality Assurance Scheme

Graeme Bowley¹

1 NSW Department of Primary Industries, NSW, Australia

Recreational fishing enhancement of native species is undertaken in NSW in accordance with the Freshwater Fish Stocking Fisheries Management Strategy, 2005 (FMS). Relevant stocking programs include the dollar for dollar program, Australian Bass enhancement program, impoundment stocking program and relevant individual stocking under Section 216 of the Fisheries Management Act 1994. The Hatchery Quality Assurance Scheme (HQAS) was prepared by NSW Department of Primary Industries (DPI Fisheries) to meet the requirements of the FMS. Hatcheries in NSW that produce fingerlings for stocking under the FMS, must be accredited. The HQAS accredits NSW fish hatcheries (Commercial & Government) for the production of native fish fingerlings for recreational fishing enhancement stocking programs and aquaculture production. The scheme outlines genetic integrity, disease control, pest or trash fish control to provide quality fingerlings for stocking into the waters of NSW. To achieve this outcome auditing and operational requirements are placed on hatcheries to ensure only quality juveniles are stocked into NSW waters. Murray Cod, Golden Perch, Silver Perch and Australian Bass are currently the only species authorised for culture under the HQAS. In 2014, DPI Fisheries prepared a Marine Stocking FMS and the HQAS will now be updated to include a number of marine crustacean and fish species.

Environmental and social benefits of engaged governance of fish stocking activities

Ben Doolan¹, Cameron Westaway¹

1 NSW Department of Primary Industries, NSW, Australia

Historically freshwater fish stockings in NSW were undertaken with minimal government intervention and were largely under the control of fish acclimatisation societies and fishing clubs. Regulation and consideration of potential environmental impacts increased with time until a statutory fishery management strategy (FMS) based on an Environmental Impact Assessment on the activity of fish stocking and its potential risks was introduced in 2005. All freshwater fish stockings undertaken in NSW public waters now require authorisation by Fisheries NSW. Stocking proposals are assessed against stringent FMS restrictions and stocking review guidelines. Native fish must be produced by hatcheries accredited under a Hatchery Quality Assurance Scheme (HQAS) which was developed in accordance with the FMS to safeguard quality assurance of stocked fish. Fisheries NSW administers a dollar-for-dollar native fish stocking program under the FMS whereby funds raised by fish stocking groups are matched with funds collected from the NSW recreational fishing licence fees for the purchase of fish from HQAS accredited hatcheries for stocking in approved sites. The incentive of matching funds for stocking groups has gained their support while assisting with compliance of fish stocking activities by reducing the temptation to purchase fish from

other sources and undertake unauthorised stockings. This provides them with the satisfaction that they are stocking responsibly with quality fish and has created a sense of ownership for stocking participants who take great pride in their stocked waterways and ensure that others respect the fishery. The benefits of engaged governance of stocking programs will be discussed.

Marine stocking in NSW.... moving ahead responsibly

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Marine stocking in NSW occurred in a myriad of forms since the early 1990's, but until a pilot research stocking program was completed in 2007, it was on a largely ad-hoc basis with variable outcomes. Marine stocking in NSW has always been a popular with the recreational fishing sector, which requested DPI to investigate options for a statewide program. Given the majority of key recreational species are being fished at sustainable levels, the focus of a potential marine stocking program in NSW was on recruitment limited estuarine systems and associated species and how fisheries in these systems could be enhanced to enhance recreational fishing opportunities. NSW has detailed legislative requirements for fish stocking activities, which required a comprehensive Environmental Impact Statement and Fishery Management Strategy (FMS). The initial stockings under the statewide program commenced in December 2014 and the monitoring results and knowledge gained are being applied into the current 2015 stocking season. The genetic makeup of the broodstock used, breeding methodology applied, hatchery biosecurity, hatchery accreditation processes, interstate regulations, disease and translocation as well as climatic events are all facets of the program which are being analysed for potential refinement after a single year of the program in operation. The marine stocking FMS dictates many of the conditions placed around the program and was designed to be as dynamic and evolutionary as the estuarine systems to which it is being applied. Initial monitoring and sampling results will also be presented.

Oral Session 2 – ASFB - 1045 – 1230

Threatened Species

Comparing sampling methods for detecting an endangered freshwater fish

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Accurately detecting the presence or absence of threatened species is vital for threatened species management, and the detection power of individual sampling methods can vary significantly between species and life stages. This study compares the detection power of six sampling methods in sampling the endangered

Macquarie perch in riverine habitats in southeastern Australia. In an initial survey in 1998 and 1999, fyke nets captured Macquarie perch at 100 percent of sites where the species was detected; gill nets captured the species at 86 percent; with no other method having >50 percent detection efficiency. Most Macquarie perch were captured by fyke nets (90 and 94 percent in 1998 and 1999 respectively), followed by gill nets (7 and 2 percent). A monitoring program at one of the survey sites over seven years returned similar results with fyke nets detecting the species in all years. Fyke nets captured primarily young-of-year (YOY) individuals, whereas gill nets captured adults and subadults. Boat electrofishing returned a high level of false negatives for Macquarie perch. This presentation discusses the the pros and cons of the various ampling methods and presents a suggested monitoring methodology that can adequately characterize population structure (adults, juveniles, YOY), minimize false negatives and detect the occurrence of successful breeding the previous year.

Ovens River demonstration reach

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Native fish within Australia's Murray-Darling Basin (MDB) are estimated to have declined by approximately 90% over the last two centuries. In an attempt to halt and reverse this trend, the Native Fish Strategy (NFS) established the Demonstration Reach concept. Demonstration reaches consist of a section of river where multiple river rehabilitation interventions are undertaken to show the community the cumulative benefits of river restoration on native fish populations. A section of the Ovens River was chosen as a demonstration reach as it was; partly degraded but fixable, supports a number of important native fish species, has excellent community support and suitable accessibility. Threats to native fish within the Ovens River Demonstration Reach include; a lack of structural woody habitat, barriers to migration, degraded riparian vegetation, riparian weeds and the presence of introduced fish species. These threats impact negatively on native fish population structure and function. Actions to ameliorate threats included; re-snagging, riparian vegetation planting and protection, fencing, removal of weeds and barriers to migration and the management of alien fish species. Eight years of monitoring data, investigating reach-scale population responses of two iconic large-bodied native fish species; Murray cod and Trout cod and the introduced Common carp to multiple rehabilitation techniques, are presented.

Patterns in abundance of southern pygmy perch and alien species in four New South Wales creeks

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Southern pygmy perch, *Nannoperca australis*, is a small freshwater fish, whose range has declined in recent

decades, particularly within New South Wales. The species is now listed as Endangered in both South Australia and New South Wales. With only three populations of southern pygmy perch remaining within NSW, the species is at high risk of becoming locally extinct within NSW. Predation by alien species is a possible cause for the decline of southern pygmy perch. However, other than evidence of the occurrence of southern pygmy perch in the stomachs of brown trout and redfin perch, there has been very little research that has attempted to quantify the impacts of alien fish on southern pygmy perch or the mechanisms involved. Repeated fish community surveys have enabled us to relate the distribution and abundance of southern pygmy perch in four creek systems in southern NSW between 2009 and 2013 to the abundance of 3 alien species, common carp, European perch and eastern gambusia. Our results showed a highly significant negative relationship between the abundance of common carp and the presence of southern pygmy perch, across all sites and years. We outline the management actions that have been undertaken in light of these findings and new incursions of alien species within southern pygmy perch habitats, and discuss the implication of these findings on the future management of southern pygmy perch and small threatened fish species more generally.

Bringing back jungle perch

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Jungle perch *Kuhlia rupestris* have declined in the southern half of their historical Australian range. They became extinct or extremely rare in most catchments south of Proserpine since the 1950s and 1960s. Similar declines have also been recorded in some other countries. A primary cause of these declines has been the construction of barriers which block spawning migrations to the ocean and movements of juveniles and returning adults back into freshwater. Since the 1990s many barriers in eastern Queensland have been removed or had fishways installed. This has provided an opportunity to reintroduce jungle perch into suitable habitats with the aim of re-establishing breeding populations. Before restocking could occur, captive breeding of jungle perch had to be developed. Early larval rearing of jungle perch had proven difficult, but the issues have now largely been solved. Keys to larval rearing success are maintaining salinities above 32ppt, provision of copepod nauplii and bright light during early feeding and sustaining copepod blooms in ponds for at least 20 days. This is followed by supplementary feeding with *Artemia* while weaning larvae onto commercial feed preparations. Metamorphosis occurs about one month post-hatch. Around 55 days after hatch fry are 25-30mm in length and robust to handling. They can be transferred to freshwater tanks for growth to a stocking size of 50mm-60mm FL. Fingerlings have recently been released into sites in south-eastern Queensland and the Mackay-Whitsunday region. They went through pre-release conditioning to predators and live feeds and have been micro-tagged for follow up monitoring.

Recovery of threatened dwarf galaxias in the Dandenong Valley, Melbourne

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The dwarf galaxias (*Galaxiella pusilla*) is a freshwater fish of national conservation significance that occurs throughout south-eastern Australia, including the Dandenong Valley, in the outer suburbs of Melbourne. With progressive agricultural, urban and industrial development, populations of dwarf galaxias have dramatically declined across the Dandenong Valley. A contraction in their distribution is mostly due to loss and isolation of floodplain habitats and the spread of invasive fish, especially eastern gambusia (*Gambusia holbrooki*). A five-year habitat restoration project that aims to re-establish a sustainable dwarf galaxias metapopulation in the Dandenong Valley is currently underway. It involves the provision of inter-connected floodplain habitats along an approximately 18 kilometre reach of Dandenong Creek, as well as reintroduction of genetically suitable fish stock from populations across the broader Melbourne region. Works are focussed on enhancement of existing landscape features and seek to create conditions that mimic natural wetting and drying regimes typical of dwarf galaxias habitats, as well as providing intermittent connectivity between habitats during floods to facilitate dispersal and colonisation. The risk of invasion by exotic fish is being managed by providing habitats with varying degrees of hydrologic connectivity, and should invasions occur, water level manipulation to remove invasive fish will be possible at some sites using outlet structures. Project objectives, habitat design principles, the reintroduction approach, and the monitoring program will be discussed, as will the potential to also reintroduce nationally threatened Yarra pygmy perch (*Nannoperca obscura*) into the same habitats.

Aerial surveys of juvenile white sharks in the Port Stephens nursery area: a step towards a baseline estimate of abundance

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Lack of reliable information on abundance and population trends for white sharks (*Carcharodon carcharias*) precludes assessments of the efficacy of conservation efforts under Australia's National Recovery Plan for the species. Previous research using satellite and acoustic tagging has demonstrated juvenile white sharks in eastern Australia seasonally migrate between nursery areas in south eastern Victoria and coastal waters off Port Stephens (NSW). The highly geographically discrete nursery area in the clearer waters off Port Stephens, combined with a propensity for juvenile white sharks to reside in the shallow surf-zone when present, provides an opportunity to quantify their abundance. Helicopter-based aerial surveys between

Newcastle and Seal Rocks in 2010-11 and 2012-13 found juvenile white sharks throughout the year, with a distinct peak in October-November when 50 (2010-11) and 64 (2012-13) sharks were observed on a single survey over 77 km of coast. Greatest numbers of white sharks were observed along Stockton Beach (2010-11) and Bennetts Beach (2012-13). The majority (92%) of white sharks sighted were juveniles (<3 m total length). Sightability of juvenile white sharks in the surf zone from aerial surveys was estimated to be 71%. Corrected abundance estimates suggest that approximately 250 juvenile white sharks may have been present in the nursery area on survey days with peak abundances. These data provide initial grounding values for population models as part of a national program to estimate abundance and trends.

Restoration of coastal wetlands assisting in the recovery of threatened native fish

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In south-eastern Australia, extensive drainage and subsequent habitat loss, coupled with periods of extended drought, has led to the decline in several freshwater native species, including the nationally vulnerable *Galaxiella pusilla* and *Nannoperca obscura*. Contemporary hydrological restoration of wetlands represents a key activity to improving the conservation status of many species. The regulation of artificial outflows of Pick Swamp, a former grazing property within the Ramsar listed Piccaninnie Ponds Karst Wetlands system in the south-east of South Australia, greatly aided the population recovery of *G. pusilla* by increasing available habitat and long-term recruitment opportunities. Following this success, recently completed restoration works in Long Swamp; a nearby coastal wetland in south-western Victoria, are expected to yield similar results and contribute to the regional recovery of key native species. We present a comparison of baseline data collected prior to restoration in 2012 and 2014 with 2015 data to explore the short-term fish responses to restoration. Specifically, we anticipate that the creation of greater wetland habitat will promote the rapid expansion of *G. pusilla* and in areas where permanent water persists, *N. obscura* and *Nannoperca australis* are expected to be favoured. Since recent works have closed the last remaining artificial outlet, it is also important to explore the responses of diadromous species, and this is aided by a concomitant study of fish communities in adjoining estuarine and marine waters. We conclude by predicting the long-term responses of fish communities in this highly dynamic freshwater coastal wetland.

Oral Session 3 – ASFB - 1045 – 1230

Recreational Fisheries

A framework for regular national recreational fishing surveys

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Fishing in Australia is characterised by diverse stakeholders, complex spatial and temporal patterns and a large number of species utilised. Data collection systems exist for commercial fisheries, but consistent information on the biological, social and economic significance of recreational fishing is lacking particularly at the national scale. A key objective of the Australian Government's Policy for a More Competitive and Sustainable Fisheries Sector is to conduct five-yearly national recreational fishing surveys. Different information needs over different scales influence the cost and complexity of these surveys. The approach that would meet the information needs of the broadest range of stakeholders is to align jurisdictional surveys to collect catch, fishing effort, social (including demographic characteristics, participation rates and attitudes) and economic (expenditure) data that can be aggregated to provide a national picture of recreational fishing. The proposed method for this approach is to use a 'hybrid' screening survey, followed by a 12-month diary survey, attitudinal survey, a survey of non-intending fishers, and on-site surveys to validate off-site components and estimate harvest weights. It is proposed that a separate survey also be undertaken to assess any differences between fishers who are listed in telephone directories and those who are not. Other methods were investigated but were found to be unfeasible in the Australian context or to be cost prohibitive. If a national survey to collect biological, social and economic data is unfeasible at the present time, then a national social and economic survey of recreational fishing may provide useful information for some stakeholders.

Comparison of recreational harvest estimates provided concurrently by two independent large scale surveys in New Zealand

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Recreational fishers account for a substantial proportion of the harvest taken from many inshore fish stocks worldwide and although the survey methods used to quantify these harvests often appear plausible, the accuracy of the estimates they provide usually remains untested. We compare recreational harvest estimates provided by two independent and concurrent surveys conducted on the north-eastern coast of New Zealand's North Island in 2011-12. The two fundamentally different survey approaches used were a large scale on-site aerial-access survey and a national panel survey, which is a sophisticated and novel form of off-site survey method. Although the estimates provided by the two surveys were similar in magnitude, the aerial-access estimates were mostly lower by 2% to 50%, with the greatest differences apparent for the less commonly caught species. Boosted regression tree modelling of spatially and temporally disaggregated estimates identified a consistent pattern of temporal bias,

which explained much of the difference between the two data sets. This pattern was confirmed by an analysis of web camera based boat ramp traffic data, which suggests that the selection of survey days in three out of four temporal strata was by chance biased to lower than average effort days. The degree of similarity between the two sets of estimates was marked nonetheless, and this comparative study has demonstrated that either of the two survey methods used is capable of providing recreational harvest estimates that can be used with some confidence by fisheries managers.

Use of web cameras to monitor long term trends in dynamic recreational fisheries

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2 NIWA, Hamilton, New Zealand

There is an increasing recognition that New Zealand's marine recreational fisheries are growing, substantial and dynamic. Although considerable progress has been made in developing reliable methods of surveying recreational fisheries in recent years, these surveys are usually conducted infrequently, because of the cost involved. Recreational harvesting can vary considerably between surveys, however, as fishing effort fluctuates and in response to changes in localised abundance. We describe a cost effective means of continuously monitoring levels of recreational fishing effort over the long term, based on web camera technology. Web cameras have been used to continuously monitor trends in recreational effort on the northeast coast of the North Island since 2005, and the west coast since 2006. The indices of effort provided by these data have given us unprecedented insight into the temporal dynamics of New Zealand's largest recreational fisheries. Although the resources required to operate these systems are relatively low, the effort required to interpret the imagery collected can still be appreciable, and strategies have, and are, being developed to substantially reduce costs and to extend the utility of the information provided.

Development of computer vision algorithms to automate web camera monitoring of recreational traffic at boat ramps

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New Zealand's National Institute of Water and Atmospheric Research (NIWA) has established a network of web cameras overlooking key boat ramps, on behalf of the Ministry for Primary Industries, to monitor trends in recreational fishing effort over time. Each web camera captures one image per minute, providing 1440 images of a monitored ramp on each day. These images are viewed in series by a technician who manually interprets the images and records a count of returning boats for that day. This process is very onerous and time-consuming. Computer vision based algorithms have been developed to automate the boat counting process, given changes in tidal

state and background luminance. The methods developed are used to detect corrupted images, identify and classify moving objects, and to track objects across consecutive images. This system has been tested on a time series of images of a boat ramp at Waitangi, in Northern New Zealand, over a three year period (230,400 images). Daily traffic counts provided by this method have been regressed against manual counts made on the same random subsample of days. The experimental results demonstrate the benefits of the proposed approaches.

Key developments in the Tasmanian recreational fishery: Teasing out the impacts of the major drivers for change

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1 University of Tasmania, Hobart, Australia

Recreational fishing is a popular pastime among Tasmanians, with a participation rate that is well above the national average. Since the late 1990s there have, however, been a number of significant changes in the fishery, these changes relate to rates of participation, the types of fishing activities and practices pursued, and species targeted. A combination of factors have contributed to these developments, they include: changes in the demographic profile of the Tasmanian population; responses to management intervention; developments in the commercial fishing and aquaculture sectors; changes in the abundance and availability of target species, including the influence of climate change; and changing preferences and attitudes of the fishers themselves. In this paper we examine several of these key drivers and, based on a synthesis of recreational survey data collected over the past two decades, evaluate how they have contributed to shaping some of the major developments in the fishery. Not only will this provide a valuable retrospective it will also assist in better understanding the responses and aspirations of the recreational sector into the future.

Recreational fishing and dredging in Darwin Harbour

Lachlan Barnes¹, Will Macbeth¹, **Marcus Lincoln Smith¹**

1 Cardno, Sydney, Australia

Harbour developments are constantly occurring throughout Australia and around the world. In Darwin (NT), the Ichthys LNG Project is constructing onshore facilities to process gas and some condensate from the Ichthys Field in the Browse Basin. The development involved a dredging program within Darwin Harbour to create a safe shipping channel and berthing area for large LNG, LPG and condensate carriers, as well as a trench for the Project's gas export pipeline. A monitoring program was designed by Cardno with stakeholder engagement to monitor potential changes to recreational fishing activities, catches and attitudes in Darwin Harbour as a result of dredging activities. Creel surveys were conducted with over 3000 fishing parties on weekdays and weekend days in and around Darwin Harbour before, during and after dredging activities between 2012 and 2014. Unsurprisingly, more fishers were interviewed on weekend days compared to weekdays. Catch per unit effort (CPUE) was variable between fishing parties and among sampling seasons.

Moreover, fisher targeting behaviour differed between sampling seasons with a higher proportion of fishers targeting barramundi during the tropical 'wet' season compared to during the 'dry' season. There was no evidence to suggest dredging activities influenced CPUE or the targeting behaviour of fishers within Darwin Harbour. Small-scale shifts in the spatial distribution of fishing effort in proximity to dredging activities were recorded due to factors such as safety exclusion zones and increased vessel traffic. Overall, the monitoring program provided an effective and efficient means of monitoring potential changes in recreational fisher activities during dredging activities in Darwin Harbour.

Oral Session 4 – ASFB - 1045 – 1230

Climate Change

Top-down pressure on small pelagic fish by eastern Australian salmon *Arripis trutta* in a changing coastal pelagic ecosystem

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A critical input parameter for ecosystem-level models is an estimate of the consumption rates and biomasses of prey consumed by fish populations. Here we estimate the annual prey consumption of an abundant nearshore predator, *Arripis trutta*, which may exert top-down control on its prey over its latitudinal range (28-43°S) in the East Australian Current (EAC)-dominated coastal waters off south-eastern (SE) Australia. Three independent techniques were used to estimate annual prey consumption at 15 and 20°C: experimental gastric evacuation experiments (coupled with stomach content analyses); bioenergetics modelling, and; empirical regression modelling. The diet of *A. trutta* contained 136 prey taxa, but was dominated (94% by weight) by pelagic baitfish - primarily *Sardinops sagax* (35%) and *Trachurus* spp. (30%) and varied substantially with ontogeny, latitude and season. Consistent with an intensifying EAC, the diet of *A. trutta* has also shifted dramatically from one dominated by krill *Nyctiphanes australis* historically (Malcolm 1966) to one dominated by baitfish. Annual food consumed/biomass (Q/B) using each technique yielded a similar range of estimates ranging from 3.20-4.02 at 15°C and 4.23-5.25 at 20°C. From an approximate *A. trutta* stock biomass of 10,000 t, total mean annual prey consumption was estimated to be 42,200 t of primarily pelagic baitfish which represents only a small proportion (~15%) of the estimated spawning biomasses of its major prey species in this region annually. This study provides an approach for making broad and repeatable estimates of annual prey consumption and highlights the impact of the increasing intensity of the EAC on the coastal pelagic ecosystem of SE Australia.

Impacts of ocean acidification on eggs and larvae of Yellowfin Tuna, *Thunnus albacares*

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Anthropogenic carbon dioxide (CO₂) emissions are increasing the amount of CO₂ absorbed by the world's oceans, which is leading to a decline in ocean pH, a process known as ocean acidification (OA). The majority of OA studies involving fish have focussed on survival, growth and behavioural responses in coastal or reef species. OA has also been shown to affect small coastal fishes by disrupting physiological processes, such as internal acid-base regulation and anaerobic response. It is not known if OA will have similar impacts on pelagic predators in the open ocean. In this study we exposed eggs and larvae of yellowfin tuna (*Thunnus albacares*) to levels of OA that are projected to occur in spawning habitat within the next 100 to 300 years. We found lowered rates of survival and larval growth at greater levels of OA, which correlated closely with histological observations of progressive degradation of vital organs. Using genetic techniques we also showed variable expression of alleles in different OA conditions that may indicate rapid selection of OA-tolerant individuals.

Climate change challenge - predicting the influence of a changed physical environment on the Australian abalone fisheries

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Abalone are gastropod molluscs that have a high commercial value. Many abalone fisheries are in decline or have collapsed, but the Australian abalone stocks have yielded relatively stable catches since the 1980s and are amongst the most valuable commercial fisheries in many Australian States. Catches are dominated by blacklip abalone (*Haliotis rubra*; 82% of Australian production) and greenlip abalone (*H. laevigata*; 15% of Australian production). Generally, abalone have reduced ability to

cope with warm water temperatures and increased acidification. While this is important, given projected environmental changes across SE Australia as a consequence of climate change, predicting the impact of an altered environment on production is challenging. To address this, we integrated biological and catch history data with physical oceanographic variables to identify potential environmental drivers of size-at-maturity, growth rates and yield. Subsequently, estimates of these physical variables from 2060 were used to provide preliminary estimates of changes in production. Outputs from this study were more reliable for blacklip abalone than for greenlip abalone, with all future physical environmental scenarios tested resulting in reduced yield. The magnitude of potential future harvests are also likely to be influenced by an increased frequency and severity of extreme events (e.g. marine heat waves) and the high spatial heterogeneity in abalone physiology. This spatial variation, coupled with the broad latitudinal distribution of blacklip abalone may result in adaptation to changed environmental conditions which may moderate any reductions in productivity

Ocean acidification leaves dispersing fish larvae lost at sea

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The dispersal of larvae and their settlement to suitable habitat is fundamental to replenishment of marine populations and the communities in which they live. Sound is a critical part of this process for some species because it can act as a cue for larvae to orientate towards suitable settlement habitat. Because marine sounds are largely of biological origin, they not only carry information about the location of potential habitat, but also information about the quality of habitat. While ocean acidification is known to have profound effects on marine life, its effect on biological sound production and its reception by navigating oceanic larvae remains unknown. Here we show that ocean acidification can profoundly alter biological sound quantity and quality of future soundscapes. A quieter soundscape indirectly penalizes oceanic larvae by reducing the detection range of coastal habitats. Remarkably, ocean acidification also caused a switch in role of marine sound cues from attractor to repellent in the auditory preferences of fish larvae. Both of these indirect and direct effects of ocean acidification put at risk the complex processes of larval orientation, settlement, and habitat connectivity.

Damsels in distress: the effects of climate change on low-latitude coral reef fish and their potential for developmental acclimation

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Marine organisms that live close to the equator may be more vulnerable to increased temperatures associated with climate change than higher latitude populations. Despite this, low-latitude populations are the least studied in terms of fitness and adaptation potential. By examining multiple physiological measures in long-term studies, our research has shown that near-equatorial species are already living extremely close to their thermal maximum and also that they have limited capacity for thermal acclimation as adults. For this reason the ability to acclimate developmentally will be critical. Based on this foundation, we examined the potential for developmental thermal acclimation in low-latitude populations of four species of damselfish. Newly settled damselfish recruits were collected from the far northern Great Barrier Reef and maintained at three temperature treatments consistent with climate change projections, for a three month period. We compared metabolism, tissue health, growth and survival among treatments and examined differences between fish that were grown out at higher temperatures throughout the plastic developmental period to those that were only exposed to higher temperatures later in development. Our results provide the first insight into the potential for developmental thermal acclimation in these extremely vulnerable populations.

Tropicalisation of the reef fish community at Rottnest Island

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Rising ocean temperatures are forcing a poleward shift in species distributions creating a tropicalisation of temperate reef communities. My study aimed to assess the extent to which tropicalisation has occurred in fish communities at temperate Rottnest Island and to determine the importance of different habitats to the tropical species now residing there. I used a novel technique that combined visual and video survey methods in an assisted stereo-DOV (ASD) to complete a comprehensive assessment of Rottnest Island's inshore fish community. I recorded a higher proportion of tropical species than any previous study, with tropical fish making up ~36% of all recorded species. Of the tropical species identified, the occurrence of *Scarus psittacus* (Palenose Parrotfish) and *Siganus fuscescens* (Mottled Spinefoot) as mature individuals and across locations suggest they have experienced a poleward range extension. I also found tropical herbivores *S. fuscescens* and *Scarus ghobban* (Blue-bar parrotfish) have increased in abundance and are now the 4th and 5th most abundant species. Comparison with long term data suggests that rather than displacing temperate herbivores, an increased abundance of tropical herbivores is occurring as an additional biomass on Rottnest Island's reefs. The current increase in biomass is likely to increase grazing pressure and may be the first step in a habitat phase shift away from macroalgae dominated reefs. The potential for long term ecological change means ongoing monitoring of Rottnest Island's tropical fish and macroalgal communities is essential, and may help in predicting future changes along Australia's south-west coast.

Habitat specialisation and the influence of temperature: investigating behavioural plasticity in coral reef fishes

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Declining habitat diversity and availability, driven by climate change, has been shown to cause dramatic losses in coral reef fish abundance and diversity. Habitat type and structural complexity can influence demographics and population dynamics of resident fishes. Understanding susceptibility of reef fishes to habitat change requires increased knowledge of species-specific habitat preferences and requirements. In addition to changes in habitat, rising temperatures will directly impact behaviour. We determine how ocean warming impacts species specialisation by examining habitat preference. Preferences of juvenile butterflyfishes (Chaetodontidae) and damselfishes (Pomacentridae) were examined in fully orthogonal choice experiments across three temperatures (ambient winter 22°C, ambient summer 28°C, and predicted ocean warming scenario of 32°C), and four habitat types (complex coral, non-complex coral, coral rubble and rocky boulder), to test effects of temperature on habitat selection. At 28°C, we found species specific differences in habitat preferences, with butterflyfishes showing high specialisation to complex corals, and damselfishes exhibiting generalist association with all habitat types. At 22°C, the most generalised damselfish species showed behavioural plasticity, shifting from no habitat preference to selection of boulder habitat, associated with a degraded reef. Specialised species maintained preference of complex coral across all temperatures. For these species, success is reliant on persistence of coral habitat and continuing loss and degradation of coral cover associated with climate change is of great concern. Our results provide the first indication of behavioural plasticity in relation to temperature and habitat selection in coral reef fishes, showing further work outside species thermal optima is needed to understand how coral reef fishes will respond to climate change.

Oral Session 5 – ASFB - 1045 – 1230

Videos, Fish behaviour

Individual personality differences in Port Jackson sharks (*Heterodontus portusjacksoni*)

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Evidence of personality, or consistent individual behavioural differences, has accumulated over recent years and has now been identified in over 100 species of non-human animals. Fish are widely used as model organisms for personality research due to the utility of breeding and housing them in a laboratory, as well as the ability to collect fish from numerous diverse habitats. Despite hundreds of studies on personality in fishes, there remains a striking

lack of research on personality in the elasmobranchs. Like other heritable traits, personality is subject to evolutionary selective pressures, and given their extensive evolutionary history, it is unlikely that personality has been evolutionarily stagnant in elasmobranchs. Personality influences every day risk-reward decisions that cause variation in individual life history fitness traits. Furthermore studying personality is crucial to understanding species flexibility in coping with a changing environment. Using two common boldness assays we are testing for individual boldness differences in Port Jackson sharks (*Heterodontus portusjacksoni*). Our results show strong individual differences that are consistent through time and across contexts. Demonstrating individual boldness differences in sharks for the first time provides valuable insight into the evolution of personality in vertebrates.

Rapidly collected behavioral data predicts the effectiveness of periodically harvested closures in Fiji

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Periodically harvested closures (PHCs) have become the most common form of fisheries management in Melanesia. Despite their popularity, their effectiveness to sustain local fish stocks remains largely unknown and anecdotal evidence suggests they are more commonly used to provide fish for short term needs. This has resulted in large variations in the time of closure (months to years) vs. opening (days to weeks). This strategy stems from the traditional objective to increase the catchability of fishes in order to provide for short term needs. This is supported by Flight Initiation Distance (FID) studies, showing that fish are less wary within well managed PHCs. However, FID methodology is additional to abundance/biomass surveys and requires extensive field time to obtain sufficient replication. We present a novel method for assessing fish wariness, Minimum Approach Distance (MAD), which can be extracted from Diver Operated Stereo-Video (stereo-DOV) surveys without altering field protocols. This method provides highly accurate length and distance estimates, increases replication and reduces field time when compared to FID. MAD data was used to assess the ability of five PHCs in Fiji, to increase catchability and determine how pulse harvest events impact on this catchability. We found that the majority of PHCs were not achieving their major objective in increasing the catchability of fishes. One well managed PHC showed an increase in catchability, however, this was lost rapidly due to an intense harvest event. The factors leading to these PHCs failing to achieve this objective are discussed.

BRUVS as a tool for assessing marine fisheries and ecosystems: hurdles and potential

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Baited remote underwater video systems (BRUVS) are a fishery-independent technique used to assess the community composition, distribution, relative abundance and size of marine fishes. The technique is non-extractive, cost-effective, repeatable and robust across a broad range of habitats and depths. As such, BRUVS minimise or remove some of the biases associated with traditionally used sampling methods including underwater visual census by divers or fishery obtained data. Continual improvements in technology, combined with the ability to collect and retain video records of fish and the associated seafloor, has resulted in wide adoption of BRUVS. However, it is not understood how differences in protocols for their deployment, analysis and interpretation affect spatial and temporal comparisons of BRUVS data. There are also many concerns regarding biases associated with the use of bait. Here we critically review a variety of BRUVS techniques (single, stereo, pelagic) by examining how they are used in the field, and issues surrounding the use of bait, video analysis and data management. The findings are discussed in relation to the ability of BRUVS to detect change in the relative abundance, length frequency and community composition of marine fish. We propose protocols for the use of BRUVS (including the use of GoPro cameras) that will minimise variability among users and allow direct comparisons of data collected. For ecosystem based fisheries management, BRUVS are an invaluable tool for providing the required spatial and temporal data on fish assemblage structure.

Biogeographical patterns in fish assemblages of the remote Pilbara region, northwest Australia

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Globally, very few coastal marine environments remain in pristine condition. For effective management of these important marine environments, knowledge of the spatial distribution of fish and their associated habitats is required. The present study was conducted in the remote Pilbara region of northwest Western Australia, where some areas of the marine environment remain in near pristine condition but coexist and are threatened by a significant and growing offshore oil and gas industry. Information on fish

assemblage structure across the region was obtained from baited remote underwater stereo-video surveys. A novel application of video analysis software was applied to obtain simultaneous coarse assessments of habitat. Patterns in the relative abundance and distribution of common fish species, fish families and fishery-target species were mapped across the inshore Pilbara region. Generalized additive mixed models were used to assess relationships between these key species groups and a range of habitat and environmental predictor variables. The results identify habitats and environmental variables that are of particular importance to different fish species groups across the Pilbara region and inform management of areas of high conservation value.

Rules of attraction: Enticing Pelagic Fish to mid-water video systems

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2 Department of Primary Industries, Huskisson, Australia

Mid-water baited remote underwater video systems (BRUVS) are becoming an increasingly popular tool for examining pelagic fish assemblages in a non-destructive, fisheries independent manner. As the technique is relatively novel, critical methodological questions such as the most appropriate attractant for pelagic fish to mid-water RUVS remain unresolved. In this study, we compared the relative effectiveness of 4 attractant treatments (sight: metallic reflectors, sound: bait fish recordings, scent: pilchards and their combination) on the time of first arrival, total abundance of pelagic fish and the relative abundance of 3 pelagic fish species: *Trachurus novaezelandiae*, *Sarda australis* and *Seriola lalandi*. Recordings were made using mid-water RUVS in the Jervis Bay Marine Park, Australia. RUVS using a combination of all attractants recorded the highest abundances and shortest time of first arrival of pelagic fish. This result was primarily driven by *Trachurus novaezelandiae*. Although not significant, the abundance of *Sarda australis* was also greatest on the RUVS with all attractants. In contrast, the type of attractant had no effect on the abundance of *Seriola lalandi*. Bait, the standard attractant used in BRUVS surveys, was a poor performer for pelagic fish in all instances. We suggest that future studies using this sampling method employ multiple attractants.

Some fish-chanting evenings: The contribution of fish choruses to soundscapes in Australia's coastal waters and implications of sampling duration

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Nearly a thousand species of fish have been reported as soniferous, producing sound in association with a number of behaviours and often calling en masse during activities such as spawning or feeding. Many of these behaviours exhibit diurnal patterns and, as a result, related vocal events like the 'evening chorus' have become well known.

Our understanding of the temporal and spatial patterns in calling and their relationship with the environmental drivers (solar/lunar/tidal/seasonal patterns, salinity, temperature etc.) with which they correlate, increases with every recording, thus more complicated patterns are becoming evident. The sounds and choruses contribute significantly to the local soundscapes and whether originating from finfish or shellfish they can act as significant cues for conspecifics and other marine fauna, thus these signals can provide marine science with significant information, particularly when considered with their cyclic nature. In recent years there has been increasing interest in the application of soundscapes as a metric for local health or recruitment suitability, however, the timescale over which soundscapes are sampled can have significant impact on any conclusions drawn from them. This paper will give a brief overview of fish signals and their diversity around Australia in temperate and tropical waters, estuarine, coastal and reef, together with some of the spatial and temporal patterns in their presence. It will also provide a brief description of some of the impacts on conclusions drawn from different sampling strategies.

Oral Session 6 – ASFB - 1045 – 1230

Fish Biology, Ecology and Management

Murray Crayfish Management Model: Development and utility

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Murray crayfish are an iconic species of the Murray Darling Basin and has been exploited as a recreational fishing species for many years. Limited research has been undertaken on Murray crayfish despite being a popular recreational fishing species. Moreover, little is known about the impacts that threatening processes have on Murray crayfish. To help manage Murray crayfish for their long term sustainability a population model was developed to include a variety of threatening processes such as fishing and blackwater events. The model uses the life history of Murray crayfish as the underpinning biological structure, and using age-length data to estimate survival rates and growth rates. A number of different fishing strategies can be examined, including slot sizes. Also the impact of blackwater events can be explored as well as other threatening processes. Alternate management actions can be modelled and ranked for their efficacy, cost and conservation value.

Carp Separation Cage effectiveness in remote Australian lowland rivers: assessing ecological benefit and commercial viability

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Various control techniques for common carp (*Cyprinus carpio*) exist in Australia, with most involving methods that employ manual removal. Carp Separation Cages (CSCs) are an innovative technology that employs a two-stage cage system that automates carp separation from native fish by taking advantage of a carp's propensity to jump. The ability of CSCs to control regional carp populations is dependent on a high percentage of carp being migratory, and the effectiveness of CSCs to capture the majority of migrating carp. To date, CSCs have predominantly been utilised in the Murray River with the cooperation of on-site lock operations staff, fish researchers, and commercial carp operators. However, little work has occurred to assess the effectiveness of CSC's at smaller lowland rivers in remote NSW. This paper collates field trials where CSC's were deployed at seven fishways within three NSW catchments. A total of 1360 carp were captured across 983 sampling days for an average of 1.4 carp captured per day. Results indicate that CSCs in smaller lowland rivers are unlikely to have any measurable impact on carp populations. Additionally, the findings confirm that operating CSCs at remote fishways is commercially unviable. Due to the costs required to fabricate and operate the cages, Fisheries NSW recommends that the insertion of CSCs is restricted to fishways located on larger rivers systems where weir operations staff are present and willing to cooperate with a viable commercial carp operator.

Early response of Macquarie perch to enlargement of an upland reservoir

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Enlargement of the Cotter Reservoir, Australian Capital Territory, has seen a 4 to 78 gigalitres increase in storage capacity to secure domestic water supply for the city of Canberra. Reservoir enlargement has the potential to impact on the resident population of the endangered Macquarie perch and so in 2010, a program was established to assess the impact of construction, filling and operation of the enlarged reservoir on this species. Monitoring since filling commenced (in April 2013) has revealed extremely low relative abundance of Macquarie

perch young-of-year, despite an increase in adult fish relative abundance and a significant increase in adult body condition. Our results shed some light on the influence of increased reservoir level, barriers to passage and sampling efficiency within a dynamic habitat matrix, with some key implications for monitoring and management context.

Comparative phylogenomics of four Murray-Darling Basin aquatic species

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Next generation sequencing opens up our ability to examine patterns of genetic diversity across the landscape based on genome wide data from thousands of loci rather than traditional methods that at best sequence up to around 10 loci. Here we examine genetic variation in four widespread species in the Murray-Darling Basin: Australian Smelt (*Retropinna semoni*), River Turtle (*Emydura macquarii*), River Shrimp (*Macrobrachium australiense*) and Yabby (*Cherax destructor*). Our goal is to determine whether any of parts of the Murray-Darling Basin are genetically distinct, and whether there are common patterns across species. Our genetic analyses are based on SNPs (single nucleotide polymorphisms) generated by ddRADSeq (double-digest restriction-site associated DNA sequencing) which generally provided >20000 loci for each group.

Demography of the eastern blackspot pigfish *Bodianus unimaculatus*, a long-lived labrid inhabiting deep temperate reefs

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Members of the Genus *Bodianus* are highly prized for consumption worldwide and fishing pressure has reduced many populations to critically low levels. Despite this, little information is available on the demographic parameters required for sustainable management, particularly for species inhabiting temperate regions. We examined the length, age, reproduction and mortality of *Bodianus unimaculatus* from commercial landings in New South Wales, Australia, between January 2005 and January 2006. Investigations confirmed that *B. unimaculatus* exhibits life-history characteristics common to species that must cope with periods of low recruitment: 1) it is long-lived, with a maximum age of 31 years recorded, 2) it is subject to variable recruitment, with relatively low numbers of 9, 14 and 19 year olds observed, and 3) it reaches sexual maturity within the first few years of life, with no immature individuals collected despite 13% of individuals aged ≥ 5 years. Gonadal examination confirmed this species is a monandric protogynous hermaphrodite, with 50% of individuals changing sex by 29 cm FL. This means the commercial fishery in NSW will be based almost entirely on males, which may affect reproductive output of females by reducing the size of sex-change. Mortality estimates indicate this species is currently fully fished, with fishing mortality (0.05-0.10) approximately equal to natural

mortality (0.10-0.15). We recommend that fished populations of *B. unimaculatus* be carefully monitored, given that targeted fishing may lead to age-truncation and reduced resilience to environmental change.

Cyprinid herpesvirus 3: a potential biological control agent for carp in Australia

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After Cyprinid herpesvirus 3 (CyHV-3, formerly known as koi herpesvirus) devastated carp aquaculture throughout the world in the late 1990s, it was considered to be a potential biological control agent for common carp (*Cyprinus carpio*) in Australia. It was imported into the high-security CSIRO-Australian Animal Health Laboratory, and, since 2007, there has been an active research program on the virus. Achievements include: (1) confirmation of the susceptibility of Australian carp to the virus; (2) demonstration of the insusceptibility of all non-target species that have been tested, including: 14 native and 1 introduced species of fish; yabbies; 2 amphibians; 2 reptiles; chickens (representing birds); and, laboratory mice (representing mammals). There has been no evidence of disease, or even infection, in any of these animals; (3) no evidence for known, or previously undescribed, cyprinid herpesviruses that could potentially be cross-reactive with CyHV-3 in 900 samples collected from throughout the Murray-Darling Basin; (4) complete sequencing, and annotation, of the genome of the Indonesian isolate of CyHV-3 that would be used in any future control program; (5) substantial progress in identifying a marker of carp that are persistently (perhaps, latently) infected with CyHV-3; and (6) great progress in the development of a model to aid in developing a release strategy for the virus in the Murray-Darling Basin. If CyHV-3 is to be released, there are still two essential requirements for success: a serological test to monitor progress of the virus in Australian waters, and a complementary, broad-scale program to work in tandem with CyHV-3.

The Ecology of *Gambusia holbrooki* in Edgbaston Springs

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Gambusia holbrooki (Western Mosquitofish) is listed in the top 100 world's worst invasive alien species by the IUCN Invasive Species Specialist Group due to their massive impacts on freshwater fishes around the world. *Gambusia holbrooki* seriously threaten *Scaturiginichthys vermeilipinnis* (Red-finned Blue-eye), one of Australia's most endangered fishes. The goal of this study was to investigate the ecology of *G. holbrooki* to determine ways to exploit aspects of their ecology to enhance control measures. This included

aspects of their habitat use and seasonal variation in their reproductive output. In addition, I examined *G. holbrooki* diet to determine whether they appeared to be having an impact on the endemic invertebrate fauna. These results will be presented and discussed in light of how we can improve the battle to control *G. holbrooki* to try and restore *S. vermillionis* populations.

Oral Session 7 – ISSESr - 1315 – 1515

Stock enh as a comp fish management tool

Quantitative assessment of fisheries enhancements: a critical review

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Quantitative assessment of the contribution a release program can make to fisheries management goals is a key requirement if enhancements are to be effective and sustainable. Following development of population dynamics theory and quantitative assessment methods for enhanced fisheries by extending conventional fisheries models with more explicit representation of key size and density-dependent processes, recent work has focused on eco-evolutionary modeling of fitness consequences, dynamic response in fishing effort, and spatial dynamics of enhanced stocks and fisheries. Following a long period during which enhancement research was predominantly experimental with limited theoretical foundation, population dynamics theory is now arguably ahead of experimental research and many of its predictions have not been rigorously tested. This is particularly true with respect to effects of interventions that are predicted to manipulate populations towards states outside the range of their natural dynamics. Theoretically informed, experimental research involving such manipulations holds the key to greater predictability of enhancement outcomes and is likely at the same time to advance our understanding of ecology and contemporary evolution in wild fish populations.

An approach to restore the stock condition of a depleted species of flounder in Northern Japan: Elucidating the spawning ecology of stocked barfin flounder *Verasper moseri* for better fishery management

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The commercially valuable barfin flounder *Verasper moseri*

population has become extremely small after the late 1970s, probably due to overfishing of young and mature adults. To restore the condition of their stock, hatchery-reared barfin flounder have been released off the Pacific coast of Hokkaido (40.2°43.4°N), northern Japan since 1987. In particular, a large-scale stock enhancement program has annually released more than one million seedlings since 2006. As a result of these trials, commercial landings around release areas have risen markedly (annual landings of 178 tons by 2010). However, despite the continual release of seedlings for over a quarter of a century, reproduction of the next generation in the wild has not been confirmed. Therefore, we examined the unknown spawning ecology of stocked barfin flounder in the wild to establish an adequate fishery plan by which reproduction can be accelerated. Combined analyses of maturation traits and fishery information revealed that major spawning grounds form at the upper continental slope off southernmost Tohoku (35.6°36.6°N) from early February to late April. Moreover, the tag-recapture surveys using matured and spawned fish revealed that barfin flounder repeat widespread spawning migration over 700 km between feeding grounds off Hokkaido and spawning grounds off southern Tohoku. Until now, a stock enhancement program and fishery restrictions was conducted for each local region. However, these results underscore the necessity of more widespread fishery management for adult barfin flounder encompassing the waters off Hokkaido and Tohoku to enhance spontaneous spawning more effectively.

Evaluation of the effectiveness of stocking Japanese Flounder

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Japanese flounder (*Paralichthys olivaceus*) is important for stock enhancement programs in Japan. The effectiveness of stocking this species has been evaluated on a geographically small scale, such as a small bay. Yet, stock assessment is conducted on geographically larger scales by the Fisheries Agency of Japan. In this study, we analyzed relationships among stocking, fishing regulation, and the biomass or catch of flounder based on the stock assessment unit. We also evaluated the effectiveness of stocking from the perspective of a fisheries management tool. There are seven recognized stocks of flounder around Japanese waters. In six, abundances of wild and released fish were estimated using virtual population analysis. Stock-specific parameters were derived from these analyses: stock abundances, fishing mortality coefficients (F), the number of wild recruits per spawning stock biomass (RPS), and stocking efficiency (survival rates of released seeds until recruitment to the fishery populations, E). Using these parameters, we simulated the expected biomasses and expected catches for the future, shown as isopleth diagrams across wide ranges of released seed number (Ns)

and F. The diagrams indicated that the relative effects of Ns and F on the biomass or catch varied among stocks. For the stocks with low RPS and/or high E, the effect of Ns was relatively higher. However, F was substantially effective for all stocks. These suggest the consistent effectiveness of fishing regulations and the importance of a combined approach of stocking and fishing regulations, corresponding to the stock status.

PauaMAX' - Holistic enhancement of New Zealand's Blackfoot Abalone (Paua) resource

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New Zealand's blackfoot abalone (paua) is a species of high customary and social significance, and supports a high-value commercial fishery. Over recent decades, paua stocks have declined in some areas due to collective fishing pressures. There is also concern about the effects that environmental stressors may have on the health of paua populations. Since the early 2000s the Industry has been investigating means of enhancing paua populations. Recently, the Industry has developed a large-scale project for paua population enhancement ('PauaMAX'). This encompasses a series of sub-projects that build on previous work that has been undertaken and investigates novel means of paua population enhancement. The overarching goal of the project is to investigate different enhancement strategies that target all stages of the paua life-cycle. Proposed work includes: (1) Assessing the viability of outplanting paua larvae as a means of enhancing local stocks, (2) investigating means of increasing the survival rates and economic viability of reseeding juvenile (10-20mm) paua, (3) investigating the utility of translocation of paua at different life stages from slow-growing ('stunted') areas to fast-growing areas, (4) investigating the effects of fishing at lower size limits (<125mm) to utilize stunted stocks, and enhance to overall productivity of the fishery, and (5) understanding the effects that environmental stressors (e.g., sedimentation and ocean acidification) have on the health of paua populations. Outcomes from this project will assist in understanding the different life-stages of paua in a wider ecosystem-based management context, and help identify the most viable management strategies for paua stock enhancement.

Potential for marine stock enhancement and spatial fisheries management in Victoria. Concepts, practice, policy needs, economics and sustainability

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Stock enhancement has application in Victoria's marine fisheries but how do you pick a winner? What are the pitfalls and how do we avoid them? What policies do we need to encourage development and application? What are

the sustainability concerns if any? What are the objectives and how do we measure them? Are there other solutions and what is the threshold for turning to stock enhancement? Consideration should be given to each of these issues in designing a stock assessment program. An overview of the first fleetings attempts (prawns, scallops, abalone, black bream) will be given and a perspective on the future potential of these technologies in the State.

Re-introduction of Trout cod in NSW: One million fish later

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A breeding program for the endangered fish Trout cod (*Maccullochella macquariensis*) based at Narrandera Fisheries Centre has been in operation since 1986. During that time over one million fingerlings have been produced and stocked to a number of locations in rivers across NSW. The breeding program has strict guidelines in place to ensure the genetic integrity and suitability for re-introduction of the hatchery produced fish. Hatchery techniques, including breeding guidelines, along with stocking locations and the status of reintroduced populations will be discussed.

Oral Session 8 – ASFB - 1315 – 1515

Threatened Species

Exploring the capacity of Murray crayfish (*Euastacus armatus*) to recover from significant population loss associated with a severe hypoxic blackwater event

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The 2010-11 hypoxic blackwater event - persisting for nearly six months and extended for approximately 1800km in the Murray River - had devastating impacts on aquatic fauna throughout the southern Murray-Darling Basin. The iconic and highly valued recreational species Murray crayfish (*Euastacus armatus*) was particularly impacted with the widespread emergence of individuals during the event noted and medium-term BACI assessment revealing significant population loss (81%) in affected areas of the Murray River (below Barmah-Millewa Forest). The severity of the impact was not lost on managers and the wider community, and prompted the most significant changes to the fishing regulations of the species since it was first regulated over 130 years ago. Whilst these management changes have afforded the species protection, the recovery of k-selected species, such as Murray crayfish, which are slow-growing, dispersal limited and late maturity, is anticipated to be slow. This recovery can be further

hampered in species that already persist as suppressed and fragmented populations. Here we offer the outcomes of continued medium-term post-blackwater event monitoring along with genetic assessment and population modelling, to provide insight into the recovery potential of the species. Is natural population recovery feasible, and if so, over what timeframes, and how can recovery be assisted? In shedding light on these questions, we will discuss the implications for the long-term management of the iconic species in a changing Murray-Darling Basin.

Habitat specialisation in threatened Murray Crayfish occupying upland streams

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Murray crayfish (*Euastacus armatus*) are a culturally and ecologically important species that have undergone severe population declines throughout the Murray-Darling Basin. To develop conservation priorities for this threatened species, we must understand their habitat requirements within both upland and lowland parts of their range.

Snorkel surveys of *E. armatus* habitat-use across two spatial scales (mesohabitats, microhabitats) within upland sections (350-550m ASL) of the Goobarragandra and Goodradigbee rivers, New South Wales, revealed strong selection by *E. armatus* towards areas of intermediate flow velocity, deeper water, and streambeds dominated by large boulders and gravel. These microhabitat preferences, along with percent cover of overhanging riparian vegetation, helped explain hotspots in *E. armatus* density among and within these upland streams. Moreover, major changes in their preferred habitat conditions within the Goobarragandra River from 2009 to 2015 (e.g., 32% and 50% decline in percent cover of boulders and overhanging vegetation, respectively) were associated with a 63% decline in *E. armatus* abundance. Given *E. armatus* are habitat specialists that appear to be sensitive to change, we suggest restoration and maintenance of these riparian vegetation and in-stream habitat conditions should be a priority in the management and recovery plans for upland populations of this threatened species.

How to non-destructively age a protected fish with no otoliths, spines, or discernible scale annuli? With an atomic bomb!

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Australian lungfish (*Neoceratodus forsteri*) are a protected species listed as vulnerable to extinction, yet there are many knowledge gaps hampering sustainable management and extinction risk. Understanding population age structures is vital for managing threatened species. *N.*

forsteri are the oldest living vertebrates on earth and lack many morphological features typically used for fish population assessments in modern teleosts. Traditional fish ageing involves destructive sampling for otoliths, vertebrae or other hard parts, or non-destructive sampling of external bony body parts like spines or scales, to interpret annual check marks formed in these structures. Lungfish do not have hard otoliths and lack external spines, however they possess thick scales. Despite scales exhibiting markings analogous to annual check marks, efforts to age them have proven inconclusive. We developed a novel technique by measuring radiocarbon trapped in their scales over their lifespan and compare this to the atmospheric pattern derived from atomic weapon testing in the 1950-1960's. Radiocarbon has been used to age fish destructively before, but this is the first non-destructive application of the technique using scales from a long lived species. Initial results from 90 fish aged from the Brisbane, Burnett and Mary Rivers support the hypothesis that lungfish are long lived with 35% being > 50 years of age, and has revealed gaps in the age structure over the past 50 years. This technique is revealing population secrets of *N. forsteri* that have been a mystery since their discovery in 1870, enabling an assessment of population drivers and their extinction risk.

Cross-border cooperation to streamline recovery actions for the endangered Murray hardyhead (*Craterocephalus fluviatilis*) in the southern Murray-Darling Basin

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2 The Murray Darling Freshwater Research Centre and Latrobe University, Australia

The Murray hardyhead *Craterocephalus fluviatilis*, a native fish species endemic to the Murray Darling Basin, listed as 'endangered' under the Commonwealth EPBC Act. The species was historically common throughout South Australia, southern New South Wales and northern Victoria. Due to compounding threats (habitat loss, changing flow regimes and pest species) the Murray hardyhead suffered a severe decline in distribution. As few as 9 remnant Murray hardyhead populations persist, generally located within saline habitats. Disher Creek and Berri Evaporation Basin in the Riverland region of South Australia have historically been used for saline water disposal. In recent decades, Murray hardyhead surviving within these sites were confined to small drainage outfall habitats. In 2012 through federal and state partnerships, innovative projects were completed increasing available habitat at both sites through on ground works, drainage diversion and environmental water to manipulate seasonal water levels. A positive response to the interventions in terms of increased abundances was detected for both Riverland populations in February 2015. This encouraging result created an opportunity to increase the area of occupancy of the species, thus reducing the risk of extinction by translocating fish from these currently robust populations to new habitats within their former range. A long standing cross-border collaboration between Victorian and South

Australian departments ensured necessary permits were fast-tracked to facilitate the relocation of a sub-population of Murray hardyhead from the Riverland sites to Brickworks Billabong in Mildura, a wetland prepared and watered specifically to create a future recovery site for the species.

Population dynamics and status of freshwater catfish (*Tandanus tandanus*) in the lower River Murray, South Australia

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Freshwater catfish (*Tandanus tandanus*) is a protected species under the South Australian (SA) Fisheries Management Act (2007). Following high flows in 2010-2012, there were anecdotal reports of increased incidental catches and perceived population recovery of freshwater catfish in the SA River Murray prompting a review of the 'protected' status of the species. This study aimed to: 1) consolidate existing biological/ecological knowledge and data on population dynamics of freshwater catfish from historical fishery and more recent long-term fishery-independent monitoring programs, 2) engage recreational fishers in collecting data through freshwater catfish fishing events, and 3) integrate these data to develop an understanding of the current population status of freshwater catfish in SA River Murray. The results indicated that freshwater catfish abundance remained very low in main channel and anabranch habitats of the SA River Murray during the prolonged drought over 2002-2009 and there was a significant increase, particularly distinct in 2011/12, following high flows in 2010-2012. The increased could be attributed to a combination of enhanced recruitment, fish movement and increased catch rate. Nevertheless, the high catch rate in 2011/12 remained an order of magnitude lower than the historical commercial catch rate just prior to 1997, when freshwater catfish became a protected species in the SA River Murray. Therefore, in the context of historical declines, freshwater catfish abundance in the lower River Murray remains low and warrants continued protection. Long-term monitoring and research to fill key knowledge gaps is essential to underpin population assessment and management to facilitate the recovery of freshwater catfish in the lower River Murray.

Combining traditional and environmental DNA (eDNA) based monitoring to improve the management of native and invasive fish species

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Detailed species distribution data is essential prior to undertaking any management actions. However, this is often challenging for invasive fish species since traditional monitoring methods (i.e. electrofishing, fyke netting, bait trapping) are often biased and unable to accurately determine the extent of the invasion front (Porreca et al., 2013; West et al., 2007). Environmental DNA (eDNA) based species detection has significantly improved our ability to detect aquatic vertebrates at low densities and is subsequently an extremely valuable monitoring method prior to deciding on appropriate management actions (Goldberg et al., 2014). Here we present the results of both traditional (i.e. electrofishing and bait trapping) and eDNA based monitoring surveys conducted in Blakney Creek (NSW). Within this system, the continued spread of the invasive redfin perch (*Perca fluviatilis*, L. 1758) is threatening one of only three self-sustaining populations of the endangered Southern pygmy perch (*Nannoperca australis*, G. 1861). The results show that eDNA based monitoring is able to determine the distribution of the invasive redfin perch with high resolution. Overall the combined results of the traditional and eDNA based monitoring survey shows that redfin perch are widely established in Blakney Creek but absent from the upstream reaches of one of its tributaries (i.e. Urumwalla Creek). Consequently, management action should focus on the Urumwalla Creek population to conserve one of the last remaining Southern pygmy perch populations in NSW.

Proposing the use of an ecoart platform to conserve Australian fishes

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Ecoart can take the form of simple and beautiful pieces that prompt appreciation of the ecological world through to politically engaging and challenging initiatives that confront issues of sustainability. Cartooning is one form of art that provides a visual means for acting along this gradient and trades substantially on the ingredient of humour. Perhaps counter intuitively, humour can provide a powerful means for brokering dialogue or raising awareness of difficult issues for society. Australian threatened marine and freshwater fishes face a myriad of impacts that are typically derived from human activity, representing a difficult societal issue. In a subset of cases, fish ecologists have knowledge of these impact pathways and may even be involved with

resourced or poorly resourced initiatives to protect species. However scientists are but one part of the puzzle. Arguably without wider public interest in the plights of these fishes progress will be at best piecemeal and based on localised triumphs. An opportunity is presented for involvement by Australian marine and freshwater fish ecologists to contribute to an initiative aimed at raising the profile of threatened species collectively.

Oral Session 9 – ASFB - 1315 – 1515

Recreational Fisheries

Murray Cod Creel Surveys - Finding out what really goes on

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Overfishing is suggested as a cause of Murray cod (*Maccullochella peelii*) decline, but few quantitative surveys exist to provide fishery-dependent data on status of the fishery. Murrumbidgee River and Lake Mulwala fisheries were assessed using a complemented fisher survey design that used progressive counts to quantify boat and shore-based fishing effort, roving surveys to obtain catch and harvest rate information from shore-based fishers, and access point surveys to obtain catch and harvest rate information from boat-based fishers. Lake Mulwala is one of Australia's premier Murray cod fisheries, whereas the Murrumbidgee River has endured historic decline. Lake Mulwala catch rates (Murray cod per fisher hour) were 0.288 (± 0.073 SE; boat-based) and 0.126 (± 0.019 SE; shore-based). Murrumbidgee River catch rates were 0.228 (± 0.047 SE; boat-based) and 0.092 (± 0.023 SE; shore-based). Lake Mulwala Murray cod harvest rates were 0.033 (± 0.022 SE; boat-based) and 0.006 (± 0.001 SE; shore-based). Murrumbidgee River harvest rates were 0.013 (± 0.006 SE; boat-based) and 0.003 (± 0.001 SE; shore-based). The effectiveness of a closed season to protect spawning Murray cod may have been suppressed by high fishing effort and deliberate by-catch. Murray cod catch-and-release was 89-95%, mostly because fish were undersize. A reduction in minimum legal size led to 57% more cod harvested. To sustain and improve Murray cod fisheries we suggest quantifying catch-and-release spawning impacts, development of a strategy to minimize closed season by-catch, and survey repetition to monitor change over time relative to management strategies applied.

Patterns of exploitation within Recreational Fishing Havens: implications for zonal management in NSW estuaries

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Effective management of recreational fisheries requires information on fine-scale spatial patterns of recreational exploitation. Such information is particularly important for specially designated regions such as recreational fishing havens (RFHs), which have been implemented to varying extents in many parts of Australia and broadly aim to facilitate equitable allocation of resources among fishing sectors as well as maintain/improve the biomass of exploited species. An integral part of assessing the performance of RFHs as a whole and effectively managing the species targeted within them, is evaluating the spatial patterns of exploitation that occur therein. Using data acquired through progressive counts and on-site angler surveys, this study quantitatively compares total recreational effort, the harvest-per-unit-effort (HPUE) for key recreational species and the overall species composition of retained catch among zonal habitats in three representative estuarine RFHs in NSW. Drawing on specific examples from the results, we illustrate how information gained from this type of study can be applied within partial protection areas such as RFHs to achieve fisheries management objectives.

Camera surveys of recreational fishing in Western Australia

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Cameras have been widely used in fisheries research, including studies examining the impacts of fishing. The capacity for cameras to improve knowledge of recreational fishing is also being considered in Western Australia. Since 2006, cameras have been installed at 15 metropolitan and regional locations across the State. These cameras provide data across an entire 24-hr day, 365 days a year. This presentation will outline the scope and limitations of cameras in collecting data on shore- and boat-based fishing. Using case studies, the potential for cameras to validate other survey techniques and to improve survey estimates will be identified. The deployment of cameras in conjunction with an aerial-roving creel survey of Perth beaches has improved the accuracy of catch estimates for Australian Herring (*Arripis georgianus*). Counts of the number of boat launches are also being compared to ramp-based estimates of fishing activity derived from surveys of recreational boat-based fishing. In addition, thermal imaging cameras in Peel Harvey Estuary are providing information on the distribution of shore-based

activity. An improved understanding of day vs. night patterns of shore-based fishing for Blue Swimmer Crab (*Portunus armatus*) may help assess the potential underestimation of catch from previous on-site surveys and will assist in estimating the catch in future on-site surveys. The largest ongoing cost in camera surveys relates to the reading of the data. Improvements in movement detection algorithms may enable automatic counts of boat movements, which could provide a cost-effective way to monitor long-term trends in recreational fishing.

Estimating fishing catch and effort from a designed artificial reef

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Surveying recreational boat-based fishing and estimating catch and effort can be complex since they occur over diffuse spatial and temporal scales. Remotely-operated camera systems have the potential to overcome some problems associated with traditional in-situ observation methods. The fishing effort of recreational species associated with a designed Artificial Reef (AR), 1.5 km east of Sydney was monitored over 2 years with a remotely-operated camera. Effort was determined via analysis of boat movements detected by remote camera video observations, and was validated using visual observer counts. Effort was found to be significantly higher in autumn and summer compared to winter and spring during the first survey year, however there was no difference between years. Effort was standardised to boat hours per square kilometre and when compared with other fisheries, the AR was found to receive up to 13 times more fishing effort per unit of area during both survey years. Harvest of the AR was calculated using the effort data together with harvest rates determined from existing recreational catch surveys in coastal Sydney waters. We found that harvest of pelagic, large reef and demersal fish was significantly higher (up to 39 times more) compared to other fish categories. Harvest was highest in autumn during both survey years. Our study demonstrates that remotely-operated cameras are useful for capturing effort data for recreational fisheries, although automated image analysis of boats on a dynamic ocean surface is needed.

Development of a flexible system for reporting recreational fishing data at fine spatial scales for Telephone/Diary surveys

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Telephone/diary surveys are designed to provide robust recreational fisheries statistics over large spatial scales e.g. state-wide and regional. Regional boundaries are often selected during the design phase of a survey with reference to areas of interest to management. For example, survey areas may include commercial fisheries zones, river catchments or marine park boundaries which enable

recreational fishery estimates from the surveys to be used to assess any potential management initiatives within these pre-defined zones. Difficulties arise when attempting to re-organise data into other zones of interest that may arise post the initial analysis. In 2007 a team from UTAS developed the 'RecSurvey' analysis package using 'R', open source statistical software to provide improved statistical analyses and more flexible outputs of large scale survey data collected via the Telephone/Diary method. We present a system that is designed to integrate with the 'Recsurvey' analysis package allowing further flexibility in creation of customised survey reporting zones and importantly this component of the survey places no additional burden on respondents. During 2013-2014 NSW conducted a state-wide telephone/diary survey to compare results with NSW data derived from the NRIFS. The locations of all fishing events in the 2013-2014 Diary Survey were assigned relevant GIS coding (latitude and longitude). In addition to direct comparison with NRFS data at the broad scale, this innovation provides flexibility in terms of alternative spatial analyses (subject to precision limits). We provide examples of this zonal flexibility, document the lessons learned from the process and provide suggestions for improvement in data collection for future surveys.

Oral Session 10 – ASFB - 1315 – 1515

Climate Change

Plasticity of tropical reef fish to future Sydney winters

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The Earth has already warmed on average by 0.3 - 0.6°C over the last century, which has already altered some species' distributions and habitat usage. Many of the observed range shifts in the marine environment have occurred in 'hot spot' areas that are warming at a greater rate than the global average, like South East Australia. For at least the past 15 years newly recruited tropical reef fish have been observed in Sydney's waters during summer (termed tropical vagrants), but they don't persist throughout the current winters (~16-17°C). Ocean temperatures in this region are projected to increase by up to 4.0°C by the end of the century, presenting the possibility that tropical fish could survive the future winter conditions. This research investigated the capacity for developmental thermal plasticity of a common tropical vagrant damselfish, *Abudefduf vaigiensis*, to present-day and two projected future coastal conditions; +1.5°C and +3.0°C above present-day. The potential for future persistence of *A. vaigiensis* was established by comparing thermal performance in a range of key physiological and morphological attributes between the three treatments. This research found evidence for present-day thermal performance thresholds at approximately 18.5°C. However, when fish were maintained at moderate (+1.5°C) future projections they improved their thermal performance above present-day in a number of traits. This research highlights that understanding the capacity for developmental plasticity of tropical fishes to future temperate winters is required to comprehend the true potential for range shifts into South East Australian waters.

Evaluating thermal performance reactions norms as a predictor of vagrant tropical fish success in temperate waters

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The recruitment of tropical fishes to temperate waters during warm summer months is a common occurrence where western boundary currents provide a larval transport mechanism. While survival and growth during the summer months is often quite high, survival over the winter period is low, thus creating a significant hurdle to the range expansion of tropical fishes into temperate habitats. Previous work has highlighted the interactive roles of thermal physiology and ecology in this overwinter survival barrier. Here we generate thermal reaction norms across 8°C for metabolic rates (resting and active oxygen consumption) and burst swimming performance for three tropical and two temperate reef fish species found in the temperate waters of Sydney Australia. We evaluate the ability of these curves to reflect the life history and predict the relative establishment success of these tropical species. Overall we found reaction norms accurately reflected the life history of the species but were much broader than anticipated. We also found general support for the prediction that the more commonly occurring tropical species exhibited generally greater performance across the thermal range of the study. While it will also be important to consider processes such as acclimation and adaption to these novel environments, this work highlights the utility of establishing thermal performance reaction norms as a means to evaluate the relative likelihood and possibly speed with which tropical fish species may permanently establish themselves in temperate habitats as global ocean temperatures continue to increase.

Effects of climate change on estuarine fish communities of southwestern Australia

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We present a synthesis of recent, observed trends in the climate of south-western Western Australia (SWWA) and a summary of future changes that are predicted for the region in coming decades. We then discuss both observed and predicted effects of climate change on the hydrology and physico-chemical environments of the microtidal estuaries of SWWA, and the ecological impacts of these changes on estuarine fish communities. Warming of marine and estuarine waters, sustained reductions in rainfall and changes in the timing, location and magnitude of extreme weather events are predicted. These are likely to cause changes in the timing and decreases in the magnitude of river flows; changes to the mouth status of bar-closed estuaries; 'marinisation' and 'tropicalisation' of estuarine waters, including increased hypersalinity in estuaries on the south coast; and changes in the extent, timing and persistence of water column stratification and hypoxia. Such changes are likely to have both positive and negative

effects on the abundance, species richness and community composition of estuarine fish faunas in SWWA, with potential implications for estuarine and nearshore marine fisheries. We highlight the broad relevance of our predictions for many microtidal estuaries in other regions of the world with a Mediterranean climate, and conclude by briefly outlining some possible adaptation responses to the probable effects of climate change on the estuaries of SWWA.

Evidence for poleward range shift in WA endemic *Choerodon rubescens*

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Global warming is changing the environmental and ecological factors that determine a species geographic range, resulting in poleward distribution shifts. Population assessments that evaluate the influence of environmental change across a species' range are therefore needed, particularly for harvested endemic species. We present range-wide density and size structure of baldchin groper (*C. rubescens*), a wrasse endemic to Western Australia (WA) and an important fisheries target. Data were collected via diver operated stereo-video surveys (DOVs) conducted across shallow reefs (<18m) spanning 12° of latitude from tropical to temperate WA, two years after a 2011 marine heat wave. Fish density and length were related to temperature (long-term average 2002-10 and short-term 2011 anomalies), habitat, and other explanatory variables. Both long and short-term temperatures affected *C. rubescens* populations. Highest densities were found slightly towards the warmer end of the species' range (22°C), at the Aboilhos Islands. Unlike adults, juveniles presented higher density towards the colder range edge contradicting expectations of limited recruit survival in colder water. This strong recruitment event towards the colder range edge was coupled with a lack of recruitment at the warmer end. Based on recruit length and estimated age, this latitudinal difference in recruitment corresponds to the 2011 heat wave. The response of *C. rubescens* populations to this short-term extreme temperature event, provides empirical support for models predicting a poleward shift in the species in response to ocean warming. These findings have important implications for the conservation of baldchin groper and the management of its fishery.

The 2011 marine heatwave and tropical fish off SW Australia

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The increasing ocean temperatures and frequency of extreme climatic events that are predicted to continue over coming decades will modify biological communities in shallow coastal environments. Such an extreme event occurred in summer 2010-11, when ocean temperatures up to 4-5°C above average combined with an unseasonal and anomalously strong poleward-flowing Leeuwin Current (LC) triggered a marine heatwave off the west coast of Australia. Above average temperatures and LC flows

persisted over the subsequent two years. Long-term fisheries catch and effort and research monitoring databases, in conjunction with validated web-based 'community' data, were interrogated to determine whether, in shallow coastal waters 30°S , the unusual oceanographic conditions enabled not only the recruitment of tropical fishes, but also their survival and maturation during and following the marine heatwave. While several tropical species were shown to have recruited and over-wintered in 2011 and 2012, only rabbitfish (*Siganus* sp.) was shown to have reproduced $\sim 200\text{--}300$ nm south of its historical southern limits. Long-term 'conventional' fisheries catch and effort data were of limited use in this study because of the targeted nature of most fishing operations. In contrast, the nearshore recruitment survey was able to detect changes in fish communities associated with tropical fish recruitment within the habitat types that are routinely sampled. This study underlines that one-off observations do not alone demonstrate range extensions rather that carefully-designed research programs that collect information on survival, reproduction and recruitment are required to adequately monitor the effects of climate change on fish and associated fisheries.

Climate change increases thermal exposure of freshwater fishes occupying tropical seasonal rivers

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Many organisms, including aquatic species such as fish and crustaceans, temperature directly controls metabolic rate, energy and therefore influences growth, resource allocation for reproduction and ultimately, population size. Evidence shows that growth rates and development in fishes tend to increase with higher temperature up to an optimum, provided there is sufficient food available. Temperature increases beyond this optimum, growth rates slow or cease, and aquatic animals again become susceptible to environmental stresses and, ultimately, lethal effects. Here we undertook laboratory thermal tolerance tests to show that the Inland Freshwater Crab (*Austrothelphusa transversa*) has a mean effects temperature of 35.9°C , after which it has to then search to regulate body core temperature. Using high-time-resolution (20 min) temperature measurements made in seasonal waterholes of northern Queensland, we derived thermal frequency curves to show how often water temperature exceeded this effects threshold. In summer, temperatures near the surfaces of waterholes were often above that suitable for this crab. At the bottom this exceedance occurred less often. An energy-balance model was used to estimate daily mean water temperature and to predict the effects of climate change on waterhole temperature and the change in exceedance of thermal thresholds. In the model, a 2°K climate warming raised waterhole temperature by $\sim 1^{\circ}\text{K}$. However small this increase might seem, it has important consequences, effectively doubling of the length of time water temperatures were in excess of thresholds for this freshwater crab. The implications of climate change on other freshwater fish species will be also explored during this presentation.

Climate Change alters competition between Australian Bass and Mosquito fish

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Stocking is critical to sustaining populations of the recreationally fished Australian Bass (*Macquaria novemaculeata*). Despite this, the competitive interactions newly released fingerlings encounter with existing species are poorly understood even though they may significantly influence the survival and growth of *M. novemaculeata*. Furthermore, no previous studies have examined if these interactions are mediated by key environmental factors, such as salinity and temperature, which is problematic considering their predicated future variability under climate change. We conducted a controlled laboratory experiment in which we examined the relative effects of temperature and salinity on the agonistic interactions of the ubiquitous invasive Eastern Mosquito fish (*Gambusia holbrooki*) and Australian Bass fingerlings (*Macquaria novemaculeata*). We subjected individuals to two levels of salinity (15° and 35°) and temperature (21°C and 28°C), in a multi-factorial design, and scored inter specific aggression. In *G. holbrooki* and *M. novemaculeata* aggression increased with elevated temperature when salinity was low, but not when salinity was high. Although there was no correlation between body size and aggression in *G. holbrooki*, there was a positive correlation in *M. novemaculeata*, with larger individuals more aggressive to hetero-specifics when temperature and salinity were elevated individually, but not when they both high. These results illustrate the complex relationship between species-specific responses to abiotic stress and agonism. They suggest newly released *M. novemaculeata* fingerlings will experience more aggression from *G. holbrooki* in warming inland water bodies where salinity does not increase.

Oral Session 11 – ASFB - 1315 – 1515

Videos, Fish Behaviour

Behavioural interactions between the threatened Australian native fish, *Bidyanus bidyanus* and the non-native, *Gambusia holbrooki*

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Native species around the world are threatened by invasive species. Understanding interactions between these groups is critical for effective mitigation. Eastern gambusia (*Gambusia holbrooki*) are one of the most pervasive and aggressive introduced fish species in Australia. They live sympatrically with threatened native, silver perch (*Bidyanus bidyanus*) where they may compete with juveniles. We investigated interactions, (chases, nips and predation) and habitat use between juvenile silver perch and gambusia using video recorded, aquaria-based experiments. We tested for effects between fish density, species ratio, and habitat provision. A low density treatment (10 fish) was

arranged with ratios of gambusia to silver perch (7:3, 5:5, 3:7). Similarly, a high density treatment (20 fish) was arranged with ratios (14:6, 10:10, 6:14). These combinations were repeated with and without habitat provision, using two size classes of juvenile silver perch to test for the interactive effects of habitat, density, species ratio and size class. We found silver perch to be a competitive species and mostly undeterred by the presence of eastern gambusia. Silver perch outcompeted gambusia across all treatments investigated and there was no evidence of adverse competition effects from gambusia on silver perch. The threatened status of wild silver perch is likely resulting from landscape scale drivers, such as river regulation, as opposed to impacts from gambusia.

Video monitoring of a fish Assemblage in a turbid tropical estuary

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Remote underwater video, established in marine ecosystems, has infiltrated the toolbox of researchers in estuarine and freshwater systems more recently. Arguably, the greatest limiting factor in the application of underwater video for surveying many freshwater and estuarine ecosystems is water clarity. Indeed some systems are perpetually turbid while others are intermittently turbid in response to flow events or tidal fluctuations. We used Baited Remote Underwater Video Stations (BRUVS) to survey the fish assemblage in a turbid tropical estuary on Cape York in northern Australia. Poor water clarity in the upper estuary prevented the identification of fishes that were not close to the baits. In an attempt to address this issue, we tested the attractiveness of two bait types and unbaited camera controls and employed Underwater Dark Channel Prior (UDCP) to enhance image quality and enable more accurate identification of species with a greater degree of certainty. In addition we present the outcomes of deploying a camera within the immediate area of interest of a large estuarine reptile.

A novel stereo-video method to investigate fish-habitat relationships

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Habitat complexity is known to influence the structure of fish assemblages. A number of techniques have been used to measure complexity; however these are usually cumbersome to complete in-situ. This study investigated the utility of a novel method for estimating complexity; whereby habitat height was measured from diver operated stereo-video (stereo-DOV). It was found that this stereo-height method produces comparable estimates to those obtained from other techniques; however, it also tends to underestimate complexity. The stereo-height method was then used in conjunction with visual assessments of relief

to investigate the relationships between fish assemblages and benthic habitat in the Pilbara region of Western Australia. The total abundance and species richness of fish were positively correlated with structural complexity and negatively related to macroalgal cover. The abundance of corallivores and target families also showed similar trends; however no habitat variables strongly predicted the abundance of herbivores. These findings highlight the importance of complex habitats for supporting fish communities in the Pilbara region. Visual estimates of relief were stronger predictors of fish assemblage parameters compared to stereo-height measurements, with the exception of corallivore abundance. Therefore further research is required to improve the efficacy of the stereo-height method. Nevertheless, this study has demonstrated that habitat complexity can be effectively assessed from stereo-video by measuring habitat height and visually assessing relief. This can be applied to a range of habitats without the need for cumbersome in-situ techniques, which will therefore benefit future studies that use stereo-DOVs to investigate fish-habitat relationships.

Monitoring fish movements and behaviour through estuary mouths using high resolution acoustic cameras. Effects of tides, light and urban modification

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Many species of fish move between ocean habitats and sheltered estuarine systems at various stages of their lives, often because estuaries offer critical habitats which are generally not found on open coastlines such as mangroves, marshes or shallow seagrass beds. Ontogenetic patterns of fish movements between oceans and estuaries have been provided by chemical analysis of otoliths, and acoustic telemetry is also highlighting movement patterns of a growing number of species. However, these approaches have not shed any light on the magnitude of fish moving between estuaries and the ocean. Acoustic cameras (DIDSON) overcome this problem as they are able to collect video type footage in turbid conditions, to a range of 20 m, allowing a cross section of an estuary mouth to be continuously observed. We have investigated the magnitude and behaviour of fish moving through a number of estuary mouths, both in Australia and South Africa. Tidal flow has a significant effect on the timing and magnitude of fish passing through mouths, with peaks in fish numbers closely related to the middle of the tide. Additionally, comparisons between spring and neap tide cycles also found tidal amplitude influences the numbers of passing fish. Another project has demonstrated large numbers of fish move into highly modified urban estuaries, despite their degraded catchments, indicating they can still provide important services to marine fish populations. A consistent

feature of these projects was the large numbers of fish regularly moving between estuaries and the ocean, reinstating the high degree of connectivity between oceans and estuaries.

Oral Session 12 – ASFB - 1315 – 1515

Rep. ELH, recruitment

Sexual ontogeny, sperm competition, and sperm performance in the bluehead wrasse

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Sperm competition occurs when sperm from two or more males compete for fertilisation of the same egg or eggs. Biological responses to sperm competition are many and varied, ranging from special structures and behaviours that exclude or remove the sperm of competitors, to increased investment in sperm numbers and motility. In this study, we examine the effects of sperm competition and sexual ontogeny on direct measures of sperm performance in a sequential hermaphrodite fish, *Thalassoma bifasciatum*. We find that sperm performance is affected both by the individual's expectation of sperm competition and by their ontogenetic pathway to male function.

Temporal growth rates of Murray Cod larvae (*Macculochella peelli*) in relation to prey availability

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It is generally accepted that fast growth during the larval stage of fish life history confers a survival advantage, since individuals spend less time at a small size, thus lessening predation risk. To understand growth during this period, a recent review modeled fish growth from 5 to 15 days old for 14 species, finding a significant positive relationship between gut fullness, as carbon concentration, and growth during the larval period. The present study investigated the relationship between the gut carbon of the larvae of the endangered Murray cod (*Macculochella peelli*) and growth rates, obtained from incremental analysis of otoliths, and from the Broken and Ovens rivers. Murray cod employ a feeding strategy where they simultaneously consume yolk and exogenous dietary items allowing them to survive periods where food may be scarce or when densities of prey items are low. During our survey period densities of micro-faunal communities increased both from slope zones to lowland areas and also from spring to summer in both

rivers. By comparing prey items in the gut of Murray cod to micro-faunal communities temporally and spatially we determine if variability in available prey organisms and not carbon content alone impact the growth rates of Larval Cod. This research highlights the importance of larval nutrition and has implications for our understanding of the adult stock structure of Murray cod.

Can computed X-ray tomography reveal otolith growth increments?

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Current techniques for extracting age and growth information from fish otoliths involve laborious preparation, including mounting, sectioning, polishing and imaging before biological information can be extracted. This study aims to determine if modern computed X-ray tomography (CT scan) techniques can be used to examine otolith microstructure in situ, without the need for time consuming preparation. Benefits include virtual otolith sectioning to obtain precise age and growth measurements. Initial results from snapper (*Chrysophrys auratus*) otoliths reveal that growth increments can be discerned in situ. These findings suggest that rapid acquisition of age and growth data from whole otoliths is possible, with considerable implications for both conservation and fisheries management.

Quantify Hydraulic conditions fish encounter passing downstream through river infrastructure

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Many fish species in the Murray-Darling Basin, Australia, are dependent on downstream migration at various life stages; including egg, larval, juvenile or adult. During these migrations fish may be exposed to a host of hydraulic stressors when passing dams, weirs and hydropower facilities. These stressors include mechanical strike, shear forces, and rapid changes in pressure, and when severe, have been shown in the laboratory to cause injury and mortality. But what is the likelihood that fish will be exposed to hydraulic ranges severe enough to cause injury, and which infrastructure types are worse for downstream migrants? Answering such questions is critical for optimising infrastructure design and operation to improve fish passage. To better understand these stressors, hydraulic conditions were measured at a range of weir and hydropower designs within the Murray-Darling Basin using state-of-the-art Sensor Fish technology. Sensor Fish is an autonomous device that can be deployed into extreme hydraulic environments to measure acceleration, rotation, pressure, and temperature. By associating the high-resolution Sensor Fish data with injury and mortality models obtained from laboratory studies, estimations of injury and survival rates were obtained for the range of structures. Estimates such as this can assist managing existing operations and with the design of future infrastructures to reduce or eliminate negative impacts on fish.

The influence of maternal body size on fecundity and egg quality in Dusky flathead (*Platycephalus fuscus*)

Tara Hicks¹, R. Keller Kopf¹, Paul Humphries¹, Peter Nichols²

¹ Charles Sturt University, Albury, Australia

² CSIRO Food, Nutrition & Bioproducts; Oceans & Atmosphere Flagships

The relationships between maternal body size, fecundity and egg quality are important because they contribute to recruitment and population dynamics. This study investigated body size-fecundity and egg quality relationships in dusky flathead (*Platycephalus fuscus*) from the Gippsland Lakes and Mallacoota Inlet in Victoria. Macroscopic and histological examination was used to identify spawning females for fecundity and egg quality estimates. Fecundity and body size was described by a log-linear relationship with estimates ranging from 112,264 eggs in a 323 mm female to 4,793,077 eggs in a 764 mm female. Egg quality was measured using egg diameter, total lipid content, lipid class composition, fatty acid profiles and energy density of ovary tissue. Unlike the 'bigger is better' hypothesis, none of the egg quality measures increased with body size in dusky flathead. This study demonstrates that bigger mothers do not always produce better quality eggs across all species of fish. We discuss why species with a periodic life-history strategy may not always conform to the bigger is better hypothesis.

Don't blame it on the moonlight: Abiotic drivers of reproductive development in greentail prawns, *Metapenaeus bennettiae*

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¹ NSW Department of Primary Industries, Mosman, Australia

² University of New South Wales, Sydney, Australia

Lunar phase is said to be a main abiotic influencer of prawn reproductive development and spawning, but recent research indicates that reproductive development in the greentail prawn, *Metapenaeus bennettiae*, varies more at smaller scales (among days) than at larger scales. Presumably other processes interact with lunar phase to influence reproductive development and spawning. We found that, when considered alongside salinity, turbidity and water temperature, lunar phase had a significant independent or interactive influence on the reproductive development of female and male prawns respectively. Salinity and turbidity also had a significant influence on whether or not a female prawn was ripe. Significant interactions reported for the males indicate situations where salinity and turbidity have inconsistent effects among the different lunar phases. Reproductive timing and spawning success of *M. bennettiae*, and potentially any species with high temporal variability in reproduction, is dependent on not only lunar phase but a number of different abiotic variables.

Reproductive characteristics of Teraglin, *Atractoscion aequidens*, Off the coast of NSW

Anne-Marie Hegarty^{1,2}, William Gladstone², John Stewart¹

¹ NSW Department of Primary Industries, Australia

² University of Technology, Sydney

Teraglin (*Atractoscion aequidens*, family Sciaenidae) is found in eastern Australian waters from southern Queensland to Montague Island. In NSW, teraglin are targeted by the Ocean Trap and Line commercial fishery and significant numbers are also taken by recreational fishers. To date, there has been no detailed study on the life history characteristics and population dynamics of the species in NSW. This study, currently underway, will describe the geographical and temporal variation within NSW in age, growth, and reproductive characteristics and compare these to southern Queensland and South Africa. The results so far have shown that *A. aequidens* is an asynchronous batch spawner with indeterminate spawning. Batch fecundity estimates ranged from 32, 431 (+/- 2,370) for a 43 cm fish to 673,813 (+/-2,929) for a 71.5 cm fish. Pooled monthly gonadosomatic index values averaged over the sampling period of January 2011 to June 2012 indicate reproductive activity for most of the year for both sexes. This is unusual for sciaenids, which typically display spring-summer spawning over 3 months of the year. Macroscopic and microscopic staging of gonads validated the occurrence of a prolonged spawning season. Preliminary analysis indicates the size at which 50% of the population matures for females is 35 cm fork length (FL) and 30 cm FL for males. In South Africa, the same species matures at 90 cm FL and 5 years of age, much larger and older than in NSW. The results of the study will be important for future fishery assessments and effective long-term management.

Oral Session 13 – ISSESr - 1545 – 1630

Stock enh as a comp fish management tool

The pathway from research on lobster translocation into a commercial enhancement enterprise

Bridget Green¹, **Caleb Gardner¹**, Klaas Hartmann¹

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Translocation of Southern Rock Lobster (*Jasus edwardsii*) involves capturing and moving lobsters between areas and has been explored in the Tasmanian fishery for decades. Lobsters in some areas are slow growing and can be captured in large numbers. These are then moved to areas with faster growth and released, achieving gains in production of around eight-fold. There were numerous concerns around this exercise which have been explored in a range of research projects including possible risk of disease transfer, economic feasibility, effects on egg

production, ecological changes in source and release areas, and change to market traits of translocated lobsters. Operations have gradually transited from small research scale operations to commercial scale operations that now increase production in the fishery by around 50 tonnes or 5%. This is fully funded by the commercial sector and provides a return on investment of around 700% each year. Although the case for investment in this exercise seems clear, the pathway to adoption of this novel approach has not been smooth with much debate amongst industry. As a result the current operations are currently well below the full potential. The project provides insight into successfully managing change by co-management with a large group of commercial fishers.

Notes

Tuesday 13 October

Keynote MDB NFF – 0845 - 0930

Does the natural flow paradigm need a rethink?

Martin Mallen-Cooper¹, Brenton Zampatti²

*1 Fishway Consulting Services, Sydney, Australia
2 South Australian Research and Development Institute - Aquatic Sciences, Urrbrae, Australia*

The natural flow paradigm (Poff et al. 1997) dominates thinking in river rehabilitation. Restoring the natural hydrological regime, to re-establish riverine/floodplain processes, habitats and biodiversity, has an intuitive logic and appeal. Consequently modelling of natural flow (i.e. discharge) is a pervasive method of quantifying impacts of flow regulation and guiding flow restoration. In applying the natural flow paradigm, practitioners primarily consider reinstating natural patterns of hydrology but ultimately ecological processes are driven by hydrodynamics - the variation in water velocity, depth, and turbulence - and connectivity, both of which are determined by the physical template of the river (i.e. channel morphology, substrate and artificial structures such as weirs). In highly modified rivers where the physical template has substantially changed, using the natural flow regime as a reference underestimates loss of ecological function and leads to inappropriate flow recommendations. The natural flow paradigm also inadvertently leads to spatial fragmentation of environmental flow objectives, so that river reaches, floodplains and wetlands are often managed as separate units. The approach is a practical response to finite water availability but further recognition is needed of the value of connectivity of flow and that riverine processes and life histories of biota (including metapopulations) occur over large spatial scales (e.g. 100s - 1000s km). In Australia, the natural flow paradigm needs to more explicitly incorporate hydrodynamics, longitudinal and lateral integrity of flow, and spatial scale. This will promote the restoration of ecological processes, promote more effective use of environmental water and create new opportunities for river rehabilitation.

Keynote– 0845 - 0930

How can we evaluate the social contribution of fisheries?

Kate Barclay¹

1 University of Technology Sydney, Australia

Over recent decades it has become widely accepted that managing coastal and marine resources means managing people's behaviour, and so social and economic understandings are important as well as biological knowledge. We have struggled, however, with effectively integrating social, economic and biological knowledge into effective decision- and policy-making. Some progress has been made with marine resource economics and bio-economic methods, but research into the social aspects of resource management lags behind. There is no systematic collection of data on important social aspects of coastal and marine resources and environments. Many of these aspects can only be evaluated in a qualitative manner, which is difficult to integrate with quantitative biological and

economic methods. In this presentation I will give an overview of the state of the field in evaluation of the social aspects of fisheries internationally, and give examples from some ongoing projects in New South Wales, Indonesia and the Maldives. There are important differences between wealthy country and developing country contexts. In Australia conflict between commercial seafood production and recreational users of coastal waters looms high on the agenda. In Indonesia and the Maldives the economic development of coastal communities through seafood production is a pressing priority. There are also similarities, however, with tensions between small-scale community-based fisheries and industrial-scale operations and between seafood production and tourism arising in all three countries. The presentation will focus on how we do social evaluations, what knowledge exists in this area, and how we go about generating knowledge that does not already exist.

MDB NFF 1 – 0930 – 1020

Environment flows and fish: Setting targets and making predictions.

John Koehn¹, Heleena Bamford², Ivor Stuart³, Charles Todd¹, Brenton Zampatti

*1 ARIER, Melbourne, Australia
2 MDBA, Canberra, Australia
3 Kingfisher Research, Melbourne, Australia
4 SaRDI, Adelaide, Australia*

Environmental flows are a key component of river rehabilitation and have great potential to benefit native fishes. To maximize environmental outcomes, water management plans should set environmental objectives based on the best available knowledge and science. Ideally, this would involve development of conceptual models, analyses of existing data sets and be complemented by predictive modelling. Nevertheless, short time-frames for the development of water management plans frequently inhibit this process, making the comprehensive incorporation of contemporary science difficult. This scenario arose during the development of the Basin-wide Environmental Watering Strategy for the Murray-Darling Basin (MDB). This paper outlines the approach used to develop Quantifiable Environmental Outcomes (QEOs) for fish in the MDB. This approach integrated contemporary science with expert opinion and considered some generic aspects of fish ecology as potential objectives for restoration: 1) distribution and abundance of species (the fish community and threatened species); 2) distribution, extent and quality of habitats; 3) habitat connectivity and water quality; 4) spawning and recruitment; 5) facilitating movement; and 6) ecosystem processes (e.g. resilience, connectivity, productivity). These QEOs are supported by a range of priority strategies for water management and other complementary rehabilitation actions were also suggested to maximize ecological outcomes. The next step in this process is to develop populations models that can be used to forecast and compare the potential changes in fish abundances as a result of a range of flow management scenarios. Model development for eight freshwater species (Murray cod, trout cod; golden, silver and Macquarie perch, olive perchlet, southern pygmy perch and Murray hardyhead) has been initiated.

Disparate responses of invasive and native fishes to engineered floodplain inundation and natural flooding

Brenton Zampatti¹, Chris Bice¹

1 SARDI - Aquatic Sciences, Adelaide, Australia

In Australia's Murray-Darling Basin (MDB), river regulation is considered a primary cause of declines in native fish populations whilst concurrently facilitating the proliferation of invasive carp. River regulation has also caused declines in floodplain overstorey vegetation; nevertheless, in an attempt to improve vegetation health in the southern MDB, further regulation in the form of weirs, levees and pumping is being trailed in an unprecedented ecological experiment. This approach decouples floodplain inundation from the riverine hydrograph and creates large areas of lentic habitat, which presents risks for native fish whilst potentially facilitating carp recruitment. During spring 2014, a 3 m high, 79 m wide regulator on Chowilla Creek in the lower River Murray was used to inundate ~3,000 hectares of floodplain during relatively low river flows (max. 10,000 ML/d). We compare fish assemblages in ephemeral floodplain habitats between engineered floodplain inundation and a natural overbank flood (discharge = 90,000 ML/d). During the natural flood, eight native and five invasive species were sampled, small-bodied native fishes (e.g. carp gudgeon) and bony herring were numerically abundant, and carp represented 1% of the catch. During engineered floodplain inundation, 4 native and 4 invasive species were sampled, native fishes were rare and young-of-the-year carp comprised 97% of the catch. Our results support the notion that engineered floodplain inundation may benefit carp at the expense of native fishes. In light of multiple floodplain regulators proposed for the southern MDB, the implications of enhanced carp recruitment on floodplain ecosystem processes and regional carp population dynamics require further consideration.

Keynote – 0930 – 1015

Increasing production in fully exploited fisheries

Caleb Gardner¹

1 Institute for Marine and Antarctic Studies, University of Tasmania, Australia

Australia's fisheries tend to be described as 'fully exploited', which is interpreted as meaning they are at their peak of both production and economic yield. This label fails to recognise that there are usually opportunities to improve both yield and value of these fisheries through changes in management systems, and that these opportunities are often substantial. A consequence of labeling fisheries as 'fully exploited' is that opportunities to improve performance and community benefit don't receive the attention they deserve. At a basic level, fisheries regulations such as size limits and seasonal controls of many Australian fisheries were established with limited data and have remained unchanged for decades. Basic regulations were rarely established with any consideration of their impacts on yield, other than coarse-level prevention of recruitment overfishing. Bioeconomic modelling has been used to examine regulations in several of our larger 'fully

exploited' fisheries. Where these models have been built, it's typically been easy to show substantial opportunities for gains, especially through adjustments to harvest rates. Fisheries are generally variable spatially and temporally so harvest strategies that are responsive to this variation can further improve performance. The many variants of stock enhancement of wild fisheries artificially increase and stabilise recruitment to increase performance above what could be achieved from natural recruitment. Outcomes of enhancement are affected by existing controls for fisheries so enhancement faces the same issue of a performance gap between current production and what is possible.

MDB NFF 2 – 1045 – 1230

Queensland Flood Recovery - rough and bumpy rivers

Greg Ringwood¹

1 River Health and Habitat Restoration

Since the millennium drought the Condamine Catchment has experienced five flood events. These floods caused localised and widespread flood damage. The 2011 and 2013 major flood events were so severe, flood recovery programs to aid agriculture recovery were required. The 2013 flood recovery program was aimed at restoring productivity and building resilience against future extreme weather events. This is the data and experience from the Glengallan and Swan Creeks Ex cyclone Oswald 2013 flood recovery program and the value of riparian vegetation. As part of the flood recovery the estimated cost of fixing the flood damage and lost productivity was recorded utilising a specialist team and each landholder. The average cost of the damage and lost productivity across this program was \$683 per ha and \$50k per Km creek frontage and even higher across the floodplain properties. Across the floodplain there were a number of properties for which the estimated cost of damage and lost productivity was much lower. The common factor on these properties was the presence of riparian vegetation. The three least affected floodplain properties estimated damage and lost productivity (\$211 per ha and \$13.3k per km of creek frontage) or around one third of the damage across the whole program. The riparian vegetation on these sites was in good condition and it played an important role in slowing the water velocity down along the creek and also slowing the water down entering the floodplain and exiting the floodplain and therefore across the floodplain.

Fish and strips: A case where less is more

Andrew Norris¹, **Michael Hutchison¹**, Greg Ringwood², Kevin Graham

1 Queensland Department of Agriculture and Fisheries, Queensland, Australia

2 River Health and Habitat Restoration

Rehabilitation efforts in Myall Creek through the town of Dalby have led to significant improvements in native fish populations and waterway health. A number of intervention activities have been undertaken at this site; however the establishment of an unmown bankside buffer has provided the greatest benefit, especially for smaller native fish. Over the last 18 months there has been a significant, ongoing

improvement in the quantity and variety of aquatic vegetation in Myall Creek. Leaving a one metre unmown buffer strip has resulted in bank-side grasses, sedges, emergents and other low vegetation becoming much more prominent in sections of the creek, as well as a 10-fold increase in the number of native tree saplings. The improvement in aquatic vegetation has coincided with significant increases in native species richness and the abundance of carp gudgeons, bony bream, Murray-Darling rainbowfish, unspotted hardyheads and two species of catfish over this time. The total fish abundance in Myall Creek has improved almost 100-fold and is now similar to that observed at more pristine sites. These increases have occurred despite a substantial fish kill and it is thought that the new vegetation helped buffer many of the smaller fish against the poor water quality. The process of leaving a buffer zone has reduced the local council's labour for parks maintenance and according to many local residents increased the aesthetic values of the area. The results of this project are easy to apply and applicable to many other waterways which suffer from urban impacts.

Prioritising instream woody habitat restoration for fish across Victoria: Case studies, knowledge gaps and future direction

Zeb Tonkin¹

1 Arthur Rylah Institute, Applied Aquatic Ecology, Department of Environment, Land, Water and Planning, Heidelberg, Australia

In-stream habitats are highly valued, broadly, because of their contribution to catchment health, biodiversity and supporting self-sustaining fish populations. There is increasing interest and investment in managing instream habitat, particularly improving instream woody habitat (IWH) for which there has been major reductions in Victorian Rivers. Directing effective IWH rehabilitation works requires knowledge of the types, pathways and scales of ecological responses that can be expected from such interventions. With a priority objective of IWH programs being an increased abundance and diversity of fish populations, waterway managers require specific guidance on IWH restoration approaches to maximise the benefits to a region's fish community for a given investment. Unfortunately, information on defining management objectives, where to target resources and how to undertake works is limited. This paper outlines the current conceptual understanding between IWH, system drivers and fish populations and; presents a series of Victorian case studies where IWH has been restored for the purpose of enhancing fish populations. We use these examples to identify key knowledge gaps and limitations of past approaches and how these are being addressed in an existing state-wide research project aimed at providing waterway managers with a tool to prioritise and refine IWH restoration practices across the state.

Recreational fishers leading fish habitat rehabilitation

Matt Miles¹, Matt Hansen²

1 Inland Waters Rejuvenation Association (IWRA), Dubbo, Australia

2 NSW DPI, Fisheries - Aquatic Habitat Rehabilitation, Dubbo, Australia

Recreational fishing groups undertake numerous projects to enhance native fish populations across New South Wales. These projects generally focus on replenishing fish stocks by restocking. Public understanding and opinions on river health, and how to improve it, can vary greatly from community to community. Recreational fishers have the potential to play a crucial role in the rehabilitation and conservation of aquatic ecosystems. In recent years some recreational fishing groups in the Macquarie River Catchment have shifted their focus to enhancing fish stocks by rehabilitating aquatic habitats. Groups such as the Inland Waters Rejuvenation Association (IWRA) and Yeoval Fishing Club have completed a range of habitat rehabilitation projects including resnagging, barrier remediation and riparian habitat management. Through the IWRA's Making Fish Happen in the Macquarie project, the availability of woody habitat has increased through the placement of 72 snags in the Macquarie River between Wellington and Dubbo. The IWRA has secured additional funding to place up to 60 snags in the Macquarie River between Dubbo and Narromine. Yeoval Fishing Club's Keeping Big Fish Moving in the Little River project has restored fish passage to 96km of habitat through the remediation of two barriers on the Little River. They are continuing to improve fish habitat through the control of invasive weeds in the Little River Catchment. Projects from these organisations have also had educational components that help increase awareness of fish and their habitat requirements. The outcomes achieved by these groups demonstrate what recreational fishers can do to improve aquatic ecosystems.

Oral Session 16 – ASFB – 1045 – 1230

Prod & Prof Fish

Formal harvest strategies and fishery status reporting

Malcolm Haddon¹

1 CSIRO Oceans and Atmosphere, Australia

When fully implemented, formal harvest strategies should define and document the process of how particular fisheries are managed, but they do not do this all by themselves. Fisheries management revolves around the determination of each stock's status relative to each fishery's pre-determined objectives, so the first step is to make those objectives explicit, which is generally done using biological reference points. Each harvest strategy can be thought of as part of operationalizing the chosen objectives. The expansion and adoption of the 'Status of Key Australian Fish Stocks' (SAFS) initiative has increased the pressure on fishery managers to use harvest strategies and to place more of the details of management in the more easily accessible public domain. The pressure to be open has been increased by the growth of consumer awareness of, and their expressed wish for, sustainably

produced sea-food; the so-called social licence to operate. All of this means that a defensible and credible fisheries management regime can enhance and protect both the fish stocks themselves as well as the markets on which the business of fisheries depends. However, harvest strategies and status reporting can be implemented in such a way that they fail to provide either an effective, a defensible, or a credible fisheries management regime. This talk will describe these different issues and potential positives and potential pit-falls.

Simulating harvest control under the new management framework of Patagonian Toothfish in Chile

Juan Carlos Quiroz¹, Caleb Gardner¹, Klaas Hartmann, Paul Burch, Philippe Ziegler, Dirk Welsford

1 Institute for Marine and Antarctic Studies (IMAS), University of Tasmania, Australia

2 Australian Antarctic Division (AAD), Kinston, Australia

Since 2014, Chile has embarked on a process oriented to establish explicit and quantitative management objectives for exploited species. Although over 23 fish stocks being managed with explicit target and limit references points emanating from this process, these are often not linked to formal harvest control rules (HCR) and quantitative management objectives that take uncertainty into account. Patagonian Toothfish (*Dissostichus eleginoides*) is one stock that is assessed as overexploited and a rebuilding plan is required. We propose that such a plan include appropriate HCRs and a risk analysis for candidate management objectives. Using reference points established in 2014, we examined the performance of fishing mortality based (F-based) and catch based (C-based) HCRs, and the trade-offs between several performance measures associated with management objectives for Patagonian Toothfish. An equilibrium age-structured operating model was developed to simulate fishery strategies under six alternative HCRs, conditioned on recent fishery parameters (e.g. selectivity) and life-history traits. Projected spawning biomass and limit catch show that F-based HCRs have a lower catch variability and move the stock closer to target reference points than C-based HCRs. Incorporating several uncertainties that impact the performance of HCRs, such as recruitment process error, catch implementation error and estimation error, suggest that recruitment variability and productivity (i.e. steepness) have the greatest effect on the ability to meet explicit management objectives (e.g. $SB > 0.4 \cdot SB_0$, at $P > 0.8$). All HCRs tested in this study performed better than the currently implemented fishery strategy of a 'constant F' that leads to a 40% depletion on spawning biomass.

The spatial extent of western gemfish stocks

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2 Molecular Fisheries Laboratory, School of Biomedical Sciences, The University of Queensland, Australia

Adequate management strategies based on the biology and ecology of biological stocks are required to underpin sustainable management of fisheries resources. Gemfish (*Rexea solandri*) have had a long exploitation history in eastern and southern Australia. Here we present outcomes of molecular and demographic analyses to determine the spatial extent of the gemfish stock in the Great Australian Bight and Bass Strait. These gemfish populations, referred to as the western stock of gemfish are caught in two jurisdictions: the Great Australian Bight Trawl Sector and the Commonwealth Trawl Sector of the Southern and Eastern Scalefish and Shark Fishery. Eastern Australian stocks of gemfish were heavily exploited in the past with peak catches approximately 20 times greater than western stock. This high level of exploitation in the eastern stock resulted in a reduction of spawning biomass to below the harvest strategy policy limit of 20% of unfished biomass. While targeted fishing for eastern gemfish ceased in 1998, recovery has not ensued. The western stock is managed via total allowable catch in one sector, and by catch triggers in the other. Stakeholders and researchers have been cooperating to collect new information on the western stock to ensure harvest arrangements will result in sustainable and profitable exploitation. Data has been collected to test the expectation of a continuous stock from the western Bight to Bass Strait as predicted by the life history of the species, which includes dispersal of eggs and larvae in prevailing currents away from spawning aggregations.

Testing new boundaries: Efficient assessment of a complex harvest strategy for a MSC accredited prawn fishery

Annabel Jones¹, Simon Clark², Craig Noell³

1 Primary Industries and Regions South Australia, Adelaide, Australia

2 Spencer Gulf and West Coast Prawn Fishermen's Association, Port Lincoln, Australia

3 South Australian Research and Development Institute, Adelaide, Australia

The South Australian Spencer Gulf Prawn Fishery is world leading for sustainable practices and is the first trawl fishery in the Southern Hemisphere to attain Marine Stewardship Council accreditation. As a commercial fishery, it is important that the ecological sustainability is balanced with economic viability presenting challenges for management. Management arrangements for the fishery that control where and when fishers can fish on a day-to-day basis have been developed by the fishers over several decades, and have evolved to be effective in maintaining stocks at sustainable levels. This complex management framework is now described in a formal harvest strategy in the management plan for the fishery. A review of the harvest strategy in 2013 led to a request to consider increased flexibility in arrangements to provide flexibility in fishing operations. The request was to allow for increased flexibility in the area fishers could operate offset with more stringent arrangements on fishing trigger limits. The challenge for the managers and the fishery was to demonstrate that the proposed arrangements were relatively as ecologically conservative with previous management arrangements. A retrospective analysis of the fishery's data under the new

and old harvest strategies demonstrated that the increased fishing area allowed for under the new arrangements was adequately offset by more stringent trigger criteria that controlled the number of fishing nights in the fishery. The new harvest strategy was therefore accepted in 2014 as the guiding framework for the fishery and has been demonstrated to meet ecologically sustainable development objectives.

Empowering industry to maximise fish size and quality in the South Australian Sardine Fishery

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2 South Australian Sardine Industry Association

This project was designed 1) to empower the South Australian Sardine Fishery to autonomously manage the size and quality of fish harvested; 2) to distinguish and predict the habitat preferences of adult and juvenile sardines; and 3) to predict sardine spawning habitat. The system includes a custom-built electronic measuring board linked to a database that includes the location, catch quantum (nearest t) and size of fish taken (nearest mm). The database is linked to GIS software that produces maps showing the distribution of target and non-target sized fish. This information is used in near real-time by industry to optimize the size of fish harvested. Generalised additive models were developed that have an acceptable ability to predict the presence/absence of juvenile (85%), and adult (72%) sardines. Adults occur mostly in waters 40-85 m deep with SSTs from 17.5-21°C and low to intermediate chl a concentrations, whereas juveniles occur in depths of <35 m, SST of <17°C or >22°C and very low or very high chl a concentrations. A full model including depth, SST, surface salinity, surface chl-a and depth of the chlorophyll maximum (DCM) predicted spawning habitat with a cross validation accuracy averaged across all years of 71%. An operation model restricted to factors readily available from bathymetric and satellite information (i.e. depth, SST and chl a) had a slightly lower predictive capacity (68%). The ability to predict the spawning habitat will help to ensure that future surveys include all areas likely support high densities of sardine eggs.

Inter-annual Variability In Blue Swimmer Crab (*Portunus armatus*) Distribution in South Australia: Implications for monitoring

Crystal Beckmann¹, Graham Hooper¹, Stephen Mayfield¹

1 SARDI Aquatic Sciences, West Beach, SA, Australia

Commercial effort in the South Australian blue swimmer crab (*Portunus armatus*) fishery is managed through individually transferable quota with separate units allocated in the Spencer Gulf and Gulf St Vincent fishing zones. The Spencer Gulf zone appears to support a substantial biomass of blue swimmer crabs, however, reduced commercial catch and decreasing fishery-independent survey catch rates were observed in Gulf St Vincent during 2011-2013. Annual fishery-independent surveys

undertaken since 2002 in Gulf St Vincent have demonstrated large variations in the spatial distribution of crabs driven by a high proportion of zero catches in low-density areas. Given the relatively small scale of the South Australian blue crab fishery, the costs and limitations of undertaking fishery-independent surveys need to be managed. Currently, surveys are undertaken at a significant cost to industry, particularly where legal-size abundance is variable and the sale of crabs is not always equitable to the cost of running the survey. Our evaluation of the survey design resulted in a reduction in the number of sites that consistently returned low abundances of crabs and that added little value to the stock assessment. The resulting decrease in survey duration may allow for additional surveys to increase temporal coverage (e.g. two surveys per year). The survey design would, however, need to be periodically evaluated to ensure sampling sites are reflective of current distribution.

Applying EBFM in Western Australia: developing resource management strategies and harvest control rules that incorporate social, economic and sectoral allocation objectives

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1 Department of Fisheries, Western Australia, Australia

To efficiently implement a regional level, risk-based Ecosystem Based Fisheries Management (EBFM) approach in Western Australia, revised legislation is currently being adopted that includes the ability to create Aquatic Resource Management Strategies (ARMS). These strategies operate at the resource level, rather than at the activity or fishery level and establish the overall objectives (ecological, social and economic) to be achieved by the coordinated management of all relevant fishing activities. In this context, the harvest control rules that are developed to deliver these coordinated outcomes must transparently and consistently determine the appropriate harvest levels (catch &/or effort) for each season by each fishing sector given the current circumstances to meet the ecological, sectoral allocation and, where relevant, any economic and social objectives established for the resource. The presentation will outline how this new management system will operate and the series of refinements that have enabled the practical application of harvest strategies for EBFM. It will also discuss how the state's MSC certification initiative helped drive formal implementation of harvest strategies and fine tune the harvest strategy policy.

Oral Session 17 – ASFB - 1045 – 1230

Climate Change & Rep. ELH, recruitment

Thermal limits of Northern Australian freshwater fishes

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In northern Australia, fish may be threatened by increasing water temperatures, as species at lower latitudes generally

live close to their maximum thermal limit. In addition, northern Australia is home to many freshwater fishes with small geographic ranges. These range-restricted species may have narrower thermal niches compared to co-occurring conspecifics with large geographic ranges. With water temperatures in northern Australia expected to increase as a result of climate change, these range-restricted species may be vulnerable to extinction. Using two species pairings from the genera *Melanotaenia* and *Syncomistes* that co-occur in the Drysdale River, we established thermal performances of range restricted and widespread species using flow respirometry. First, we performed a temperature ramping experiment to investigate the resting metabolic rate at increasing water temperatures in each species. Second, we ran aerobic scope experiments to determine resting and maximum metabolic performance at two temperatures, representing the current and potential future maximum (late dry season) water temperatures these species experience. Thermal performances clearly differed between widespread and range restricted species pairings. Both range restricted and widespread species occur in water temperatures close to their maximum thermal limit and as a result may be vulnerable to climate change. If species are unable to adapt to increased water temperatures or exploit thermal refuges, many species of freshwater fish in northern Australia may be vulnerable to extinction as a result of anthropogenic climate change.

Implications of Climate Change on Aestivating Fishes

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The Salamanderfish, *Lepidogalaxias salamandroides*, and Black-stripe Minnow, *Galaxiella nigrostriata*, are aestivating fishes endemic to the south-western most corner of Australia; a region that is projected to continue to undergo considerable drying due to climate change. This study aimed to assess the current conservation status of these species and determine the key physicochemical and hydrological variables associated with their distributions to help project future viabilities under hydrological change scenarios. Of the 53 sites surveyed, 39 historically contained *L. salamandroides* and 28 historically were occupied by *G. nigrostriata*. Of these only 26 currently contained *L. salamandroides* (66.67% of their historical distribution) and 20 contained *G. nigrostriata* (71.43% of their historical distribution). Both species were absent from the four eastern-most sites sampled which may represent a range retraction for both species. Historical sites were predominantly ephemeral, acidic (pH) (mean 4.77 (± 0.12 SE)) wetlands of low salinity (mg/L) (mean 0.23 (± 0.01 SE)) and shallow (<1m) depth to groundwater. Depth of sites in winter and length of the annual dry period were identified as variables of importance for *L. salamandroides*, with connectivity a key variable of importance for *G. nigrostriata*. As groundwater models project that the water table within this region will decrease by up to 4 m by 2030, further population losses may be expected. This research has considerable implications for future management of these aquatic ecosystems to help ensure survival of these enigmatic species in light of projected climatically driven hydrological change and novel approaches may be

necessary to help ensure their survival.

Reproductive performance is influenced by the thermal environment experienced in present and previous generations

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Predicting the impacts of climate change to biological systems relies on an understanding of the ability for species to acclimate to the projected environmental change through phenotypic plasticity. Determining the effects of higher temperatures on individual performance is made more complex by the potential for environmental conditions experienced in previous and current generations to independently affect phenotypic responses to high temperatures. We used a model coral reef fish to investigate the influence of thermal conditions experienced by mature pairs and their parents to affect reproductive output and the quality of offspring produced. We observed an interaction in the effect that developmental and reproductive thermal conditions had on reproductive and offspring attributes. When both the current and previous generation developed at +3.0°C greater than present-day there were impacts to reproductive performance of adults and the phenotypic attributes of their offspring, even when breeding occurred in normal thermal conditions. However, this affect was not observed when two generations were maintained at conditions +1.5°C greater than present-day. Our results suggest that transgenerational effects differ depending on the absolute thermal change and during what life stage the thermal change is experienced.

Using Redmap data as an early warning system for changes occurring in the marine environment: the value of community engagement through citizen science

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Shifts in species' ranges are a frequently reported and globally ubiquitous impact of climate change, with rates of movement being particularly high in the sea. Early indication of which species are potentially extending their ranges can provide useful guidance for managers regarding investments in impact assessment, monitoring, or potential management intervention. Participants in citizen science projects have the capacity to record observations of their

environment with precision and accuracy. Redmap (Range Extension Database and Mapping project, www.redmap.org.au), invites Australians to submit photographs and data about unusual observations of marine species made while undertaking marine activities. A distributed data verification system uses 'managed crowdsourcing' of scientists for data verification and processing of submitted observations. Therefore, Redmap can potentially generate significant amounts of previously unavailable data for researchers, while engaging the communities in climate science (using their own data). Using three years of data from Redmap and building on methods used in the early detection of invasive species, we developed a cost-effective and rapid screening assessment tool to classify levels of confidence in potential range extensions for a variety of marine species. From our assessment of 47 species, eight were classified with 'high' confidence as potentially extending their ranges. The 'high' confidence classification of these species suggests they are worthy of prioritisation when investigating potential ecosystem impacts. As such Redmap is an early warning system for changes occurring in the marine environment, and has the potential to play a pivotal role in informing management decisions and actions.

Fine-scale vertical distribution of black bream *Acanthopagrus butcheri* larvae explains poor recruitment in the Blackwood River Estuary

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The black bream *Acanthopagrus butcheri* is an important recreational fish species in the estuaries of temperate Australia and contributes to the commercial fishery in some of these systems. As this species completes its life cycle within its natal estuary, the stock of this species in any given system is particularly susceptible to overfishing and other anthropogenic effects. There is evidence that over the past three decades there has been a marked decline in black bream stocks in the Blackwood River and this is often attributed to fishing pressures. However, there has also been a significant decline in freshwater discharge over the same time period. This study investigates the link between the distribution of black bream eggs, larvae and various environmental factors that could explain the reduction in recruitment. We used a plankton net to sample the ichthyofauna at ten sites, during day and night, at 1 m depth intervals. Black bream eggs were distributed throughout the mid-water column along the length of the salt-wedge. In contrast, the greatest concentrations of larvae occurred at water depths >3 m that were hypoxic. We explore the possible reasons, including water clarity, prey availability and feeding competition, as to why larvae are moving to the deeper, less favourable, hypoxic waters. This movement of larvae into deeper hypoxic waters as a result of declining freshwater discharge must presumably lead to mortality among the larval assemblage. It is proposed that the above movements contributed to the decline in the abundance of black bream in the Blackwood River Estuary.

Vertical distribution of temperate reef fish larvae off NSW

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Little is known about the ontogenetic vertical migration of temperate reef fish larvae. Most studies have focused on tropical coral reef fishes, which show a downward trend in the water column with developmental stage. The aim of this experiment was to investigate if similar ontogenetic vertical migration patterns also occur for temperate reef fishes of NSW. The vertical distribution of temperate reef fish larvae were sampled using EZ Net tows. Each tow was constrained to the top 100m of the water column. Tows were conducted within frontal eddies and along the continental shelf over a two week period. Larval fish were identified to the lowest taxonomic level possible, their length measured and classified as either pre-flexion, flexion or post-flexion based on their developmental stage. Statistical analyses were conducted to determine if there was a pattern of downward vertical migration with developmental age. Stage-specific depth distributions were complex and species specific. These results have implications for our understanding of the biological drivers of connectivity patterns in temperate reef fishes and can be used to parameterise biophysical connectivity models.

Oral Session 18 – ISSES - 1045 – 1230

Evaluating Outcomes

Evolution of marine stock enhancement in Florida, USA

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The Florida legislature initiated a marine stock enhancement program in 1985, which resulted in a partnership dedicated to this effort involving the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute (FWRI) and Mote Marine Lab (MML). The initial focus of the partnership was on replenishing depleted common snook populations in South Florida. But common snook aquaculture production technology proved to be more difficult than anticipated and the target species shifted from snook to red drum, for which ample production techniques exist. Thus, FWRI initiated stocking trials with red drum, whereas MML launched efforts to develop snook aquaculture production technology. Pilot studies to evaluate red drum release strategies began in 1988. Following those initial studies, the program began to focus on large-scale releases of small juvenile red drum into Biscayne Bay to establish a red drum fishery there. However, stocking experiments in Biscayne Bay revealed limited availability of sufficient nursery habitat to support small juveniles and the program's efforts were transferred to Tampa Bay, where red drum thrive. To evaluate the potential of red drum stocking to increase the recreational fishery catch in Tampa Bay, pilot release experiments were launched in 2000 to develop release strategies for a large-scale 'test of concept'. Five years of pilot releases in Tampa Bay identified release habitats for optimizing the survival of small juveniles and revealed major differences in performance of stocked juveniles based on release site.

Hatchery source water quality issues, logistics and economic factors eventually curtailed moving forward with the large-scale 'test of concept' stocking of red drum in Tampa Bay, and the program began to focus on developing intensive rearing systems and preparations for relocation of the FWRI hatchery. Parallel to the FWRI research on the effectiveness of red drum stocking, MML researchers launched pilot releases of common snook in 1997 in Sarasota Bay, and with red snapper in 2000 on offshore artificial reefs. After several years of red snapper pilot release experiments, funding limitations prevented continuation of this research in Florida. Release experiments with common snook showed good potential for restocking to be successful (eg., following environmental stresses that periodically can greatly reduce snook spawning stock biomass locally). Owing to the positive results from snook pilot release experiments, MML shifted research efforts with common snook out of the field work to join in research at MML to develop snook mass-production technology needed for a larger-scale 'test of concept'. Quantitative fisheries assessment and modeling expertise was brought into Florida enhancement research in 2007, initially through a MML-Florida State University partnership endowment and since 2010, through establishment of a research group at the University of Florida. This has enabled assessment of snook and redfish enhancement strategies from a fisheries management perspective, taking account of stock dynamics and likely angler effort responses and evaluating tradeoffs and synergies between the goals of achieving angler satisfaction as well as stock conservation in the face of growing recreational fishing pressure.

Evaluation of stocking effectiveness of Tiger Puffer

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The Tiger puffer *Takifugu rubripes* has a high market value and strong market demand in Japan. This species, distributed in the northwestern Pacific Ocean, might include local groups that populate the sea around Japan. The Ise-Mikawa Bay stock in the Tokai region is a new fishery resource that became available around 1975. The catch exceeded 400 tons in the bumper year of 1989. The importance of this stock has increased. The stock size fluctuates considerably, mainly because of the effect of dominant year classes that cause fluctuation of recruitment. Since the 1980s, hatchery-reared puffer have been released in an effort to stabilize the catch. To assess stock enhancement success, we developed an efficient and low-cost method for detecting released puffer. Using this method, we estimate that approximately 30,000 hatchery-reared juveniles can recruit into the Ise-Mikawa Bay population annually. The ratio of released puffer in the catch has fluctuated considerably, ranging from 2% to

56%, depending on the wild recruit size. The ratio of released puffer in the catch was estimated as approximately 50% when the recruitment of wild juveniles was low during 2011 and 2012. Our assessment showed that the release of puffer was effective for stabilization of the catch.

Evaluation of fish quality and microhabitat for release in the hatchery-reared tiger puffer juveniles

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Tiger puffer *Takifugu rubripes* has declined in the wild and stock enhancement programs are performed in many prefectures in Japan. There are feasible cases when hatchery-reared juveniles were released at large size (> ca. 7 cm SL). On the contrary, releasing small-juveniles (< ca. 5 cm SL) has resulted in unsatisfactory outcomes. We hypothesized that hatchery-reared juveniles in small body size have inferior behavioral traits than the wild and this will be the causes of low fish quality. Therefore, we investigated changes in behavioral traits with growth of hatchery-reared tiger puffer juveniles; 1) the effects of tetrodotoxin (TTX) administration on behavior and survival after release, 2) salinity selectivity, 3) settling behavior and 4) food selectivity on bivalves. 1) TTX administration significantly improved the fear response of juveniles and resulted in higher survival after release in a mesocosm. 2) Large juveniles (>6.2 cm SL) showed more positive selectivity to the low salinity (10-16 ppt) than smaller juveniles. 3) Spring-water from the bottom sand and low salinity water (15 ppt) stimulated settling behavior. 4) 83% of the large juveniles (8.9 cm SL) fed on bivalves, while only 42% of small juveniles (5.4 cm SL) fed on bivalves. Behavioral observations demonstrated that that tiger puffer juveniles select low salinity (10-16 psu), become benthic and increase their availability of benthic food items from over 6 cm in SL. These findings indicated that small hatchery-reared juveniles are in low fish quality release, and we can propose the optimal microhabitat for releasing small juveniles.

Enriched environment promotes shelter-seeking and survival of hatchery-produced juvenile European lobster (*Homarus gammarus*)

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High instant mortalities of hatchery-reared European lobster juveniles upon release for stock enhancement and sea

ranching could be a result of deprived rearing environment. Our objective was to study if an enriched environment had an effect on shelter-seeking and competitive behaviour. Experiments were conducted to assess the effect of two treatments; Conditioned and naïve. In the Conditioning treatment, juveniles experienced substrate, shelter and interactions with conspecifics, whereas juveniles in the naïve treatment were raised in single compartments without substrate and shelter. The conditioning period varied in the different experiments from six weeks to five months. Releases were made into semi-natural systems with substrate and shelter. Number of shelters were set to half of total number of juveniles to ensure competition. Conditioned juveniles were advantageous to naïve in occupying more shelters and with higher survival; 69-91% compared with 9-30% in the naïve. Behavioural studies were further conducted to assess if these differences could be observed on an individual level. Few differences in shelter-seeking behaviour were found comparing single juveniles while in interaction studies naïve juveniles more often initiated the first aggressive encounter. Our results demonstrate that an enriched environment did not improve shelter-seeking behaviour in single lobster juveniles, but when a large number of lobsters competed for a limited number of shelters in a semi-natural environment, experience of environmental complexity had a clear positive effect. Since exposure to a complex environment may increase survival in newly released juveniles, such treatment should be considered in future stock enhancement and sea ranching strategies.

Increasing production from an under-exploited fishery - Enhancing the yield and colour of the roe of the Urchin, *Centrostephanus rogersii*, by reducing density or transplanting individuals

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A large proportion of the sea urchin, *Centrostephanus rogersii*, resource in south-eastern Australia is not harvested because their roe is considered poor quality at market as it is dark in colour and small in size. The urchins with poor quality roe occur mostly in Barrens, where high densities of urchins and their grazing maintain areas free from foliose algae, which is their primary source of food. We investigate how the quality of roe can be improved by reducing densities or transplanting individuals from Barrens to habitats dominated by foliose algae. Reductions in density resulted in significant improvements in the colour and yield of roe after short periods of time (i.e. 3 months) and greater improvements were observed after one year. Significant increases in the yield of roe occurred where density was reduced by as little as 33%, but the greatest increases (i.e. >200%) occurred where density was reduced by 66%. Sea urchins transplanted to habitat dominated by foliose macro-algae showed significant improvements in the colour and yield of roe in only 6 weeks, although this depended on the density of individuals and season. The improvement in quality of the

roe from reducing density and transplanting did not reach the quality of commercially harvested roe during the experimental period, but did provide a commercially-viable roe for market. These results demonstrate significant improvements in roe quality can be made to a large proportion of the *C. rogersii* resource in south-eastern Australia, leading to the potential for increased production from this under-exploited fishery.

Exposure to predator odors enhances shelter seeking and competitive behaviour in hatchery reared juvenile European lobster (*Homarus gammarus*)

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Releases of hatchery reared juvenile European lobster have been made throughout Europe since the 19th century. Predation on newly released hatchery reared juveniles is substantial and presumably caused by behavioral deficiencies. Lobsters can recognize and discriminate different chemical cues and modulate the behavior accordingly. In the present study, shelter-seeking and competitive behavior was compared in juvenile lobsters reared in single-cell compartments (naïve) and juveniles exposed to a mix of predator odors (Conditioned). Odor exposure was hypothesized to serve as a form of habitat enrichment increasing the motivation to find and compete for shelter. Three experiments were made in environments of gradually increasing complexity. Behavioral assays on individual lobsters in a low-complexity environment indicated no effects of odor exposure on shelter-seeking or general activity. In contrast, when allowing for intraspecific competition in the same environment, Conditioned lobsters were significantly more dominant, evident through a higher ability to win agonistic interactions. The winners also spent more time in shelter and less time roaming than the opponent. When performing a small-scale release in a more complex semi-natural environment, naïve lobsters initially performed better than the Conditioned. However, the Conditioned lobsters significantly increased shelter occupancy as the experiment progressed over a 35-day period. The results suggest that there is a long-lasting effect of prolonged odor exposure. Prolonged exposure to predator odors may either positively influence behavioral plasticity or elevate the underlying fright-related motivation in competing for shelter. Further studies are needed to confirm an effect of odor exposure in a more realistic release setting.

Murray Darling Basin Native Fish Forum – 1315 – 1500

Fish under the pump: The case for screening water diversions in the Murray-Darling Basin

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Irrigated agriculture is the largest user of water in the Murray Darling Basin (MDB) and there has been substantial development over the past 100 years in water diversion and storage. Larger-bodied fish enter irrigation canals or can be entrained by pumps, and early life stages (eggs, larvae and 0+ fish) are entrained in significant numbers owing to their drifting dispersal strategy and poor swimming ability. To improve native fish populations in the basin there is a need to capitalise on the huge potential that exists for irrigators to be stewards for native fish recovery. The success of fish screening programs around the world demonstrates that coordinated efforts to screen irrigation diversions could make huge inroads into improving fish stocks in the MDB while also being of direct benefit to irrigators. Although no screening program currently exists in the MDB, significant progress has been made in understanding the scope of fish losses and defining screen design criteria suitable for native fish and local conditions. This presentation outlines the 'state-of-the-art' of fish screening in the MDB and discusses what need to be done to overcome the financial and institutional barriers that are hindering irrigators and fisheries managers collaboratively establishing a basin-wide screening program.

Keynote Murray Darling Basin Native Fish Forum

Collaborative fish screening pilot projects for the MDB: What lessons can be learned from the Pacific Northwest United States

Les Perkins¹

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If there is a desire to embark on a fish screening program in the Murray-Darling Basin, it will pay to look elsewhere in the world to understand the best practices required to maximize project success. Fish screening laws in the United States date back to the late 1800's and the sheer number of fish lost to irrigation diversions in the Pacific Northwest was first quantified early last century. For much of the time since then there has been an ad hoc approach to screen design and installation, with many projects failing over the long-run. But failure drives innovation and improvement, and quite often the most valuable lessons are those learned when things don't go as planned. In this keynote presentation, Les Perkins from the Farmers Conservation Alliance (FCA) outlines how the approach to fish screening in the Pacific Northwest has evolved from being non-systematic and often ineffective, to more recent years where screening projects are strategically coordinated, underpinned by solid research, development and monitoring, and taken from concept to completion in close collaboration with the irrigation industry. FCA has

been designing and implementing fish screen projects over the last decade and now has 35 projects installed in 5 states. By accumulating project experience and learning when things don't go to plan, FCA has developed a process for implementing successful projects that ensures a screen is designed specifically for a site and that all project partners have a clear understanding of what to expect and who is responsible for delivering each project component.

Murray Darling Basin Native Fish Forum – 1315 – 1500

Rehabilitating an Australian Icon: The Sea to Hume Fish Passage Program

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Construction of instream barriers, preventing fish from accessing spawning, nursery and feeding habitat, is a major issue impacting fisheries sustainability throughout the world. Since European settlement, development in the Murray -Darling Basin for irrigation and potable water supplies has led to the construction of over 10,000 barriers to fish movement. The Native Fish Strategy listed fish passage as a major driving action and was proactive in progressing cost-effective solutions to help inform large-scale rehabilitation programmes. The strategy identified a list of high-priority barriers for mitigation works based on feedback from jurisdictional agencies. Work culminated in the implementation of the biggest every fish passage restoration program in Australia; the Sea to Hume program. The program specifically sought to rehabilitate fish passage along the entire Murray River (some 2,250km) by constructing vertical slot fishways. The construction program completed in 2014 and for the first time in 80 years, fish are now able to negotiate the entire Murray River. Completing the construction component was a critical first stage, but there are many challenges to ensure that the program succeeds in the longer term.

Fishways - Cheaper or not at all?

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All freshwater native fish need to migrate to complete key lifecycle stages. Unfortunately in NSW alone, over 6,000 barriers including weirs and dams restrict fish access to key spawning, nursery, and feeding habitats. These barriers are a principal reason behind the 90 % decrease in native fish populations since European settlement. One objective of the Fisheries Management Act is to address the deleterious effects of fish passage barriers on aquatic habitat connectivity and native fish populations via the provision of fishways when weirs and dams are constructed, altered, or modified. Since 1994, 101 fishways have been constructed in NSW which have reinstated fish access to over 15,000 km of priority waterway. Research has conclusively demonstrated the

effectiveness of fishways in passing native fish; however, fishways are inherently expensive, with construction costs increasing significantly over the past five (5) years with technical fishways (e.g. vertical slot, lock) now being priced upwards of \$1.0 to \$1.5 M per vertical meter of differential head. These high costs have created challenges for asset owners and Government to finance compliance driven fishway projects, as well as for DPI Fisheries to proactively address high priority fish passage barriers. This presentation will utilise examples to detail the general breakdown of technical fishway costs per design element and highlight options to reduce expenditure by reassessing biological, hydrologic, and structural criteria while also addressing risk and contingency factors. A general discussion will follow where we welcome the audience to provide proven or novel options and ideas to reduce fishway costs.

Oral Session 20 – ASFB - 1315 – 1500

Prod & Prof Fish

Subsistence fishing on Pacific atolls can maintain near-pristine fish communities

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Fish are a major source of protein for Pacific island nations and these fisheries often target and remove large predatory fish from coral reefs. Heavy fishing of large predators can affect trophic dynamics and reef fish community composition by reducing top-down predation effects on small reef fish. Differences in fish communities between heavily fished and unfished reefs are well documented, but it is also important to quantify the impact of low-technology subsistence fishing. Here, we compare fish assemblages for three coral atolls in the Republic of the Marshall Islands that experience different fishing pressures: Rongelap Atoll, negligible fishing over the last 40 years (near pristine); Ailuk Atoll, low-technology subsistence fishing; and Majuro Atoll: intense commercial and subsistence fishing. Total biomass of reef fish did not differ among atolls, but the proportion of biomass attributable to large predators was much higher at both Rongelap (38%) and Ailuk Atolls (32%) than at Majuro Atoll (5%). The removal of large predators at Majuro Atoll led to an apparent increase in the biomass of small (15-45 cm) fishes (>2.5x higher). Our results show that the subsistence fishing at Ailuk Atoll has not measurably altered fish biomass or communities from an entirely unfished state. We suggest that low-technology subsistence fishing by up to 500 people can provide food for the community but also maintain near pristine levels of large-predatory reef fish.

Pelagic fish catching efficiency in Marmara Sea, Turkey

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Marmara Sea is an important migration area for economic sea pelagic fish. The Marmara sea of data in current study aimed to reach each fishing the year of economic pelagic fish. Fishery conservation measures will be revised based on these results. Istanbul Bosphorus entry - Tekirdag along the line were made in a total of 48 days and 124 purse seiner catching operation during the fishing season. Approximately 25 % of the participation of the provided 124 gear winding was carried out under 24 m. The majority of the catching section, 31.5 %, is provided between 24 - 28 m. 29 % of the catching between 28 - 32 m, 10.5 % between 36 - 40 m and finally 4 % of the catching between 36 - 40 m was carried out. Catch rates are analyzed according to the proportion of the fish species, the largest proportion of the total catch belongs the 64.8 % of horse mackerel. All caught fish belongs to 30.5 % of blue fish, 4.2 % of sardine, 0.4 % of blue fish and lastly % 0,1 belongs to other fish species (Atlantic bonito, tub gurnard, toric, turbot and etc.). The Marmara Sea, has been observed in various parts of mucilage in while this research was made 2013 - 2014 fishing season. Catching efficiency is quite reduced in mucilage seen places and difficulties while gear taking was experienced during trip such as; loss of time, labor and fuel loss.

What's the catch? Shark fisheries in Eastern Indonesia

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Indonesia has the world's largest shark fishery, but very little locally relevant information is available on catch statistics or life history characteristics of targeted species. This poses major challenges for fisheries management and shark conservation in the region, particularly in the more remote coastal communities of Eastern Indonesia. Shark fishers from three coastal communities were interviewed and trained in data collection in their fishing grounds in the Seram, Aru-Arafura and Timor Seas. Of the over 30 species recorded by the fishers, we assessed ten species based on criteria including proportion of total catch, high intrinsic vulnerability to fishing pressure, and market and conservation value. Using a combination of fishers' data and published life history characteristics, we estimated the intrinsic rate of population growth to evaluate the relative vulnerability of each species, and compared the observed size structure with established fisheries reference points. The interviews revealed that the fishers generally perceived sharks in their fishing grounds to be declining in numbers and size. Our study found that the fishery is catching several high risk species, such as hammerheads and guitarfish, with catches predominantly comprised of immature individuals and a high level of fishing mortality. Involving fishers in data collection and interpretation provided data and information in regions with low management and research capacity. Additionally, close collaboration with the fishers provided fundamental insights into the circumstances that shape fishers' decision-making

and the ecological and socio-economic requirements that must be addressed for management initiatives to be effective.

Expression of fishery trends at different spatial scales: at what scale does the crystal ball become cloudy?

Craig Mundy¹

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At broad spatial scales we often observe declines in fishery performance over sequential years when harvest consistently exceeds recruitment and somatic growth. This would suggest that within larger areas of decline, the same temporal sequence might be observed at much finer spatial scales such as at the scale of fishing events or individual populations. Where this is the case, fishers will report clear trends, with a consistent view expressed by the majority of fishers. However, a consistent message across the majority of fishers is more uncommon than observed incidences of regional scale decline. This suggests that the local dynamic may depart from the global dynamic, and perhaps explain why frequently there is disparate opinion expressed by fishers about the state of a resource. Spatial statistical methods are used to explore local-scale spatio-temporal patterns in harvest and fishery performance within the Tasmanian abalone fishery. Two areas with contrasting fishery performance are explored to understand how large scale patterns might (or might not) be expressed at local scales.

Understanding changes in spatial-structure of snapper fisheries in southern Australia

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While boundaries of marine fish stocks are often considered from a management perspective as lines on a map, the spatial distribution of fish stocks may expand and contract. This variability has consequences for management and assessment when the influence of a stock on fisheries production in particular jurisdictions or regions changes over time. Further, within a management jurisdiction, changes to stock distributions, or meta-population structure, can create uncertainty in spatially-structured assessments and regulatory arrangements. In south eastern Australia, there are several adjacent regional snapper fisheries operating in South Australian (SA) and Victorian waters that are managed using different strategies. Over the last decade the snapper fisheries in western/central Victoria and SA have experienced major changes. In Victoria fishery production has increased greatly, and in SA the spatial structure of the fishery has changed, with a major decline occurring in Spencer Gulf, while at the same time a major increase in production has occurred in northern Gulf St Vincent and the south east coastal region. We compared life-history profiles of otolith element:Ca ratios among four cohorts (1991, 1997, 2001 and 2004) to investigate changes in snapper stock structure and fishery production over the

last 20 years. These data combined with other information such as recruitment surveys and age/length compositions help explain the processes behind the changes in spatial structure of the snapper fishery in SA, and how expansion of the Victorian western stock created a new fishery in south-east SA.

Cool, windswept and interesting: The New South Wales Sea Mullet Spawn Run Fishery

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Sea mullet (*Mugil cephalus*) represent the largest and most valuable fishery in NSW, averaging 3,500 tonnes per year since 2000 and valued at around \$11 million at the point of first sale in 2014. More than half of the commercial sea mullet fishery targets the ocean spawning run that occurs between March and July each year, using either haul nets from ocean beaches or mesh nets in the lower reaches of estuaries before the fish run to sea. The fishery has operated for more than a century and despite very heavy targeting of spawning aggregations has proven to be incredibly resilient. This resilience to fishing has resulted in the mantra that the population is stable and the fishery sustainable despite long-term excessive levels of mortality estimated from the age composition of the spawn run fishery. Recent detailed analyses of the spawn run fishery reveal a more dynamic situation with variable year class strength, gender variation in growth rates and age at recruitment and highly skewed sex ratios. Preliminary data on the chemistry of sea mullet otoliths also suggests variation in the age at which individuals first participate in the ocean spawning run with evidence that not all mature fish run to sea each year. These results raise issues for assessment of the stock as a whole in addition to explanations as to why this is considered a sustainable fishery in the face of high fishing pressure on spawning aggregations.

Oral Session 21 – ASFB - 1315 – 1500

MPAs, Marine Estate

Enhancing marine biodiversity conservation in the Hawkesbury Shelf marine bioregion

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A current initiative of the NSW Marine Estate Management Authority is to conduct a threat and risk assessment along the central part of the NSW coast with the objective of developing options to enhance marine biodiversity conservation. The stretch of coast from Newcastle to Wollongong is the only coastal bioregion in NSW that does not have a large marine park. However, there are 10 smaller aquatic reserves and a marine extension of a terrestrial National Park which provide some level of

protection to marine biodiversity. As part of the overall bioregional assessment, current activities and management arrangements within these existing reserves will be evaluated. Although there has been no systematic monitoring of marine biodiversity across these sites, there are several existing data sets which collectively provide an insight into the sorts of measures that might be recommended. The approach being used for the Hawkesbury Shelf Marine Bioregional Assessment will be described and the role that the existing reserves play will be illustrated with particular reference to data on shallow rocky reef fish assemblages.

Embracing complexity in Marine Protected Area governance

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Managing our marine and coastal environment in a way that protects marine biodiversity while maximising our opportunities for resource use and enjoyment is a complex problem that requires the collaboration of biological and social scientists. Marine Protected Areas (MPAs) are one tool in the vast toolbox of approaches to marine governance that can be highly beneficial to marine ecological systems but also have the ability to have significant impacts on the relationships that people have with their environment. MPAs are often established in data poor environments. Biological scientists and policy makers have responded to these information gaps by developing a range of techniques to make sense of the complex marine ecosystems they seek to manage. These techniques provide a guide for MPA placement, size and management arrangements, including the development of protection 'targets'. While these systems may work well in managing biological systems they often come into conflict with equally complex social systems. We will examine these complexities and highlight the ways they can be reconceived as opportunities to provide insight into the way planning and management can be adjusted and improved. In particular we will look at how conflict between stakeholder groups, difficulties in integrating different forms of knowledge and the influence of politics and the media can all provide valuable insights into how we can improve the social acceptability of MPAs and ultimately secure their ongoing viability as an important tool for achieving long term sustainability in our oceans.

Using fishermens local knowledge to guide collaborative management of seagrass habitat

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The knowledge of local communities that work with and often depend upon natural systems can provide unique insights into ecological processes and their relationships with human activities. In coastal marine systems, the local knowledge of fishermen can be employed to document ecosystem change, identify natural ecological variability, alert managers of problems, spatially guide management initiatives or improve the accuracy of scientific studies. This approach is of particular interest to many of Australia's

coastal fisheries where ecosystem health and fisheries productivity are strongly influenced by external sources such as land based activities and climate. Seagrass habitats are an important source of fisheries productivity around Australia and are well documented as in decline globally. Seagrass extent and condition is often influenced by water quality determined by catchment inputs, and hence fishermen often have little control over the condition of the habitats they rely on. Over the past two years, commercial fishermen in Corner Inlet, Victoria, have offered their local knowledge to guide collaborative management of seagrass habitats. A strong and possibly unique partnership between scientists, commercial fishermen, farming groups, government authorities and Landcare was built to address the issues of poor water quality contributing to seagrass decline. We demonstrate a methodology in managing ecosystem related declines in fisheries productivity by fostering collaboration and understanding between researchers, fishers, land owners, farming industry groups and management agencies working to a common goal. By addressing declines in ecosystem health, we aim to see the continued viability of a long-running fishery and livelihoods for small scale coastal fishers through seagrass habitat conservation.

Resource type modifies the effects of reserves and connectivity on ecological functions

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Connectivity is a pivotal feature of landscapes that affects the structure and functioning of ecosystems. It is also a key consideration in conservation planning, yet the potential functional effects of connectivity are rarely evaluated in a conservation context. Herbivory is a key ecological process on coral reefs that promotes coral growth and recruitment. Many reef herbivores are harvested and some use other habitats (like mangroves) as nurseries or feeding areas. Thus, habitat connectivity and marine reserves can jointly promote herbivore populations on coral reefs thereby influencing reef health. We used a coral reef seascape in eastern Australia to test whether seascape connectivity and reserves influence herbivory. We measured herbivore abundance and herbivory rates (turf algae and macroalgae) on reefs differing in their level of mangrove-connectivity, and their level of fishing protection. Reserves enhanced herbivore biomass and promoted consumption of turf algae. Consumption of turf algae correlated with surgeonfish that are exploited outside reserves. By contrast, reserve status and connectivity influenced herbivory on macroalgae, which was greatest on fished reefs far from mangroves, and not strongly correlated with any fish species. Our findings suggest landscape connectivity and reserve status can jointly affect ecosystem functioning, but these effects can differ markedly depending on resource type (i.e. turf algae vs macroalgae). Therefore, effective conservation depends on our ability to understand how these interactive effects structure the distribution of ecological functions. These findings have wider implications for the spatial conservation of

heterogeneous environments and strengthen the case that the impact of conservation on ecosystem functioning is contingent on how reserves are positioned in landscapes.

Planning guidelines for spatial management synthesised from three long-term (>10 yr) reef-fish studies in the Solitary Islands Marine Park

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Synthesising findings from separate long-term monitoring programs in a Marine Protected Area provides insight into the spatial management strategies applied, increasing potential for effective spatial planning. The present zoning scheme in the 720 km² Solitary Islands Marine Park (SIMP), NSW, was established in 2002. Three reef fish monitoring programs with different methods and objectives commenced in 2002: 1) timed-swim log-abundance counts examining persistence in assemblage patterns; 2) diver transects comparing abundance of selected taxa in small sanctuaries, large sanctuaries, and two different fished zones; 3) Baited Remote Underwater Videos (BRUVs) to assess influence of sanctuaries on abundance and length of fishes relative to partially protected (fished) zones and areas outside the SIMP. Findings from these programs were synthesised into generalised spatial management planning guidelines: i. There are strong persistent assemblage patterns and unique sites cannot be effectively represented by other sites. ii. Sanctuaries are a key zone in a marine park. Prevalence, abundance and length of targeted species, especially site-attached, will increase in sanctuaries in a short period. iii. Assessment of community changes require longer than the decadal scale. iv. Larger sanctuaries produce clearer trends than smaller ones, and sanctuaries should be replicated to account for spatial and temporal variability (e.g. due to habitat preference, perturbations, recruitment). v. Response in sanctuaries relative to fished areas can vary strongly over time due to high natural variability; a consistent increase is an unrealistic expectation. These different programs provided a range of discrete and complimentary findings. Synthesising findings into planning guidelines helps integrate research and management.

Predicting fish distributions for marine spatial planning in MARXAN

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Systematic spatial planning benefits conservation, but spatial management tools require full coverage of biological data, which is a challenge to obtain in marine environments. Thus it is common to use surrogates, i.e. depth, rather than biological point data in spatial conservation. Evolving technologies, as swath habitat-mapping, and statistical tools are enabling the generation of reliable species distribution models (SDM) at high resolutions. We used SDM for 8 target and by-catch species and 5 fish taxonomic groups of interest for conservation and fisheries to inform spatial management planning. Fish data were generated using Baited Remote Underwater Videos. Two type of environmental explanatory variables were used: (1) GIS-generated spatial variables, e.g. depth, distance from coast; (2) habitat complexity metrics generated from Geo-swath mapping, e.g. rugosity, curvature. Two 100 km² areas, with complete Geo-swathed data from Solitary Islands Marine Park, were used to generate the species predictive maps, which were used in Marxan to explore the use of SDM in marine spatial planning. Overall depth was the more frequent predictor for species and groups, influencing 10 of the 13 fish species / groups. Species were mostly influenced by both depth and distance from coast, while fish groups were mostly influenced by depth (4/ 5 groups). Interestingly, 3 groups were mainly influenced by Geo-swathed predictors: target predators, target piscivores, and benthic sharks. Marxan spatial planning outputs were improved by using detailed predictive maps, compared to only using available point data. These results suggest SDM should be used in spatial management planning.

Benchmarking human use of Eighty Mile Beach Marine Park prior to implementation of the management plan

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2 WA Department of Fisheries, Perth, Australia

Human use of the coast between Broome and Port Hedland was examined prior to implementation of a marine park. Monthly aerial surveys were conducted using a Cessna 210 aircraft and two observers equipped with digital cameras and a GPS logger. There was much higher usage in the dry season than the wet season. Areas with highest densities of people were near 80 Mile Beach Caravan Park, Cape Keraudren and Barn Hill and, to a lesser extent, Port Smith and Bidyadanga. Of the people recorded, 46% were fishing from the shore. Fishing was particularly popular near Eighty Mile Beach Caravan Park with anglers and their associated four-wheel drive vehicles spread along about 30 km of coastline. Camping along the coast during the dry season was largely within the confines

of the large caravan parks at Eighty Mile Beach and Port Smith. Boating activity occurred mainly in the northern area around Port Smith and near Cape Keraudren. These recreational boats were engaged in fishing or motoring and pearling vessels were also recorded in Gordon Bay. The distribution of human use was examined relative to the designated sanctuary zones of the new Eighty Mile Beach Marine Park. The survey proved to be an efficient method for investigating human use over 500 km of remote coastline. The study provides spatially explicit data on fishing and other coastal recreational activities that can be used by managers as a benchmark of use prior to the implementation of the management plan for the marine park.

Oral Session 22 – ISSESER - 1315 – 1500

Evaluating Outcomes & Adv in aquacult tech

Understanding the ecology of the Western School Prawn to maximize restocking success

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Historically the Western School Prawn (*Metapenaeus dalli*) was an important and iconic catch for commercial and recreational fishers in the Swan-Canning Estuary. However, the abundance of this penaeid declined dramatically since the 1960s, resulting in the closure of the commercial fishery and essentially the cessation of the recreational prawning. In 2012, a restocking and associated research program was initiated to try and increase the abundance of this popular species. Monthly sampling, for two years, of the fish and crustacean faunas of the shallow and deeper waters of this estuary has shown that; 1) the abundance of *M. dalli* changes markedly throughout the year, particularly in the shallow waters. 2) *M. dalli* moves into the shallows between November and March to spawn, but that that timing changes slightly among years according to environmental conditions. 3) The distribution of adult and juvenile prawns changes temporally and can be used to inform broodstock collection and release sites. In addition, dietary analysis was performed on 11 abundant fish species in the estuary to determine those species that predate on post-larval *M. dalli* (direct predators) and those that also target other small crustaceans (potential predators). Key predators included the Gobbleguts *Ostorhinchus rueppellii* (all sizes) and the Black Bream *Acanthopagrus butcheri* (<100 mm in length). These dietary results together, with monthly prawn and fish abundance data for 36 sites across the estuary have been used to design an effective release strategy and highlight the value in restocking programs being supported by robust quantitative faunal surveys.

A responsible stocking program for Eastern king prawns (*Penaeus plebejus*) in Australia

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Eastern king prawns support an important commercial fishery (\$35M p.a in NSW), and are a popular target species for recreational fishers. With the potential for recruitment limitation, a collaborative project is investigating whether stocking a coastal lagoon could support or enhance a popular recreational fishery. Lake Tyers is frequently closed to the ocean and larval supply, and without stocking, some years have few adult prawns (including the years of our experimental stocking). Multiple quantitative approaches were averaged to estimate ecologically appropriate stocking densities. First, we estimated that there was 592, 500 m² adult and 143, 800 m² nursery habitat, which could be stocked between 1.7 million to 3.3 million larval prawns, respectively. Second, stocking density was estimated from historical adult numbers to match previous catches. Lastly, oxygen consumption and growth experiments were completed to model the prawn population's energetic requirements and impacts. Growth rates during the summer (20-25°C) were approximately 10 mm per week, and oxygen consumption rates were 0.45 mg O₂/g/h, suggesting the stocked prawns consume 100.2 kJ/g/day. Averaging these estimates revealed that 1.5-2.5 million post larvae (15 mm total length) could be optimally stocked in Lake Tyers. In February and December 2013, 300, 000 and 1.3 million post larval prawns respectively were stocked into Lake Tyers. Approximate growth rates suggest that the majority are harvested in 3-4 months at only 100-150 mm total length. Key considerations now are monitoring the growth and abundance of stocked prawns, and how best to evaluate the success of the stocking.

Maximising benefits and minimising adverse impacts from marine stocking: A case study from Australia

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The role of stocking in fishery systems is becoming increasingly integrated into traditional fisheries management frameworks in many countries. New South Wales (NSW) is the first jurisdiction in Australia to approve and implement an ongoing marine stock enhancement program for the purpose of enhancing recreational fisheries. As part of the approval process an Environmental

Impact Statement (EIS) was prepared, using a novel approach tailored to generic (albeit restricted) marine stock enhancement activities in NSW estuaries. In the absence of strict management controls, there is potential for marine stock enhancement to have ecological impacts and socio-economic costs in addition to potential benefits. As part of the EIS, tools were developed to determine which of 158 NSW estuaries could be the most appropriate for the marine stock enhancement of seven recreationally-targeted species (4 fish, 2 crab and 1 prawn species) and criteria for optimal stocking. Estuaries within three stocking regions were selected using a multi-criteria analysis of 20 factors considered important to the success of stocking. Predictions of the predatory impact of stocked species and estimates of the productivity of the selected estuaries were used to determine the most appropriate stocking rates for various sizes of the target species. These tools fed into the risk assessment in the EIS, the outcome of which guided the focus of the Fishery Management Strategy for the program. In this paper we describe how the tools developed have sufficient flexibility to be applied elsewhere to holistically assess proposals for marine stock enhancement activities in other jurisdictions.

Optimising methods for community-based sea cucumber ranching: Experimental releases of cultured juvenile *Holothuria Scabra* into PNG seagrass meadows

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Hatchery-cultured juveniles of the commercial holothurian, sandfish (*Holothuria scabra*), were used for release experiments in a variety of marine habitats under traditional marine tenure near Kavieng, Papua New Guinea. Juveniles of approximately 4 g mean weight were released inside 100 m² sea pens installed within seagrass meadows nearby partner communities, under the care of local 'wardens'. Within each sea pen, varying levels of protection (free release, 1-day cage and 7-day cage) were provided in order to determine if short-term predator exclusion improved survival rate. Ossicles of juvenile sandfish were tagged with different fluoro-chromes for each treatment and sandfish survival and growth was recorded after release. A range of bio-physical parameters were recorded at the four sites. Contrary to expectations, short-term cage protection did not lead to higher survival at three sites, while a fourth site, despite meeting all criteria for suitable release habitat, experienced total loss of juveniles. There were significant site differences in mean weight of juveniles after 4-months. Multivariate analysis of bio-physical factors clearly separated the sea pen habitats, strongly differentiating the best-performing site from the others. However, further research is needed to elucidate which bio-

physical or human factors are most useful in predicting the quality of potential sea ranch sites. Methods developed or refined through these trials could be used to establish pilot test plots at potential ranching sites to assess site suitability and provide guidance on the level of animal husbandry required before commencing community sea ranching operations in New Ireland Province, PNG.

Hatchery related effects on post-release survival of Spotted Seatrout *Cynoscion nebulosus*

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Over 800,000 hatchery-reared (HR) Spotted Seatrout (50-100 mm) have been released since 2006 in Mississippi, but few have been recaptured. To explore possible causes for the low recapture rate, we investigated the potential role of hatchery-induced maladaptive responses in a series of controlled experiments. In successive side-by-side laboratory feeding trials, wild fish captured and consumed more live prey than HR fish, but feeding success of HR fish improved across trials. Previous experience with novel live prey in the absence of habitat structure facilitated feeding success in complex habitat. In laboratory and field mesocosm experiments, HR fish preconditioned to simulated habitat or habitat plus a predator survived better than unconditioned HR fish. However, there was no difference in survival between fish conditioned in the presence of habitat alone and fish conditioned in the presence of both habitat and a predator. In laboratory and field experiments, cortisol in 48- and 80-day post-hatch (dph) age classes increased additively during handling, tagging, and release procedures; the 80 dph age class displayed a muted cortisol response relative to the 48 dph age class. In field mesocosms, post-release survival was high for 48 dph fish in both unstressed and stressed treatments, but unstressed 80 dph fish survived better than stressed fish. Unstressed fish were generally in better condition than stressed fish. These studies show that juvenile Spotted Seatrout possess the physiological and behavioral plasticity required to acclimate to post-release life, but that informed modifications to feeding, rearing, and releasing practices could improve post-release success.

The development of techniques for the collection of fertilised snapper *Chrysophrys auratus* eggs from Cockburn Sound spawning aggregations and their culture for enhancement purposes.

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Snapper is an iconic recreational and commercial fish species across its range in southern Australia and northern New Zealand. In many of these locations, stocks have been reduced to low levels by fishing. The ability to economically restock or enhance the species, while ensuring genetic diversity, would be improved if fertilised eggs could be collected from the wild during their spawning aggregations. This project developed effective techniques to collect snapper eggs from the extensively studied spawning aggregations in Cockburn Sound in Western Australia and to assess the genetic diversity of the offspring produced. Optimum weather conditions, times of day, methods and locations for egg collection were identified during the project. The selection of snapper eggs based on their diameter and oil globule size proved to be a reliable method of separating potential snapper from other eggs within the collections. Samples of these eggs were confirmed to be snapper using real-time PCR, comprising a snapper specific probe and a general fish probe. A microsatellite-based comparison of a sample of juveniles raised in the hatchery from wild spawned eggs with a sample of wild-caught individuals from Cockburn Sound tested the genetic integrity of this collection and culture method. A number of snapper cultured from this project were marked with alizarin complexone and retained in the hatchery to test for mark integrity over time.

Murray Darling Basin Native Fish Forum – 1530 – 1700

Invasive species and river regulation turn Murray-Darling Basin fish assemblage structure upside down

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Invasive species, combined with other human disturbances, can profoundly alter the structure and function of food webs. We show here for the first time how river regulation and invasive cyprinid fishes transform fish assemblage biomass pyramids and energy flows across the Murray-Darling Basin. Invasive cyprinids and natural flow regime alteration contributed to inverted biomass pyramids and a trophic cul-de-sac. These human disturbances divert energy away from the longer food chains of native fish food webs and into a trophic cul-de-sac, where biomass accumulates in large-bodied, but low trophic level, invasive cyprinids. This study demonstrates how invasive species can interact with other human

disturbances to distort energy flows and community structure at macroecological scales.

The countdown to Carp control: progress with implementation of a biological control program for Common carp in Australia

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Cyprinid herpesvirus-3, or CyHV-3 has been identified as a potential option for the biological control of Common carp in Australia. Since 2005/06 the Invasive Animals CRC has facilitated research by CSIRO led by Dr Ken McColl into aspects of the biology, epidemiology, specificity and efficacy of CyHV-3 as a biocontrol agent for Carp in Australia. Results to date confirm the virus to be a viable prospect. Importation and use of CyHV-3 in Australia would require approval under several pieces of legislation. The NSW Department of Primary Industries is currently representing the IA CRC as lead proponent in that process. A key component of this work is the compilation of data necessary for risk assessment processes and cost-benefit analysis. A study tour was recently undertaken to several countries having a lengthy experience with CyHV-3 affecting carp populations; the USA, UK, Israel and Japan, to investigate key knowledge gaps relating to impacts of the virus within natural systems, and on relevant industries. Priority areas of interest include: 'understanding long term impacts of the virus on Carp populations and freshwater ecosystems'; 'determining the duration of immunity post infection'; 'documenting effective biosecurity measures to protect Australian ornamental Koi carp producers, retailers and enthusiasts; and ' assessing any human health implications of the virus, if any. A large amount of useful information was obtained through the study tour, although a high degree of misinformation, inconsistency and lack of monitoring was observed within many of the case study countries.

Effectiveness of Murray cod and golden perch stocking in MDB waterways: contrasting systems, targets and life-history

Jamin Forbes¹, Jason Thiem¹

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Stocking of large-bodied native fish has been used as a management tool in the Murray-Darling Basin (MDB) for decades, and objectives of these stockings have generally focussed on conservation and fishery enhancement. Recently, chemical batch-marking techniques have been applied to hatchery-spawned Murray cod and golden perch that enable retrospective evaluations of stocking effectiveness. Two separate studies were conducted using Murray cod and golden perch. The first assessed variability in stocked fish survival and growth between rivers and poundments, and the contribution of stocking to wild fisheries. The second study examined the contribution of

stocking to population recovery following widespread fish kills within a single system. The results from both studies indicated that, generally, wild spawning, recruitment and/or emigration of both species contributed more to populations than stocking in the rivers monitored, and at the levels of stocking that occurred. Conversely, little evidence of wild spawning or recruitment was identified in impoundments. Variability among years, systems and species is discussed in the context of life history strategies and system dynamics.

Oral Session 24 – ASFB - 1530 – 1700

Prod & Prof Fish

MSC certification with limited data: to B or not to B?

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The Government of Western Australia initiative to support assessment of fisheries against the Marine Stewardship Council (MSC) principles and criteria for sustainable fishing has presented scientists with a number of challenges. Despite the many benefits to industry and other stakeholders with regards to demonstrating that a fishery meets the high standards set by the MSC, it is not a straightforward process for the many small-scale fisheries that often lack extended time series of reliable data required for estimating biomass (B) of target stocks. To improve the accessibility of the MSC program to fisheries without conventional stock assessments, risk-based tools have been developed and integrated into the Fishery Certification Requirements, leading to a number of data-limited fisheries successfully obtaining MSC certification in recent years. This study examines the MSC certified fisheries for which the Risk-Based Framework (RBF) has been applied to score the performance indicator measuring stock status of target species and compares their scores to those of similar species that have obtained certification without employing the RBF. The advantages and disadvantages of this and other alternative assessment approaches for data-poor fisheries are discussed, with the focus on how limited resources may be best spent to maximise the chances to successfully obtain and maintain MSC accreditation.

How effective is Australia's management of sharks in commercial fisheries?

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Shark populations are declining globally, mainly due to unsustainable catch in fisheries. A fishery's sustainability is directly correlated to the effectiveness of managing the catch of sharks. A management effectiveness evaluation (MEE) was developed to evaluate current management of Australian fisheries that catch sharks. The MEE examined 23 different attributes across 5 categories (management

context, management arrangements, non-targeted catch, fishing patterns, and compliance and enforcement). Attributes for each fishery were score, weighted, and summed to give provide a percentage effectiveness. Almost half of Australian fisheries were found to catch sharks as either target, byproduct or bycatch; and 16% had insufficient data available to determine if sharks were caught. In over 75% of commercial fisheries sharks were caught incidentally rather than being targeted. Overall management effectiveness of Australian commercial fisheries ranged from 8-71% of a perfect score, with a mean of 42%. The best performing fisheries, on average, were those that only caught sharks as bycatch and did not keep any sharks or shark products. Within each of the 23 attributes, some fisheries performed very well while others did not. This means there are already management solutions in place for some areas of weakness in Australian fisheries management of shark catch. A fishery that scored poorly in a specific attribute could improve their management in that area by incorporating policies from a fishery that performed well in that area. This may lead to Australian commercial fisheries having improved management of their shark catch in the future.

Characterising the spawning patterns of jack mackerel (*Trachurus declivis*) off eastern Australia to optimise future survey design

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The daily egg production method (DEPM) was applied to jack mackerel off eastern Australia in January 2014. Ichthyoplankton and adult surveys were conducted concurrently between Port Stephens, New South Wales (NSW) to South East Cape, Tasmania. Information was used to assess the environmental factors that determine spawning patterns and make recommendations for optimising the design of future surveys. Adults were collected using a modified demersal trawl deployed during daylight hours. Eggs were most abundant in sea surface temperatures 15-20°C and depths < 130 m. Large fish were collected from both the inner shelf and shelf break; spawning fractions were high inshore and low offshore, conflicting with previous studies that suggested most spawning occurs at the shelf break (~ 200 m). Future ichthyoplankton surveys should target waters with SSTs between 14-23°C at depths between 30-250 m. Adult surveys should cover a similar depth range and be stratified by depth, but should also extend further north and south than the ichthyoplankton survey to provide information on the relative abundance of non-spawning adults outside the spawning area. Ichthyoplankton and adult sampling should be conducted in the main spawning area periodically (e.g. every two weeks) during the main spawning period (December to February) to determine if the depth at which most spawning occurs varies over the season. Applications of the DEPM typically overlook non-spawning adults outside the spawning area. The adult sampling method outlined here may provide a way to address this issue.

Oral Session 25 – ASFB - 1530 – 1700

Tech. Ecol. Telemetry

Movement Of Snapper (*Chrysophrys auratus*) In South Australia From Acoustic Telemetry

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Snapper is a significant, inshore, marine finfish species throughout the temperate regions of Australasia. Despite substantial research effort, its movement behavior and habitat use at the small scale of 10s of km, remains poorly understood. In South Australia through the late 2000s, annual catches of snapper in Northern Gulf St. Vincent (NGSV) have made significant contributions to State and National commercial catches. To facilitate the sustainable management of this regional fishery, this study aimed to develop a better understanding of the space and habitat use, and movement behaviour of snapper. Acoustic telemetry was used during a three year study in NGSV throughout an area of approximately 160 km². Up to 41 VR2W Vemco acoustic receivers were strategically deployed, whilst 54 small to large snapper were tagged with Vemco tags. A total of 521,567 detections were recorded, with the numbers and detection periods highly variable amongst individuals. No fish was detected continuously indicating that none was a permanent resident. Whilst some fish were recorded daily at a single station for up to several months, others were only detected occasionally with few detections. However, other fish were classified as mobile, partial residents, as they were detected on numerous occasions for considerable durations. They demonstrated different types of movement behavior with respect to timing, the distances moved and places involved that were categorised as: inter-regional; seasonal, inter-habitat; episodic; and local movement. Snapper are highly mobile, capable of moving 10s of km very quickly and showed refined skills of navigation.

Movement of fishes among reefs and over soft sediments within a temperate embayment: the necessity and implication of movement data for spatial management

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Quantifying patterns of fish movements is essential to effectively manage fish stocks and marine biodiversity. Understanding the movement of fishes should assist greatly in identifying the spatial-scales that fish stocks should be managed and in determining whether spatial management such as marine protected areas could be useful. Here, we focus on the movements of fishes among 20 reefs separated by 100 - 3000 m and large areas of soft sediments (i.e. >100 hectares) within the temperate embayment of Jervis Bay (NSW, Australia). This bay is part of the Jervis Bay Marine Park and the reefs representatively cover both habitat protection zones and multiple sanctuary zones (no take zones) and are replicated within each zone. We quantified the movements patterns among these reefs for 5 fish species (luderick, bream, smooth rays, Port Jackson sharks and bluespotted flathead) using a combination of active and passive acoustic tracking over periods of 1.5 - 24 months. To date, this ongoing study has revealed a diverse range of movement patterns among species. Some species showed strong site attachment while others were highly mobile within the embayment. There was also considerable variation within-species with highly individualistic patterns consistently arising suggesting that within-species variation may be common.

PIT-tagged: Investigating the movement of estuarine fish and crustaceans

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Many commercially and recreationally important fish and crustaceans species use spatially distinct habitats as juveniles and adults. The underlying movement patterns are largely unknown. PIT (passive integrated transponder) tags in combination with an autonomous antenna system can provide a cost effective and reliable method to detect movements of fish and crustaceans in marine environments. Here I present a new type of autonomous antenna system that can overcome the problem of high resistance in saline water and detect PIT tags over longer periods of time and can cover a larger area. I introduce two independent research projects that have utilised this technique with success. In the first research project 52 different estuarine fish species were tagged and monitored for 9 month while moving in and out of a mangrove creek. In the second research project over 800 mud crabs were PIT tagged and monitored over a 4 month period. Detections of individuals were analysed for environmental preferences and behaviour. The results of the modified antenna system demonstrate application in future aquaculture and fisheries research.

Oral Session 26 – ISSESr - 1530– 1700

Advances in aquacult tech

Enriched stable isotope mass marking techniques for aquaculture and restocking

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Determining the value of re-stocking wild fisheries with hatchery reared fish requires the ability to identify and quantify the survival of hatchery fish post release. However, to obtain accurate estimates of survival rates, multiple fish identification techniques are often used, making monitoring of re-stocking inefficient and costly. We tested three stable isotope otolith fingerprint mark delivery techniques for mass marking farmed Atlantic salmon (*Salmo salar*) to determine if they could differentiate between hatchery and wild salmon and the point of release with 100% accuracy. Otolith fingerprint signatures created with Ba, Sr and Mg isotopes were delivered via: 1) Maternal transfer: where an isotope marker is injected into broodstock, and thus in turn passed on to the offspring; 2) Egg immersion: where fertilised eggs are left to swell in an enriched isotope solution; and 3) Larval immersion: where yolk sac larvae are immersed in an enriched isotope solution. Analyses of otolith signatures were carried out using Laser Ablation Inductively Coupled Plasma Mass Spectrometer (LA-ICP-MS). 100% mark success was achieved with all three techniques at specific marker concentrations. Material cost to mark starts at 0.0002 \$US per fish. No measurable side effects of marking on growth, condition, or mortality were observed for fish grown to 4 kg. We conclude that marking hatchery breed salmonids with enriched stable isotopes is a viable method to identify hatchery fish post release. The techniques are broadly applicable across many species and are now in use to mark millions of salmonids, eels, and Australian native fish.

Thermal regimes during the spawning migration of the barfin flounder (*Verasper moseri*) and its link to final oocyte maturation and ovulation

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Although photoperiod is an important cue in fish reproduction, water temperature plays a secondary role, acting on final oocyte maturation (FOM), ovulation, and spawning. The reproductive performance of barfin flounder (*Verasper moseri*) is particularly sensitive to temperature perturbations. Under captivity, post-vitellogenesis flounder maintained at constant temperature fail to undergo FOM and occurred just in those, which experienced the slowly-elevated water temperature regime (SETR). Moreover, diurnal temperature fluctuations (DTF) during the spawning period accelerated ovulation and produced higher quality eggs. Wild barfin flounder migrate 750 km south to their spawning site, which is the continental slope off the Pacific coast of Tohoku (35.6–36.6°N), using biologging techniques we examined how fish chose depth to experience SETR during the spawning migration, and DTF at the spawning site. We show that fish moved into deep

(400-600 m) and cold water (around 3°C) during the initial migration period and experienced warmer water (around 6°C, 300-400 m) at the spawning site, suggesting that SETR is one factor that induces FOM in the wild. Most tagged fish experienced DTF, however they made little excursions during the spawning period. A semi-diurnal internal tide may be responsible for the DTF.

Stage-specific vulnerability of juvenile common snook to spinal deformity: morphological responses to water velocity and rearing environment

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Spinal deformity is a common obstacle in finfish aquaculture and has been attributed to a variety of causes including nutritional deficiencies, rearing environment, and genetic heritability. Earlier research with common snook *Centropomus undecimalis*, has shown that spinal deformity can be induced (42% in treatment groups) by subjecting 70 days-post-hatch juveniles (DPH) to water currents (Brennan et al., unpublished data). The present study examined earlier stage-specific vulnerability to spinal deformity influenced by water flow. At 40 DPH (0.54g mean wt.) snook were removed from the nursery rearing tanks and 120 individuals were stocked into each of 4 replicate experimental tanks (circular, 1.54 m diameter x 60 cm depth) containing either continuous water currents (gflow h treatment, water currents .110 mm/s [2-4 body length/s] or control gno flow h treatments with no obvious water currents [0]12 mm/s). Using automatic belt feeders juvenile snook were fed Daily with 3 mm diameter slowsinking pellet feed (1-5% body wt./d, 40% protein, 11% lipid). Visual examination of the study fish occurred at 1, 2, 3, 4 and 8 weeks after study onset to collect data on weights, lengths and visual deformity estimates. Spinal deformities were categorized as lordotic, kyphotic, or scoliotic, and enumerated in an anterior-toposterior order of occurrence. On week eight, all fish from each tank (about 1,600 total fish) were harvested, anesthetized, and individually weighed and examined for spinal malformities. Each fish was also digitally photographed from a standardized camera mount. Fish were photographed on their sides and were aligned along a mounted ruler on a standardized mount. Overall, juveniles exposed to gflow h treatments for 8 weeks has significantly higher rates of spinal deformities (treatment mean= 82%, control mean =34%) and these rates were approximately twice as high as 70 DPH snook observed in an earlier study subjected to the same duration and intensity of flow treatment (82% versus 44%). A subset of fish, removed from the production cohort at 25DPH, and held in a separate control gno flow h system was also examined at this time and these had 0% spinal deformity indicating that some of the observed deformity in the control tanks originated in the production cohort system prior to study onset. Morphometric analysis of the digitized images showed that snook subjected to the experimental flow conditions were more gmuscular h, had proportionally larger heads, higher dorsal profiles and shorter fins. The severity of the particular spinal deformities also increased over time.

Keynote – 0845 - 0930

Spyglass into aquatic biological diversity - use of environmental DNA (eDNA) to detect rare and invasive species

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A major challenge in aquatic biodiversity research is the ability to rapidly survey large numbers of water bodies in efforts to detect invasive pests and/or rare species. This challenge can be exacerbated in remote regions where it is often hard to obtain boat access so that traditional survey tools can be used. A rapidly growing field of genetic research which has the potential to revolutionise how aquatic biodiversity surveys are undertaken is that of environmental DNA (eDNA). eDNA is an efficient, non-invasive and easy-to-standardise sampling approach that relies on the detection of DNA from cells shed into the water column by target organisms. eDNA technology can be targeted to detection of specific organisms such as invasive fishes, or more recently using advanced DNA sequencing technologies, offers the future potential to survey complete aquatic communities in one pass. Of particular value, is that the eDNA approach is extremely sensitive and has been shown to detect a single fish in a waterbody after only a few days. It also has application in both marine and freshwater systems. In this plenary our experience with development and use of eDNA technology to the detection of the invasive pest fish tilapia, rare species such as sawfish and frogs, and aquaculture pathogens will be highlighted, along with important considerations on how this technology can be integrated with other traditional survey technologies.

Keynote – 0930 - 1015

Sea ranching of Abalone - Flinders Bay, Western Australia

Brad Adams¹

1 Ocean Grown Abalone Pty Ltd, WA, Australia

Brad Adams is a former commercial abalone diver, abalone aquaculturist and businessman who with the backing of a group of investors has spent a number of years researching and developing sea ranching science for the growout of Greenlip abalone (*Haliotis laevigata*) in Flinders Bay, Augusta, Western Australia. The success of this work has led to the development of Australia's first commercial abalone ranching business. The company, Ocean Grown Abalone Pty Ltd (OGA) has obtained three long-term seabed leases in Flinders Bay that make up 120 hectares in total. The location of these leases was carefully selected to provide all the biological and environmental requirements of wild abalone populations with the exception of low-lying, offshore granite reefs that were absent. OGA provide that critical abalone habitat by constructing purpose built reefs and locating them within the seabed leases. These artificial reef modules termed by OGA as ABITATs are then stocked with the juvenile abalone approximately 40mm in length that are purchased from a commercial land based abalone hatchery and growout facility located in Bremer Bay,

Western Australia. The abalone are then left to grow for up to 3 years before they are harvested by divers. The abalone on the ranch feed on the abundant algal wrack naturally drifting around Flinders Bay. It is expected that the reefs will yield an annual harvest of 100 tonnes per annum. This keynote presentation will outline the innovative science and business model that are the basis of the OGA Abalone Ranching business.

Oral Session 27 – ISSES & ASFB - 1045 – 1230

Adapting to a changing env & Artificial Habitat

Growth and survival of *Holothuria scabra* juveniles in bottom-set trays

Jay R Gorospe¹, Marie Antonette Junio-Menez¹

1 Marine Science Institute, University of the Philippines, Diliman, Quezon City

Scaling up hatchery production of sandfish is constrained by the need for large hatchery areas, and the high operational and materials costs of production, from larval rearing to juvenile nursery systems. In this study, the potential of bottom-set trays with and without artificial substrates as ocean nursery units for sandfish *Holothuria scabra* was evaluated. Post-settled juveniles were stocked in the trays which enclosed in fine mesh net and secured to the seafloor with bamboo stakes. Growth of juveniles at a stocking density of one hundred to two hundred individuals per tray was significantly higher than at high stocking density of four hundred to five hundred individuals per tray with or without artificial substrates after sixty days. The coefficients of variation in length at high stocking densities were significantly higher. Growth of juveniles was not significantly different in the trays with artificial substrates but survival was significantly higher across all stocking density treatments. Coefficients of variation in length was lower in trays with artificial substrate suggesting that the artificial substrate reduced intraspecific and interspecific interactions. The bottom-set tray is a cost-effective alternative ocean nursery unit for sandfish juveniles particularly during seasons where sea surface conditions are not favorable. With improved design coupled with density management, juvenile survival and growth can be increased. The bottom-set tray can also be used for mass release of early sandfish juveniles in restocking and stock enhancement areas.

Challenges in Tiger Shrimp Stock Enhancement in the Philippines

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2 University of Tokyo, Tokyo, Japan

3 Fukuyama University, Fukuyama, Japan

4 Research Institute for Humanity and Nature, Kyoto, Japan

In central Philippines, the Aquaculture Department of the Southeast Asian Fisheries Development Center (SEAFDEC/AQD), with strong collaboration and support from the Research Institute for Humanity and Nature (RIHN) of Kyoto, Japan, has been looking into the stock enhancement of tiger shrimp *Penaeus monodon* in the New Washington Estuary (NWE), province of Aklan. Tiger

shrimps were dominant in catch in NWE until the early 90s when these were observed to decline in volume, replaced by smaller and cheaper species. This was coincidental with the rapid decline in mangrove cover for ponds and huge increase in fishing pressure. Site-specific assessments were conducted to evaluate fisheries and social prospects of shrimp stock enhancement while comparative experiments were done to identify strategies especially in the delicate intermediate acclimation rearing. Conservative simulations of capture of released stocks showed that fishers can increase income by about 300%. To decrease fishing pressure in the area, number of gears per fisher may have to be reduced but shrimp catches will be relatively high-priced. Release experiments showed that 60-d old (~15mm CL, ~70mmTL, ~1g BW) shrimps have higher chances of survival when released in the upper estuaries. Intermediate rearing runs showed that density of 40-60 shrimps m⁻² is optimal for <2 mo intermediate rearing in a mangrove pen. In the Philippines, typhoons that carry prolonged rain and colder temperatures occur from October to March, so rearing and release activities are best programmed from April to September.

Adaptive and integrated culture production systems for *Holothuria scabra*

Marie Antonette Juinio-Menez¹, Elsie Tech², Isidora Ticao³, Jay R Gorospe¹, Rose Angeli Rioja¹, Christine Mae Edullantes¹, Glycinea de Peralta¹, Karl Angelo Lambio¹

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2 Palawan Aquaculture Corporation, Baquid Island, Coron, Palawan

3 Alsons Aquaculture Corporation, Alabel, Sarangani Province

Unregulated harvesting and trade have resulted in the depletion of the of sea cucumber resources in Philippines. Culture-based production and resource management systems are being piloted in seven regions to restore depleted populations and increase the supply of premium grade sized sandfish *Holothuria scabra*. Development of sandfish production clusters is guided by information on genetic connectivity, opportunities for strategic multi-sectoral partnerships and biophysical conditions in different sites. The strategy to scale-up juvenile sandfish production through private commercial hatcheries, and the use of low-cost ocean nursery systems to engage community participation was implemented in two sites in northern Palawan and southern Mindanao. The hatchery culture of sandfish was readily adopted and further refined by the commercial hatcheries. Different types of nursery systems were tested and useful under different biophysical conditions. Diversification of low-cost ocean nursery systems can expand potential areas for nurseries and growing season, and engagement of local communities. Release of cultured juveniles within each production cluster can be linked to community-based resources management efforts and the program of local government units to manage the coastal fisheries and provide livelihood opportunities to their constituents. The local research and academic community can provide technical assistance in the evaluation of release sites and monitoring. Given the diverse biophysical conditions within and between production sites, spatial and temporal planning and

providing opportunities for the involvement of stakeholders in different stages of production can optimize production potentials and sustainability of culture-based fishery restoration.

Substrate preference of Sandfish *Holothuria scabra* juveniles: Implications for Grow-out and Sea Ranching

Jon Altamirano¹, Charlemagne Recente¹, Roselyn Noran¹

1 SEAFDEC Aquaculture Department, Iloilo, Philippines

Growth, survival and substrate preference of sandfish *Holothuria scabra* juveniles were investigated through laboratory and field experiments to determine the optimal habitat for potential grow-out culture, sea ranching or stock enhancement in the Philippines. Sandfish prefers burying in sandy-mud and prefers feeding on either sandy-mud or sand, and better with seagrass. Negative growth rate was found for sandfish reared in mangrove mud. Muddy substrate, typical of culture ponds in the Philippines is toxic to sandfish. More than 75% of individuals bury from 3 am and most re-surface to feed after 3 pm. In a confined space, like our experimental tanks and pens, growth was confirmed to decrease when mass density of 200g/m² is reached.

Stock recovery initiative for a commercial roes abalone fishery decimated by an environmental event

Lachlan Strain¹, Jamin Brown¹, Anthony Hart¹

1 Western Australian Fisheries and Marine Research Laboratories, Perth, Australia

A Roes abalone fishery in Western Australia (Area 8) suffered catastrophic mortality (99.9%) due to an anomalous environmental event in the summer of 2011. During this event a sustained period of elevated sea surface temperatures rose to lethal levels for Roes abalone and effectively wiped out an entire stock. Natural recovery within the foreseeable future has been considered unlikely, thus providing a unique opportunity to test fishery restoration strategies for abalone. The objective was to establish viable breeding populations of at least 500 adult Roes abalone at densities greater than 3 per m² on the reef platforms. Five founder populations were created through the translocation of 9,000 mature adults and 15,000 hatchery-reared juvenile Roes abalone. Translocated adult Roes abalone had an initial survival that ranged from 0.24 to 35% and exhibited a distinct behavioural characteristic (clustering), with densities averaging 103.9 (15.9 SE) abalone.m² and the clusters accounting for nearly 50% of the surviving abalone. The natural mortality rate (M) of translocated abalone at 3 years post-release was estimated to be 0.31 (0.03 SE). This mortality rate has been combined with estimates of the initial release mortality to calculate the number of adult Roes abalone required to produce founder populations of effective breeding size at any given time post translocation. Given the current course of climate change and the prediction that significant environmental events are likely to become more regular and intense, it is imperative that

stock recovery initiatives like this are able to assist in the restoration of not only commercial fisheries but populations of at risk marine species.

Role of research in the development of NSW Artificial Reef Program

Michael Lowry¹, Iain Suthers², Matthew Taylor¹, Heath Folpp³

1 NSW DPI, Port Stephens, Australia

2 UNSW, Sydney Australia

3 NSW DPI, Coffs Harbour, Australia

The history of Australia's artificial reefs has been well-documented and reflects a more general global pattern with initial deployments characterised by the extensive use of 'materials of opportunity'. The dubious environmental quality of early artificial reef construction materials, lack of pre-established objectives combined with a non-existent or ineffective monitoring approach limited the capacity of researchers and managers to assess the role of artificial reefs within a broader fisheries management framework. Artificial reef systems have transitioned over the past decade to structures designed to provide ecological benefits for target species and assemblages. Research objectives have tracked a similar trajectory with initial work aimed at understanding baseline information concerning the colonisation of designed reef systems in estuarine and off shore waters. Current projects seek to understand the more complex and important aspects of the interaction of these systems with the broader marine environment and in particular the ability of these systems to facilitate production. Recent work indicates that artificial reefs do not function exclusively as attractors or producers; instead, they can have some combination of attraction and production qualities, which vary in relation to factors such as site fidelity, movement within and between reef complexes, management regimes, and interspecies interactions. The aim of this presentation is to outline the development of NSW DPI Artificial Reef Program, with a focus on how the results of this work have provided a foundation for the extension of designed reef systems and the role that designed structures have in the context of broader marine environment.

Oral Session 28 – ASFB - 1045 – 1230

Environmental Flows

The Queensland approach to assessing environmental flows

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Water use alters river flow regimes and there is broad recognition that water resource development can impact ecosystems and their provision of goods and services. This spawned the concept of environmental flows to protect or restore flow regimes to achieve ecological outcomes; and this is now embedded in water policy and legislation in many parts of the world. In Queensland there is obligation to manage allocation of water resources to balance outcomes for consumptive users and the environment, to maintain environmental sustainability. This requires

evaluation of alternative water management options. Consideration of existing environmental flows approaches identified several deficiencies precluding their adoption. Firstly, many ignored the obvious reality that river ecosystems are subjected to many threatening processes as well as flow regime alteration, so ecosystem condition outcomes cannot be achieved by environmental flows alone. Secondly, many focused on providing flows for particular ecological responses without considering how often such responses are necessary for sustainability. Finally, few considered flow requirements at spatial-scales relevant to the desired outcomes, with frequent focus on individual places rather than the regions supporting sustainability. Consequently, we developed an approach which: identifies ecosystem aspects sensitive to flow alteration and linked to desired outcomes, quantifies their flow dependencies to model opportunities for relevant ecological responses and applies thresholds for the provision of opportunities needed to sustain the outcomes. Management options are evaluated using risk to the outcomes at the spatial-scales over which they function. This overcomes the deficiencies identified above and provides a vital input to water planning decisions.

Q-catchments: an adaptive monitoring program using fish as an indicator of riverine condition

Peter Negus¹

1 Department of Science, Information Technology and Innovation

The Water Resource Planning process has required much effort to be put into assessing ecosystem requirements of flow regimes in Queensland. There are however, many other threats to riverine ecosystems besides hydrological modification resulting from water resource development. Q-catchments is a broad-scale river condition assessment program that aims to provide some context to hydrological modification in light of these multiple threats to riverine ecosystems in Queensland. Fish are traditionally used for measuring ecosystem condition in many monitoring and assessment programs. Fish are also a commonly identified ecological asset for environmental flow assessments in Queensland. However, for Q-catchments, the multiple and variable threatening processes, differing water quality conditions, workplace health and safety issues and the natural variability in fish community compositions ensures that sampling and assessment techniques are not universally applicable. Q-catchments embraces the concept of 'adaptive monitoring' to gather information on priority threats to riverine ecosystems. Still amongst many other indicators of ecosystem condition, fish are often used because they are ubiquitous in riverine systems and responsive to many threats. However, because of the application of an adaptive monitoring approach no one technique for monitoring and assessing fish has been applicable across all regions. Relevant and innovative techniques for sampling fish and assessing changes to fish populations and communities have been applied to successfully support Q-catchment assessments on threatening processes and ecosystem condition.

Links between riverine flow regimes and movement and reproduction of Golden Perch

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Understanding key life history processes and relationships with environmental conditions is needed to develop appropriate and defensible conservation initiatives (e.g. 'environmental flow' programs) to restore disturbed or regulated river ecosystems and their biota. We used drift sampling, acoustic telemetry and electrofishing over five years (2009-2014) to investigate relationships between environmental conditions and movement patterns and reproduction of golden perch in the Goulburn River. The results of the study show that movement behaviour was spatially and temporally complex and included long-distance movements associated with elevated discharge and temperature during the spawning season. Spawning activity of golden perch was also associated with increased flows in spring. Population surveys revealed no strong relationships between increased flows and recruitment of juvenile fish, suggesting that increased golden perch spawning during high flow years may not necessarily translate into recruitment of juveniles into the local population. The study's findings have the potential to contribute to the development of defensible conservation initiatives, particularly in relation to environmental flow recommendations

Catadromous fish migration: Can dam releases match natural flow cues?

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2 Seqwater, Queensland, Australia

Management of water resources in regulated rivers is a balancing act between environmental requirements and anthropogenic uses. Understanding the environmental flow requirements for fish spawning migrations and upstream dispersal is essential in determining if current flow management rules, dam release strategies and fishway operations are effective. Here we used acoustic telemetry to understand the migratory movements of three catadromous fish: *Percolates novemaculeata*, *Mugil cephalus* and *Trachystoma petardi*. Over a 24-month period the movements of 239 fish were tracked using an array of 47 acoustic receivers in the Logan River, south-east Queensland. The inclusion of a prescribed release from Wyaralong Dam in 2014, paired with a natural river flow, gave us the opportunity to compare fish responses and evaluate if dam releases could stimulate migrational movements. In the winter of 2013 *P. novemaculeata* showed evidence of a spawning migration cued by two flows. In 2014 *P. novemaculeata* did not show any indication of a spawning migration from upstream habitats after cues from natural and prescribed flows. However, in early autumn fish located in the mid-estuary from the previous years migration, did migrate to the lower estuary. *T. petardi* and *M. cephalus* showed evidence of downstream migrations to the lower estuary in late summer

and autumn respectively, after large flows. All species showed evidence of upstream dispersal throughout the study period. The outcomes will inform water resource planning in south-east Queensland by understanding critical flow requirements for fish and the development of new environmental flow rules.

'Life history pressure points' as a basis for environmental flow development

David Crook¹, Wayne Koster²

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A major goal of environmental flow delivery is to maintain or increase the abundance of aquatic fauna. In Australia, environmental flow research has progressed from a focus on the minimum river discharge required to maintain adult habitat, towards consideration of the various processes that underpin recruitment and population size. The outcomes of a series of key events in the life histories of fish strongly influence recruitment success and population productivity. Such events can be viewed as 'pressure points' for environmental flow research and management, requiring specific research focus (in order to understand what is required to facilitate the event) and targeted management action (in order to deliver the conditions required to achieve the event). An obvious example of a life history pressure point for fish is spawning, which often requires specific environmental conditions prior to, during and after the event. Other examples include migrations to specific locations, ontogenetic transitions between micro- or meso-habitat types, and switches in feeding strategies or foraging locations. We present findings from a series of studies conducted on diadromous species (short-finned eel *Anguilla australis*, Australian grayling *Prototroctes maraena*, tupoong *Pseudaphritis urvillii*) in coastal Victoria to illustrate how a focus on life history pressure points can be used to identify the conditions required for achieving key life history events. By placing such events within conceptual frameworks, such an approach can be used to prioritise research and form a basis for the development of targeted environmental flow recommendations.

Environmental flow releases trigger spawning migrations by Australian grayling *Prototroctes maraena*, a threatened, diadromous fish

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1. Monitoring fish movement can test the effectiveness of environmental flow releases when they are used to trigger spawning behaviour. Environmental flow releases have been used to enhance Australian grayling (*Prototroctes maraena*) spawning in regulated rivers in south-eastern Australia and resource managers require knowledge of the effectiveness on the conservation of this threatened species. 2. Australian grayling movement was monitored in the Thomson River, south-eastern Australia using acoustic telemetry to determine whether the species undergoes a spawning migration, where they migrate and timing in

relation to environmental flow releases. Drift netting was used to verify whether spawning took place. 3. Adult Australian grayling undertook downstream spawning migrations (up to 140 km) to the lower Thomson River, coinciding with environmental flow releases. 4. The findings of this study support the use of environmental flow releases to trigger spawning migrations by Australian grayling. In addition, they provide resource managers of other species with an example of the potential effectiveness of environmental flow releases in triggering fish migration or spawning that can assist in rationalising this management intervention.

Molecular measures of population viability in response to altered flow regimes

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In Queensland, aquatic ecosystem monitoring undertaken by DSITI focuses on two main aspects: firstly on the effectiveness of Water Resource Plans in achieving outcomes of ecological sustainability, and secondly on assessing the broad-scale condition of our river systems using ambient assessments. In both cases scientific knowledge of cause-effect relationships between threats to ecosystems and the ecological responses to those threats inform our monitoring. In effect the monitoring focuses on aspects of ecosystem condition that are sensitive to particular threats. We present an innovative approach to measuring population health using molecular techniques that provide a cost-effective and sensitive tool suitable for monitoring. We applied molecular genetics techniques to test and validate the predictions from an ecological risk assessment of threats to aquatic ecosystem condition in rivers of the Wet Tropics in Far North Queensland. A significant risk to the long term viability of populations of fish was predicted to occur in direct response to the threat imposed from changes to the natural flow regime resulting from dam releases for hydroelectric power supply. We used the purple spotted gudgeon (*Mogurnda adspersa*) as a model organism to assess the impacts that barriers and flow changes have on the population characteristics of individuals in 'natural' and impacted environments. We found significant impacts to the levels of diversity and blockages to the natural pathways of connectivity which validate both the risk assessment process and the threat from flow modification. This also highlights the utility of molecular genetic approaches as monitoring tools for directly assessing population responses across spatial and temporal scales.

Oral Session 29 – ASFB - 1045 – 1230

Tech. Ecol. Telemetry

Are soft sediment fishes always highly mobile? An assessment of the movement patterns of the Bluespotted Flathead

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It is widely considered that on relatively homogenous soft sediment habitats such as sand, fish are unlikely to show site fidelity. This poses challenges for fisheries management and the evaluation of the efficacy of marine protected areas. The bluespotted flathead (*Platycephalus caeruleopunctatus*) is a commercially and recreationally exploited species found on sand in coastal waters of South East Australia. There is no published data on adult movement patterns. Here we aim to quantify movement and habitat-use of bluespotted flathead to: (1) determine whether site fidelity is shown, (2) identify migration or aggregation movements, (3) compare movement to current no-take reserve design. We use surgically implanted acoustic tags and the DPI array of 48 acoustic receivers within Jervis Bay to assess movement. Twenty of these receivers make up a VEMCO Positioning System (VPS), providing fine-scale (<1m) positioning across 81 hectares. The remaining receivers line the Bay perimeter or gate the entrance to the Bay, allowing the detection of broader scale movements. Bluespotted flathead were caught and tagged within the VPS in spring 2014 (n=25) and autumn 2015 (n = 15). Bluespotted flathead exhibit strong short-term site fidelity in Jervis Bay, with 37 fish detected within the VPS for longer than 2 months. Though the study is ongoing, long-term site fidelity was suggested; with 16 fish tagged in spring remaining in the VPS for up to 7 months and 13 fish tagged in autumn remaining after 2.5 months. Taken together these outcomes indicate that bluespotted flathead show considerable site fidelity.

The relationship of home range and marine protected area size for the Giant Shovelnose Ray (*Glaucostegus typus*)

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The biology and ecology of the Giant Shovelnose Ray (*Glaucostegus typus*), remains relatively unknown and given its vulnerable status requires further research. Large amounts of fishing pressure in parts of South-East Asia have resulted in population declines, while in Australia they are threatened by habitat loss and both commercial and recreational fisheries. *G. typus*, is thought to be a highly residential species for portions of the year and then move away from near-shore habitats for large portions of the year. The aim of this study is to determine the influence of no-take zones on the habitat use and home range size of the *G. typus* in Moreton Bay. Within Moreton Bay, South-east Queensland, a large multiple use marine park is in

place with a total of 16% declared as no-take zone. We used VEMCO V13 acoustic tags, inserted into the abdominal cavity of *G. typus*. We found that there was a substantial percentage of the home range area of *G. typus* was within the no-take zones. This study will provide the necessary background information for management, on the home range and habitat use of *G. typus* in South-east Queensland. The results suggest that given the relatively small home ranges for large portions of the year, this is a species that would benefit from spatial habitat protection. However, more information is required on all stages of the life cycle of this species and the dependence on numerous habitats within the Moreton Bay region and further offshore.

Assessing fine-scale diel movement patterns of an exploited reef fish

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Understanding movement patterns of species requires that the spatial and temporal scales of experimental designs are appropriate to the proposed ecological questions. Previous research on large-scale movements of the exploited reef fish *Lethrinus miniatus* suggested that adult individuals may use coral reef slope habitat during the day, shifting to adjacent deeper sandy habitat at night. To verify this diel activity pattern at a fine spatial and temporal scale, a closely-positioned acoustic telemetry system monitored movements of 11 *L. miniatus* over three months. Movement patterns among habitats from the reef crest, to reef slope, and deeper adjacent sandy habitat were compared among four different three hour periods of the day: dawn, day, dusk and night. Horizontal and vertical space use was consistently larger across shallow crest to deeper sand habitat during crepuscular and night periods, compared to during the day. Area of activity space within the water column and proportional overlap among areas used during different periods of the day varied among weeks, and displayed a pattern consistent with full moon periods. Increased luminosity during dawn, dusk and night periods may cause *L. miniatus* to utilise a larger search area for foraging, and further research is required to confirm foraging during the hours of twilight and darkness. This fine-scale approach identified patterns in nocturnal activity for an important reef teleost. Knowledge of these temporal and spatial differences in *L. miniatus* behaviour and movement are important to our understanding of how this species coexists within ecological niches.

Environmental influences on the behaviour of *Lethrinus nebulosus* at Ningaloo reef

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The spangled emperor *Lethrinus nebulosus* is an important generalist predator across a wide range of habitats in northwestern Australia and throughout the Indo-Pacific. At Ningaloo Reef it is a popular target for recreational fishers and a key indicator species in terms of both conservation and fisheries management. An effective understanding of its ecology is central to implementation of measures to manage this species in the face of ever growing numbers of visitors and residents in the region. The Mangrove Bay tracking array (35 sq km) at Ningaloo is part of the AATAMS Ningaloo Reef Ecosystem Tracking Array and we have based tagging and tracking efforts of spangled emperor around this location since 2007. Previous work has focused on habitat use by this species and here we describe how habitat use varies with a variety of environmental factors including seasonal, tidal, and diurnal cycles as well as in relation to transient weather factors such as cyclones.

Drivers of temporal and spatial movement patterns in *Girella tricuspidata*

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Girella tricuspidata (Kyphosidae), known as luderick, is a common teleost found in estuaries and near-shore waters of eastern and southern NSW. Luderick is commercially exploited in estuaries and targeted by recreational fishermen. This study determined the movement patterns of luderick (i) at a small spatial scale using a VEMCO Positioning System (VPS) in relation to habitat and fish activity and (ii) within estuaries, in relation to environmental factor, and the (iii) exchanges between estuaries and migratory pathways along the New South Wales (NSW) coast were also studied. Ten accelerometer and depth transmitters (AP tags) were deployed in luderick within a VPS in the Clyde River, Batemans Marine Park. At a small spatial scale luderick demonstrated strong diel and tidal activity patterns, but no consistent association to seagrass. 61 adults were acoustically tagged in three estuaries along a 200 km stretch of the NSW coast. Each estuary was monitored with an array of acoustic receivers covering the entire brackish extend of each estuary. Within estuary, movements of luderick were greatly influenced by salinity variations associated to important rainfall freshwater inputs. In addition to the estuarine receiver arrays, an extensive coastal receiver network (over 500 receivers) was spread along the NSW coast. Luderick were detected up to 500 km away from their tagging site and some fish swam over 50 km per day; the departure from the estuarine system occurred in conjunction with heavy rainfall events.

Sympatric Coral Trout niche partitioning indicated by movement and diet

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The coral trout complex (*Plectropomus* spp.) consists of at least seven different species, three of which have economic significance in the recreational and commercial reef fisheries of the Great Barrier Reef. Management regulations are biased toward the more abundant and better studied *P. leopardus*, despite some species (e.g., *P. laevis*) being listed as Vulnerable on the IUCN Red List. The goal of this study was to improve understanding of space use and foraging behaviour of sympatric coral trout at both inshore (*P. leopardus*/*P. maculatus*) and offshore reefs (*P. leopardus*/*P. laevis*) using passive acoustic telemetry and dietary indicators (stable isotope analysis). Fifty-eight acoustic receivers were deployed at three reefs to track the movements of 156 tagged coral trout. Muscle tissue and blood components were sampled from the three species at four reefs for stable isotope analysis ($\delta^{13}C$ and $\delta^{15}N$). Preliminary results showed that movement and foraging data were complementary and demonstrated similar behavioural patterns. *Plectropomus laevis* used a horizontal area >4 times the size that *P. leopardus* exploited, and spent more time foraging in deeper benthic habitat away from the reef crest. At inshore reefs, behavioural differences between *P. maculatus* and *P. leopardus* were less pronounced, although *P. maculatus* foraged deeper and occupied a smaller home range than *P. leopardus*. This apparent niche separation has significant implications for the efficacy of management in the Great Barrier Reef and highlights the need for species-specific data and regulatory initiatives.

Divergent use of a south-western Australian estuary by four key recreational fish species: evidence from acoustic telemetry

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By examining fish movements in estuaries we can gain a better understanding of how fish respond to environmental changes in these highly dynamic environments, compare how co-occurring species use estuarine systems, and determine areas where populations may be most vulnerable to fishing pressures. In this study, four important fishery species; Black Bream (*Acanthopagrus butcheri*), Southern Bluespotted Flathead (*Platycephalus speculator*), Snapper (*Chrysophrys auratus*) and Tarwhine (*Rhabdosargus sarba*), are being tracked using acoustic telemetry in the permanently open Walpole-Nornalup Estuary, a popular recreational fishery on the south coast of

Western Australia. A fixed array of 17 Vemco VR2W acoustic receivers has been deployed to track the movements of fish surgically implanted with internal acoustic transmitters. 23 Black Bream, 16 Southern Bluespotted Flathead, 10 Snapper and 10 Tarwhine have been implanted with transmitters (Vemco V8 or V9 - dependent on body size). Preliminary analyses of acoustic telemetry data reveals marked differences in movement patterns, habitat preferences and spatial area use of the system among species. Likewise, key environmental and biological factors, including salinity, water temperature, tidal phase, reproduction and body size, have varying effects on the movements of the four study species. For managers, this information can enhance existing knowledge of how fish use south-western Australian estuaries, particularly the degree of connectivity between regions and populations, potential habitat overlap between species, and how fish populations may respond in varying ways to a changing climate and increasing anthropogenic pressures.

Oral Session 30 – ASFB - 1045 – 1230

Est. Coast Con. Hab

Life-History movements of the world's toughest sport fish

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The black (*Lutjanus goldiei*) and spot-tail (*L. fuscescens*) bass support highly valuable sport fisheries in remote parts of Papua New Guinea. Despite their economic value and conservation significance, very little is known about the ecology of these fish. Comparing otolith chemistry profiles of black and spot-tail bass from the rivers of West New Britain with those of freshwater and marine-resident species provides clues as to the life-history movements and possible spawning locations in this region. Preliminary results suggest that black bass recruit to estuaries and rivers from high-salinity waters. They appear to spend the first few years of life in either freshwater or brackish parts of upper estuaries before moving into estuaries and making periodic migrations into high salinity waters. The coastal seascape context of West New Britain (small rivers, short estuaries, coral reefs and deep water very close to river mouths) differs markedly from that elsewhere in the species' ranges, such as the black bass stronghold in the Gulf of Papua. Testing the models developed in West New Britain with samples of these fish from other regions will clarify their life-history movements, identify key habitats and connectivities, and determine the consistency of their ecology throughout their ranges.

The role of fish predation in Estuarine Zooplankton biomass variation

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Estuarine zooplankton integrate energy from both the catchment and ocean in the form of nutrients and phytoplankton, but the influence of planktivorous fish upon zooplankton biomass is understudied. This study examined the importance of predation by planktivorous fish in Sydney Harbour by comparing gut contents and size-structured zooplankton biomass, between flood and ebb tides. The diets of three planktivorous fish were dominated by copepods, with 97 % of all guts containing copepods and 90 % of prey items within a size range of 390 - 870 μm equivalent spherical diameter. During a three month study period, zooplankton prey biomass (390 - 870 μm) varied by two orders of magnitude (53 - 1408 mg m^{-3}) and on one day the biomass varied by 971 mg m^{-3} among sampling sites less than 2 km apart. There was no significant difference in zooplankton prey biomass between flood and ebb tides ($F_{1,8} = 1.29$, $p = 0.30$). However during ebb tides a 320 mg m^{-3} average decline in zooplankton prey biomass was observed between the innermost estuary site and the estuary entrance. Using a consumption model, it was estimated that fish predation could only account for 2 % of this decline. The observed variation in zooplankton prey biomass was likely due to complex hydrodynamics within the estuary.

Habitat quality drives seasonal hotspots in seaweed-associated fishes

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Habitat is widely considered to be a key driver of fish biodiversity across seascapes, although there is less consensus on what measures of habitat structure are critical for supporting coastal fish populations and communities. Part of the challenge has been identifying how fishes respond to different elements of habitat change, with most studies to date focused on habitat loss arising from stochastic events (e.g., storms, heatwaves, drought). We explored how fishes associated with seaweed patch habitats at Ningaloo, Western Australia, respond to regular seasonal changes in canopy habitat structure. From our analysis of juvenile and adult fishes spanning a range of trophic groups, we find certain aspects of seaweed canopy structure can provide powerful predictors of change in fish diversity and abundance over multiple scales of space and time. Importantly, we found that some seaweed meadows, which maintain high quality canopy habitat over both summer and winter, provide seasonal hotspots for many ecologically and commercially important fish species, especially those which strongly select and depend upon canopy-forming seaweeds. Consequently, these scalable measures of habitat quality can provide a useful metric to identify, monitor and protect critical habitats that support both juvenile and adult fishes within a seasonally dynamic seascape.

Dissolved oxygen in mangrove ecosystems and impacts as productive habitat

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Mangroves are often used to dump nutrient-rich effluents from aquaculture and other urban development areas in many places. These effluents contribute to eutrophication which alters the natural rate of Dissolved Oxygen (DO) cycling, and may intensify low DO events occurring in mangroves. DO is a fundamental parameter of water quality, but few studies have examined DO dynamics and the associated impacts on mangrove fishes. This study examines the DO diel-cycling in natural and disturbed mangrove ecosystems in Australia and New-Caledonia, and identifies the factors driving these fluctuations. This understanding is being used to investigate how low DO influences fish assemblages, behaviour and their mangrove utilisation. DO and water level are being recorded using multi-parameter probes for several tidal cycles. A weather station is being deployed to record environmental parameters. Underwater cameras are being used to observe fish utilisation and behaviour in mangrove forests in response to DO. Initial results show that hypoxia occurs usually at dawn, following night-time respiration, and is particularly evident during the summer months. These hypoxic episodes result in critically low conditions (<10% saturation) that can last several hours. These fluctuations affect how fish behave and utilise mangroves, implying that mangroves might be low value habitats when low DO events occur. This study provides important data to assist managers achieve a balance between services essential for ecosystems and humans.

The value of mangrove Forests as fish feeding ground

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Estuarine mangrove forests are an important ecosystem that fulfils a variety of ecological roles, including nurseries and feeding grounds for many marine and freshwater species. However there has been little research aimed to describe what animals reside within the forest, and hence little understanding of the food availability for juvenile fish. The present study investigated the density and species composition of the benthic fauna of mangrove forests across multiple estuaries in north Queensland, Australia. Many forests are species-poor and lack taxonomic groups of particular importance to fish diets. This contrasts with known benthic compositions within estuaries indicating a strong habitat specificity in prey availability. The study also explored the environmental factors that could explain the depauperate benthic composition and concluded that substantial fluctuations in dissolved oxygen (DO) condition inside the forest is probably a major driver of benthic composition. In fact, as well as mangrove sediments being highly anoxic the overlying water within the forest is also strongly oxygen depleted. DO measured over multiple tidal cycles indicated fluctuations influenced by a variety of

factors including root density, forest elevation, tidal phase, and height. These variations correlate with substantial changes in fauna composition, suggesting that not all forest have the same ecological values for fish. Furthermore this finding are particularly important if we consider that in the last few decades there has been a net increase in human induced hypoxia in coastal waters around the globe and this could have detrimental effects on how fish utilize mangrove forests.

Re-writing the link between mangroves and fish

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Findings from two concurrent studies of habitat use in Australia's tropical estuaries muddy the link between fish and mangrove forests while revealing that value emerges at the system level. One study used an array of unbaited underwater videos to investigate the extent and mode of mangrove forest utilisation. Only a restricted subset of the fish species commonly found in north-eastern tropical mangrove estuaries made extensive use of mangrove forests. It appears that the role of mangroves as direct feeding sites is more restricted than previously thought, with the nutrition of many species supported through complex food web links. Similarly, patterns of utilisation of mangroves differed from expectations, implying the need to rethink our ideas about the ways in which mangroves provide refuge. The second study also used arrays of unbaited underwater videos, investigating subtidal fish-habitat relationships throughout the coastal mosaic on a fine scale. Many areas were found to be devoid of fish, with most species concentrated in areas of structure or vegetation, with subtidal boulder fields and submerged trees harbouring the highest diversity. Importantly, the species mix using these structures varied according to where they occurred in the coastal system, indicating that part of the value of different habitats is conferred by location. Together, these patterns of habitat utilisation support the idea of more intricate links between fish, mangroves and mangrove estuaries, and suggests that many of the advantages for using mangroves may be derived at an ecosystem scale, with mangroves part of a complex life-supporting mosaic.

Identifying important fish habitats through archived catch data, a tropical Australia case study

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Fish habitat and connectivity research has accelerated over the last two decades. However, this increased focus on habitats has highlighted a large gap in understanding of fish habitat use, particularly for commercial and recreational species. This knowledge gap can be addressed on a large-scale platform using the Habitat Classification by Archived Catch Data approach. This novel approach uses archived catch data, satellite imagery, and Geographic Information System habitat classification. A case study of this approach was conducted using an archive of 20 years of fish catch

data from the Hinchinbrook Channel in Tropical Queensland Australia. Tagging locations of 14 selected commercial and recreational fish species, including Barramundi (*Lates calcarifer*), Mangrove Jack (*Lutjanus argentimaculatus*) and Golden Snapper (*Lutjanus johnii*), were assessed using open access satellite imagery for habitat classification. This low cost method can be applied to other datasets, regions and fish species to obtain robust results. Importantly, this allows for a variety of spatial scale analysis, enabling large datasets to be viewed at relevant management and research scales.

Oral Session 31 – ASFB - 1045 – 1230

Rec Fisheries

Survivorship and recovery of fish species subjected to catch-and-release practices

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Recreational fishing is one of the most widespread leisure activities in Australia, with over 5 million participants nationwide spending billions of dollars yearly. This level of participation means that recreational catches can have significant effects on fish stocks, with catches exceeding commercial landings for some species. Recreational catch-and-release practices have been promoted to increase the long-term sustainability of fish stocks. For catch-and-release to be effective, the fish must survive. However, some fish are unable to recover and die quickly or suffer long-term negative effects. Our project is investigating the survival rate of recreational fish species involved in catch-and-release practices in North Queensland, and evaluating the immediate and long-term physical and physiological impacts of catch-and-release. The work includes external examination to identify visible physical damage and responsiveness, blood chemistry to quantify stress levels, and acoustic tagging and recovery cages fitted with video cameras to assess post-release mortality and monitor fish recovery. The work includes novel components, such as investigating the potential for immediate-post release predator mortality. Although initial results are broadly consistent with previous studies there are some unexpected features suggesting some tropical species have different responses to catch-and-release than those seen in previous studies. The findings will underpin the development of best fishing/handling practices and guidelines for fisheries management, recommending appropriate changes to current regulations to improve long-term sustainability of fish stocks.

Capture stress and post-release survival of Southern Bluefin Tuna from recreational fishing

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Southern Bluefin Tuna (SBT) are an iconic large pelagic species commanding one of the highest prices for seafood

per kilogram on international markets. The demand for this species led to significant commercial overfishing in the past. Australia currently holds the largest quota share of SBT with the species found in relative abundance off the western, southern and southeastern coastline of the continent. At times of the year schools of SBT migrate along the coast of Australia within range of recreational fishing boats. In recent years the popularity of the recreational fishery for SBT has increased significantly. Given this increase in fishing effort and the stringent international management of this species gaining an understanding of the Australian recreational fishery is seen as filling a crucial knowledge gap. Here we investigate capture stress and post-release survival of SBT caught using recreational fishing techniques. For 233 fish we assessed factors such as fight time, hooking damage and handling duration against physiological stress indicators including glucose, lactate, pH, cortisol and osmolality levels in blood plasma. For 59 of these fish we then assessed survival post-release by attaching pop-up satellite archival tags to monitor the fish's behavior and movement for up to 180 days and assessed these results against potential explanatory factors of mortality listed above. The results will be used to develop a scientifically robust code of practice for the handling of SBT and the post-release survival rates will be available in conjunction with planned surveys to estimate the un-accounted mortality from the national recreational fishery for integration into stock assessment models and consideration.

Sustainable sampling: the non-lethal tissue sampling of recreational species by citizen scientists

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Increasing fishing pressure and uncertainty surrounding recreational fishing catch and effort data has promoted the development of alternative methods for conducting fisheries research. A pilot investigation was undertaken to engage the Australian game fishing community and promote the collection of tissue samples from the black marlin *Istiompax indica*, a valuable recreational-only species in Australian waters, for the purpose of future genetic research. Recruitment of recreational anglers was achieved by publicizing the project in magazines, local newspapers, social media, blogs, websites and direct communication workshops at game fishing tournaments. The Game Fishing Association of Australia and the Queensland Game Fishing Association were also engaged to advertise the project and recruit participants, with a focus on those anglers already involved in the tag-and-release of marlin. Participants of the program took small tissue samples using non-lethal methods, which were stored for future genetic analysis. The program resulted in 165 samples from 49 participants across the known distribution of *I. indica* within Australian waters, which was a sufficient number to facilitate a downstream population genetic analysis. In addition, the ecological data on date, location

and estimated mass (kg) of the fish sampled, provided baseline information on seasonal fluctuations in the catch rates and size of *I. indica* among locations. The project demonstrated the potential for the development of citizen science sampling programs to collect tissue samples across a large geographic range in order to achieve targeted research objects in recreationally caught species.

Oral Session 32 – ASFB - 1315 – 1500

Artificial Habitat

Sydney Offshore Artificial Reef: Benthos and Demersal Fish Gradient Study

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The deployment of purpose-built reefs is becoming increasingly used by fisheries managers across Australia with the aim of enhancing fish habitat and providing greater opportunity for recreational fishing. Artificial reefs deployed in offshore environments are often located in areas of bare soft sediment with a goal to provide additional productive structure in otherwise habitat-limited situations. It has been demonstrated that artificial structures in such environments have potential to influence the physico-chemical and biological assemblages associated with sediments adjacent to and up to several hundred metres away from the structure. Mechanisms driving these changes may include organic enrichment, change in sediment composition, contamination and increased predation by fishes (known as the 'halo' effect). This study examines how the Sydney Offshore Artificial Reef (OAR) has influenced the surrounding soft sediment environment by sampling sediment properties and associated macroinvertebrate and demersal fish assemblages. Sediment samples were collected at increasing distances from the OAR and analysed for PSD, metals, TOC, macroinvertebrate abundance and taxon richness. The foraging behaviour of demersal fish was also examined using un-baited Remote Underwater Video Stations (RUVs). Although no patterns in the physical parameters measured were evident, distance was a significant factor in structuring the macroinvertebrate assemblage. One reason for this change may be fish predation, as RUVs observed an increased abundance of demersal fish close to the OAR. Goatfish (Mullidae) and grey morwong (*Nemadactylus douglasii*) in particular were found to spend >90% of total benthic foraging time within 15m of the OAR.

The influence of an offshore artificial reef on the abundance of fish in the surrounding Pelagic environment

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Artificial reefs are a popular fisheries management tool, but the effect of these reefs on the abundance of fish in the surrounding pelagic environment is uncertain. Pelagic baited remote underwater video (PBRUV) was used to observe the fish assemblage surrounding an offshore artificial reef (OAR), near Sydney, Australia. PBRUVs were deployed at three distances (30, 100, 500 m) from the OAR, and compared with a drop camera deployed directly over the OAR. There was a significantly greater abundance of fish on the OAR, but no significant difference in abundance at the 30, 100 or 500 m distances. Two highly mobile non-resident species, (*Seriola lalandi*, *Pseudocaranx dentex*) were significantly more abundant on the OAR, but this association was not detected 30 m away. These results suggest that any association with the OAR is on a localised scale (< 30 m) which may be due to its proximity to numerous natural reefs. The results from this study have consequences for management of artificial reefs, in particular the isolation of artificial reefs and the spacing between reef modules.

Artificial reef materials, orientation and predation on the epibenthic community

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Artificial reefs (AR) are a common strategy to enhance recreational fisheries but most studies have concentrated on fish that are of economic value. More focus is needed on epibenthic assemblages that grow on the ARs to better understand the fisheries' ecosystem productivity, especially reefs designed for fish habitat. Three factors of the epibenthic assemblage were assessed: the effect of reef surface material, exposure to fish predation and surface orientation. The coastal AR was deployed in 38m depth off the coast of Sydney in October 2011. Settlement plates made of four different materials (sandstone, Perspex, wood and steel) were deployed in three orientations (upward, downward and vertical). After 3 months, steel had 50% less recruitment of sessile invertebrates due to initial surface oxidation. Wood, Perspex and sandstone surfaces had similar communities and downward surfaces had 50% more barnacles. The fish predator exclusion experiment revealed that barnacles were 40% more abundant in the presence of fish predation, suggesting an intermediate trophic interaction involving mesopredators (such as flatworms). Barnacles also showed rapid recruitment (50% higher barnacle recruits) and mortality (25% more dead barnacles) in the presence of predation, suggesting nutrient transfer to higher trophic levels. Barnacles were also found to be more abundant on downward surfaces and there was evidence that they were consumed 35% more by mesopredators on vertical surfaces. Epibenthic assemblages are an important component of the spectrum of possible outcomes in the production to attraction of various components of the AR's fish assemblage and fishery.

Zooplanktivory a key process for fish production on a coastal artificial reef

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Artificial reefs continue to be deployed in coastal areas to enhance local fisheries. An important process influencing the success of artificial reefs may be the provision of refuge for zooplanktivorous fishes, which use artificial reefs as a base to forage the surrounding zooplankton. A numerical model was developed to quantify this trophic pathway on a designed coastal artificial reef, using field-parameterised data for zooplankton biomass, current velocity, and the consumption rate and abundance of a reef-resident zooplanktivorous fish. The model estimated that this species consumed approximately 2.9 kg (1.0 g m⁻³) of zooplankton per day on this artificial reef, which represents only 0.34 % of the total available zooplankton biomass. The ability of this artificial reef to support an average 130 kg standing stock of this species suggests that the zooplankton pathway is a reliable mechanism for fish production. A second model explored the influence of reef size on zooplanktivorous fish densities and the supply of zooplankton required to sustain their consumption rate. As reef size increased, the density of reef-resident zooplanktivorous fish also increased, but the ability to achieve their required consumption rate declined. These findings indicate that per-capita food supply is maximised on smaller reefs, while fish density surrounding a reef is maximised on larger reefs. Reef size should be considered carefully during the planning of artificial reefs, as it can greatly influence the dynamics of reef-resident zooplanktivorous fishes.

Conservation potential of anthropogenic waterbodies on a heavily modified agricultural floodplain

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With tropical floodplain wetlands ranking among the world's most threatened ecosystems, anthropogenic waterbodies are an often under-appreciated potential conservation resource for aquatic fauna in these heavily modified environments. This paper describes the fish communities in 27 anthropogenic waterbodies of three different management and design types (ditch recycle pits, generic recycle pits and constructed wetlands) on a heavily modified floodplain in northern Australia. In these anthropogenic waterbodies, constructed wetlands housed significantly higher mean native fish diversity, followed by generic recycle pits and finally ditches, whose communities were numerically dominated by exotic fish. Environmental parameters such as waterbody depth and riparian zone condition were the descriptors that best explained fish community composition across waterbodies. Comparison with collated fish survey data representing broader floodplain-diversity identified that >70% of regional fish diversity was housed in anthropogenic waterbodies, with constructed wetlands alone accounting for 68% of freshwater species known from the floodplain. Additionally,

native species site (?) diversity in constructed wetlands did not differ from site diversity in remnant, relatively intact natural waterbodies, and was significantly greater than species diversity in heavily degraded, natural floodplain habitats. Study results provide strong evidence that anthropogenic waterbodies can make useful contributions to biodiversity conservation through provision of artificial habitat in an agriculture-dominated environment.

Do boat moorings alter fish community composition in an urban estuary?

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As the human population continues to grow, so does the reliance on coastal areas. The increase in human activity has led to an increase in the construction of artificial structures in marine habitats. Differing physical properties of artificial structures in contrast to nearby natural habitats often result in a distinct community composition. Common artificial structures in estuarine habitats include those built for boat storage (marinas and moorings). Boat moorings disturb the benthic habitat and while their detrimental effects on seagrass habitats are well established, their effects on other components of the ecosystem, including fish, are less well understood. Given that fish are often attracted to artificial structures, and that environmental managers in highly urbanised estuary of Sydney Harbour are aiming to reduce the number of moorings in use, we aim to understand how fish communities interact with boat moorings. Utilising underwater video at six sites in Sydney Harbour, we are assessing how fish activity varies at two scales; among sites that contain or lack boat moorings, and within mooring sites variation with distance from existing moorings. We will present the latest data on fish abundance, composition and feeding activity from this ongoing sampling program.

A best practice guide to development and evaluation of designed reef programs. Lessons learnt from a NSW perspective

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Many artificial reef projects worldwide are criticised for their insufficient planning with subsequent impressions of poor performance compounded by inadequate and often irrelevant research objectives set in isolation from the objectives or perceived risks of the reefs installation. The approval and subsequent long term operation of artificial reefs in offshore coastal waters around Australia is permitted through a complex legislative framework that varies at a State and Territory level. However, reefs planned in open waters (including within the 3 nautical mile state water limit) are required to obtain an artificial reef permit, also known as a sea dumping permit, under the Environment Protection (Sea Dumping) Act 1981. The conditions placed on artificial reef proponents by this

permitting process provides an ideal framework for justifying and establishing long-term monitoring programs aimed at addressing consent conditions, while providing a longer term data set with broader applications. What is advantageous is that proponents are provided the opportunity to draft monitoring plans based on their own expertise and resource availability that investigate identified high level impacts and perceived long term operational risks. In NSW, a number of offshore artificial reefs have been established under this existing legislative frame work and the NSW DPI has maintained and continues to refine its artificial reef monitoring program. A case study is presented that outlines the complexities of this permitting process and illustrates the very important link between management objectives and research priorities promoting a synergy between the two.

Oral Session 33 – ASFB - 1315 – 1500

Environmental Flows

The rise and fall of the Snowy River: consequence of altered flow regime on Australian bass

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Alteration of natural flow regimes is seen as one of the most serious and continuing threats to ecological sustainability of many river systems throughout the world. The Snowy Mountains Hydro Scheme (SMHS) in southeast Australia, provides a good example of changes that can occur in streams when water is transferred and natural flow regimes are altered. We investigated the relationship between flows and recruitment and growth of Australian bass in the Snowy River post-SMHS using contemporary and historic data, and determined the suitability of estuarine regions for spawning (based on salinity and temperature). Results suggest declining flows as a response to the SMHS, and severe long term drought from the mid-1990s, resulted in poor recruitment and an age related decline of the population despite suitable water parameters suggested as being present in the estuary to enable spawning. This strongly suggests failure of downstream pre-spawning migration by Australian bass. It is likely that, without an increase in flows in early spring of suitable magnitude, pre-spawning migration to spawning areas and subsequent natural recruitment of Australian bass, is unlikely to occur.

Basin-wide environmental watering strategy for The Murray-Darling Basin

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In simplest terms, fish need water; therefore, there is great potential for native fish to benefit from water reforms in the Murray-Darling Basin (MDB). The Basin Plan 2012 set a legislative framework to improve management of water resources to alleviate some of the adverse effects of river regulation. One of the key initiatives in the Basin Plan is the development of a Basin-wide environmental watering

strategy (the Strategy). The Strategy will help coordinate the management of environmental water in the Basin and will also guide development of long-term watering plans by each of the MDB states/territory. The Strategy focuses on four key themes of river flows and connectivity; native vegetation; water-birds; and native fish. For each of these themes, the Strategy sets environmental objectives, targets and watering strategies. For native fish populations and habitats, key outcomes in the long-term will be a more diverse native fish community with sustainable populations occupying a greater proportion of their historic distribution. The Strategy also seeks to ensure no loss of native species and contribute to improved movement, recruitment and population structures and distribution of key species.

No flow, no go! Diadromous fish movement in Central Queensland

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This project forms part of the Whitsunday Basin Environmental Flows Assessment Program (EFAP). It is designed to quantify the flow requirements necessary for breeding stimulation and/or migration to estuarine and marine spawning grounds for priority diadromous fish species. Eight mangrove jack (*Lutjanus argentimaculatus*), 16 jungle perch (*Kuhlia rupestris*) and 66 barramundi (*Lates calcarifer*) are currently being tracked in the O'Connell River - a small, unregulated coastal drainage in the Whitsunday region of Central Queensland. Individual fish movements are being monitored over a two year period using acoustic telemetry transmitters (V9) and receivers (V2RW) (VEMCO). The acoustic array has been strategically designed to include waterholes and barriers (e.g. causeways) along the O'Connell River main channel, larger tributaries and estuary, as well as an adjacent river system. River flow data is being obtained from existing Department of Natural Resources and Mines gauging stations and additional in situ loggers where gauging data is unavailable. Movement data collected during this project will aid in sustainably managing water resources in the Whitsundays Water Resource Plan area. Triggers for diadromous fish movements and migration, including the influence of water flow (baseline flow, low flows and flood flows), water quality, barriers to migration and subsequent use of fishways, habitat preference and utilisation (e.g. waterhole use, spawning locations) will be outcomes answered by this project. Specifically, these outcomes will help define the availability of water in the O'Connell River sub-catchment and help establish environmental flows that maintain a balance between continued use of water resources and natural ecosystem functions.

Ecological risk assessment of the Burnett Basin Water Resource Plan

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An ecological risk assessment was conducted as part of the ten-year review of the Burnett Basin Water Resource Plan (WRP). This plan is subordinate legislation under the

Water Act 2000 and is the framework for allocation and management of water within the Burnett Basin in south-east Queensland. The science used in the risk assessments was the result of ten years of research targeting the critical water requirements of ecological assets. (Environmental Flows Assessment Program (EFAP) Ecological risk assessments tested the changes to the critical water requirements for ecological assets using a daily hydrological model. Different scenarios were tested and compared to 'natural' scenarios. The risk to assets posed by changes in the flow regime were then communicated to stakeholders, along with further explanation of the results where required. As the risk assessment was to be used to make decisions on water management, stakeholder involvement in the process was critical and consultation provided a good understanding on community values. The outcome was a successful adoption of new environmental management rules for dams that will provide environmental benefits to the aquatic environment, whilst still delivering outcomes for the community and water stakeholders. These changes were both supported by water managers, dam operators and the community primarily because there was trust in the science and two-way communication throughout the process.

Quantifying the freshwater flow requirements of Estuarine Fish

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Estuaries are naturally dynamic and complex environments characterized by large spatial and temporal fluctuations in abiotic conditions. This complexity can make it difficult to work out how different environmental variables affect biological processes. Nonetheless, freshwater inflows are widely acknowledged as a master driver in estuaries. Flows deliver nutrients that promote system productivity, mediate habitat availability, provide cues for spawning and affect water column stratification and water residence times that, in turn, influence larval fish retention and survival. Here, we discuss the results from two studies that have used the unique information naturally archived in otoliths to quantify the role of flow in driving growth and recruitment patterns in co-occurring estuarine fish. Our biological time series, up to 46 years in length, show that flow can have disparate effects not only among species, but also among traits within species. Black bream recruitment is highest during low-flow periods whereas estuary perch recruitment is highest in high-flow periods. Estuary perch recruitment is related to high flows in the spawning season whereas estuary perch growth is related to low flow conditions across the year. Combined, our results have important implications for the management of freshwater flows into estuaries because the provision of water for one species may detrimentally affect another, and different types of flows benefit different aspects of a species' biology. These disparate patterns are likely to occur in other estuarine systems, making predictions of future population productivity and flow recommendations challenging.

Using a population model to manage flows and carp

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Environmental water allocation is considered an essential management tool for the rehabilitation aquatic environments within the Murray-Darling Basin (MDB). Carp are a widespread and abundant alien pest fish species whose populations may expand rapidly following flooding. Hence, there is concern that environmental watering may lead to increases in Carp populations. This paper illustrates the utility of a carp population model to investigate carp population dynamics under a range of flow scenarios, including: natural floods; within-channel flows, targeted delivery to floodplains and wetlands and; flow sequences. Recommendations from this work include ensuring that: environmental flow objectives for native biota remain paramount; carp are managed as a coincident risk in conjunction with water management; carp management plans are developed and implemented for each carp 'hotspot' and major watering site; and there is monitoring of the response of carp populations. Case studies are presented for four habitat types in the lower MDB 1) terminal lakes, 2) floodplain redgum forest, 3) complex river channel system and 4) artificial floodplain inundation using a regulator. These case studies highlight the unique nature of outcomes, depending on site, time, location and management/flow regime.

Recruitment dynamics through time and space: A multi-population investigation of Macquarie perch recruitment across Victoria

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Knowledge of the reproductive ecology and subsequent recruitment dynamics underpin the conservation and management of fish populations. A wide range of biotic (e.g. competition, predation, disease) and abiotic (e.g. flow attributes, temperature) factors influence the recruitment processes of fishes, with strong recruitment produced when combinations of such factors align. Research investigating the role of flows in governing fish recruitment in Australian temperate rivers has risen dramatically over the past decade, due largely to the restoration approach of environmental flows. Much of this work however, has focussed on flow-dependent species with a well described link between key population processes (e.g. spawning) and flows. However, our understanding of the key drivers influencing recruitment dynamics of more generalist species, which dominate Australian temperate systems, remain limited. The nationally endangered Macquarie perch *Macquaria australasica* are one such species. This project examines the spatio-temporal dynamics of Macquarie perch recruitment across Victoria. Specifically, we

investigate how key biotic and abiotic variables, in particular flow and temperature, influence recruitment strength by analysing survey data of five Macquarie perch populations from 2007 - 2015. Results are discussed in relation to implications for environmental water management and the phenomenon of spatial synchrony. We also discuss the applicability of our approach to generate similar information for other long-lived fish species, such as Murray cod.

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Tech. Ecol. Telemetry

Optimising the integrity of a national network of acoustic telemetry research infrastructure in Australia

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The Australian Animal Tracking and Monitoring System (AATAMS) is part of the Integrated Marine Observing System (IMOS), a national, collaborative research infrastructure program. IMOS brings together universities and publicly funded research agencies working in marine and climate science. AATAMS supports a national acoustic tracking and monitoring network currently comprising more than 175 registered researchers using 2000+ acoustic receiver stations in arrays to track over 110 species. The resultant 60 million (and growing) detections comprise one biological component for IMOS data streams that also include oceanographic and meteorological observations. After almost a decade of acquiring acoustic telemetry data nationwide, we analysed the number of detections, transmitters, and detected species per station of the AATAMS arrays to improve their existing design and thereby reduce service costs. While some arrays already displayed an optimal configuration, others had room for improvement regarding the number and position of acoustic receiver stations. This cost-benefit analysis will streamline this national research infrastructure to ensure its sustainability and viability as a publicly funded facility into the future. Additionally, results from this meta-analysis will provide guidance for scientists wishing to maximise the output from their own acoustic arrays. Performing this analysis is critical to secure potential funding for the collection of long-term datasets that are vital to detect and predict changes over long time periods. The AATAMS national acoustic tracking and monitoring network is a unique ocean observation platform that will continue to be pivotal in defining how aquatic management practices and policy decisions evolve with changing climatic conditions.

Identifying movement patterns of reef predators: A network modelling approach

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Reef predators are known to play a central role in maintaining coral reef ecosystem structure and function. Modelling intra-reef movements provides a better understanding of the complex interaction between predators and their environment. Long-term movements of *Caranx ignobilis*, *Carcharhinus albimarginatus* and *C. amblyrhynchos* individuals were tracked using acoustic monitoring in central Great Barrier Reef from 2012 to 2014. Using network modelling, network structure of predators' intra-reef movements was examined and compared to four simulated theoretical networks with known properties. Network properties were similar between species, however, significantly different between reefs. Individuals at Helix Reef moved more and had more paths than those in Lodestone and Wheeler reefs. Individuals at Lodestone Reef had more clusters and moved more rapidly and directly than those in Wheeler Reef. All three species exhibited similar network structures with rapid and direct intra-reef movements, high number of clusters which indicated they used specific parts of a reef; characteristics that have been identified in a variety of real-world networks. However, individual network structures varied greatly, ranging from scale-free and small-world to random networks and may be due to reef differences. Network modelling provided insight into predator intra-reef movements that assist in the development of effective management plan.

High-precision, low-cost animal positioning in passive acoustic telemetry

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Passive acoustic telemetry is a widely used tool to study the behaviour, movement and site fidelity of fish in both marine and freshwater environments. However, the poor resolution of location data sometimes prevents the identification of fine scale patterns of habitat use. Two methods are commonly used to obtain finer positioning. The first, which requires careful design and implementation, is to obtain high precision estimates of animal location using hyperbolic positioning for example the Vemco Positioning System (VPS). The second method, is to calculate rough Centers of Activity (COA) based on

weighted means of the detecting receivers' positions. Here we present a third—recently developed—method based on a state space model of fish locations. We benchmarked the positioning error of the three available methods against GPS positions of a boat-towed tag. We found that the state space model which integrates the fish movement process, and both detection and non-detection probabilities offers position estimates that are comparable to VPS at a fraction of the cost. VPS is more accurate under ideal conditions, but our model is more robust to increased environmental noise or structural complexity. While computationally more intensive, the proposed approach is vastly superior to COA. By offering high-precision low-cost estimates of fish position, we believe this method has the potential to have a large positive impact on both current management approaches, and fish spatial ecology research. Finally, we introduce 'PACTeR', an R-package with a suite of statistical tools to easily estimate animal positions, and to analyze and interpret acoustic telemetry data.

Partial migration of marine predators: Is habitat the key?

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Understanding animal movement decisions that involve migration is critical for evaluating population connectivity, and thus persistence. Recent work on sharks has shown that often only a portion of the adult population will undertake migrations, while the rest may be resident in an area for long periods. Defining the extent to which adult sharks use specific habitats and their migratory dynamics is essential for assessing the risk of exposure to threats such as fishing and habitat degradation. The present study used acoustic telemetry to examine residency patterns and migratory behaviour of thirty-three adult bull sharks (*Carcharhinus leucas*) along the East coast of Australia. Males and females were detected in the central Great Barrier Reef (GBR) year-round, but their abundance and residency peaked between September and December across years (2012-2014). A large portion of the population (49%) undertook migrations of up to 1,400 km to other coral reefs and/or inshore coastal habitats in Queensland and New South Wales. Most of these individuals were mature females, and the timing of migrations coincided with the austral summer (Dec-Feb). All migrating individuals (except two) returned to the central GBR, highlighting its importance as a potential foraging ground. Our findings suggest that adult bull sharks appear to be highly dependent on coral reef resources and provide evidence of partial migration (females may undertake seasonal reproductive migrations, potentially to give birth). Given that estuarine habitats face constant anthropogenic pressures, understanding partial migration and habitat connectivity should be a priority in adult bull sharks.

Individual variation in juvenile blacktip shark movement patterns in a tropical coastal nursery

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This study examined the residency and space use of young of the year (YOY) and juvenile Australian blacktip sharks, *Carcharhinus tilstoni* in a northern Australian nursery using acoustic telemetry. The goal of this study was to compare *C. tilstoni* movements to those of other nursery species. Presence and space use patterns exhibited by *C. tilstoni* were highly variable among individuals. The majority of YOY left the nursery area within three months of release, while most juveniles exhibited long-term residency (6 months - 1 year). In addition, YOY individuals used smaller amounts of space than juveniles. Variable activity space size and location also indicated individuals used different areas and often moved into new areas. High individual variation in residency and space use in juvenile populations is atypical and starkly contrasts with other shark nursery species, many of which are known to exhibit high residency and consistent space use patterns. The unique patterns observed among *C. tilstoni* may be due to a number of factors, including differences in nursery habitat, population structure, resource availability, and the impact of competition. Further study of *C. tilstoni* populations in this and other regions will help elucidate differences in habitat use to that of the widely accepted norm for sharks in coastal nursery areas. This study highlights the importance of investigating nursery behaviour across different habitats and populations.

Temperature-mediated spawning migrations of an estuarine dependent sillaginid

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Understanding spawning cues and movement dynamics of fish is fundamental in determining which environmental and physical conditions contribute to spawning success. Acoustic telemetry was used to examine the large scale (>1 km) movements of *Sillago ciliata* in two estuaries in southern NSW between 2009 and 2013. Movements were typified by regular rapid migrations, which would only occur during the spawning season, from upstream residences to locations adjacent to river entrances. Movements would consist of between 5 and 30 migrations across distances up to 50 kilometres. *S. ciliata* displayed high levels of fidelity for to both spawning locations and upstream residences.

These spawning movements were followed by periods of decreased activity and reduced movement throughout the estuary. Further examination of movements during the spawning season showed that fluctuations in oceanic water temperature and increased freshwater flow triggered downstream migrations. Increases in oceanic water temperature during the spawning season are driven by strengthening of the EAC caused by southerly trade winds. We suggest that *S. ciliata* requires increased temperatures to progress larval development and strong northerly currents to aid in dispersal.

Where are my PJs? Movement of Port Jackson sharks at breeding aggregation sites

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Understanding the movements, site fidelity and behaviour of mesopredator species is essential for understanding their basic ecology, defining their role in ecosystems and assessing the potential effects of human impacts on populations. This study investigated the movement patterns of adult Port Jackson sharks (PJs; *Heterodontus portusjacksoni*), a highly abundant mesopredator in temperate marine ecosystems. Acoustic tracking data from PJs were collected between 2012 and 2014 to monitor shark movements within the Jervis Bay Marine Park and examine sex-specific differences in space use and site fidelity. We found that PJs show extremely high levels of site fidelity at their breeding aggregation sites, with males showing a significantly higher level of site fidelity than females. On average, 98% of all male detections occurred at their preferred location in Jervis Bay compared to 83% for female PJs. There was no correlation of site fidelity level and total length of the individuals for either sex, suggesting site fidelity is not significantly influenced by age. Further, intra-specific variation was observed in the spatial and temporal patterns of movement within Jervis Bay, with some sharks displaying more crepuscular detection patterns, while others appearing more diurnal. The findings of this study highlight the importance of considering individual variation in behaviour, which may be driven by a combination of demographic factors and environmental variables. In addition, the high levels of site fidelity detected for PJs in this study may be a strategy used by individuals to increase their reproductive success through increased familiarity to habitat, food resources and conspecifics.

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Est. Coast Con. Hab

Detecting impacts of nutrient pollution in tropical Australian estuaries

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Coastal communities must manage their use of estuaries to maintain the livelihoods and lifestyles provided by these

systems. However, estuaries and their component habitats are increasingly faced with degradation from pollution and development. For instance, increases in agricultural land use in Great Barrier Reef catchment areas produces an increasing flow of nutrients to coastal waters, causing varying degrees of eutrophication, with potentially damaging follow-on effects. The study investigated the immediate (days-weeks) to longer (weeks-months) term effects of terrestrial runoff in estuaries in tropical north Queensland. We assessed the biomass and stomach contents of key ichthyofauna (Clupeoid, Leiognathid) groups and Penaeids. Our data shows significant changes in diet composition of the consumer groups after nutrient pulse events. Comparisons of near-pristine estuaries and those with high levels of agricultural land use revealed significant differences in biomass of certain consumer groups. Stomach content analysis results demonstrate changes in productivity sources following longer term increases in nutrients in estuaries. Therefore this study may be used to provide extremely useful indicators of system health and the effects of nutrient pollution on tropical estuaries. The results will enable managers and industry to better regulate use of the Great Barrier Reef's catchment areas to protect valuable community and industry resources. Furthermore the study also provides a comprehensive assessment of medium term and direct impacts of nutrient pollution on the productivity and trophic relationships of tropical estuarine fish communities.

Habitat condition underpins fish biodiversity within estuarine sponge gardens

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Estuarine sponge gardens are considered key habitats for many ecologically, culturally and/or economically important fishes. Given these habitats face real threats from both natural (e.g. sediment smothering from storms) and anthropogenic (e.g. anchor damage, coastal development) disturbances, we need to understand how fishes respond to differences in sponge habitat condition. We explored how the composition and canopy structure of sponge habitats inside and outside a sanctuary zone of Port Stephens Great Lakes Marine Park, New South Wales, were related to patterns of fish diversity and biomass in two common fish families (Labridae & Sparidae). Underwater visual surveys of fish and habitat condition ($n = 8$ per site) revealed that mean canopy height, sponge functional group, and sponge percentage cover were key predictors for fish diversity and abundance. Once habitat was taken into account, we also found an overarching positive effect of sanctuary zones upon fish biomass within the fisher-targeted Sparidae species. Our results suggest an overriding influence of habitat condition upon fish biodiversity within a temperate estuary, which should be considered in spatial management programs to monitor and protect key fish habitats in the face of both natural and anthropogenic threats.

The functional role of soft coral in temperate estuaries

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Identifying the functional role of organisms is critical to ecosystem conservation because it allows the focus of management to be on the protection of those species whose roles are closely linked to ecosystem processes and function. The soft coral *Dendronephthya australis* exists within a limited distribution along the central NSW coastline, forming a habitat that supports commercially significant and protected marine species. Within the Port Stephens Great Lakes Marine Park (PSGLMP) *D. australis* habitat exists exclusively outside the protection of 'no take' sanctuary zones and is vulnerable to human disturbance from recreational activities such as fishing and boating. The functional role of *D. australis* was assessed and compared to that of sponge habitats, a similarly structured and abundant benthic invertebrate which happens to occur within marine park sanctuary zones. Samples of marine organisms, from primary producers to tertiary consumers, were collected from *D. australis* and sponge habitats within PSGLMP in summer 2014. In total 300 samples representing over 60 individual species were collected. Stable isotope analyses of $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ were used to construct food web models of soft coral and sponge communities. The flow of energy within each habitat was determined, trophic links between *D. australis* and other species identified, and the food web structure of both communities compared. The results highlight the significance of the ecosystem services provided by the soft coral and underpin the need for conservation management of this species.

Physiological plasticity versus inter-population variability: understanding drivers of hypoxia tolerance in a tropical estuarine fish

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Physiological plasticity and local adaptation are two key drivers in determining the capacity for species to cope with environmental change, yet the relative contribution of each parameter has received little attention. Here, we investigate the acclimation potential of two geographically-distinct populations of the barramundi (*Lates calcarifer*) to diel hypoxia. Fish were exposed to a daily hypoxia challenge of 6 h below 62% saturation, down to a minimum of $10 \pm 5\%$ saturation, followed by a return to normoxia. Respiratory and haematological variables were assessed after 8 and 16 d of daily hypoxia exposure. Hypoxia tolerance (measured as the critical oxygen tension; $[O_2]_{crit}$) was not different between populations and not different from control fish after 8 d, but improved similarly in both populations after 16 d. This improvement corresponded with increases in

haematocrit and haemoglobin, but not an increase in the mean cell haemoglobin concentration. Given the similarity of the response between these two geographically-distinct populations, we conclude that hypoxia tolerance for barramundi may be more dependent on physiological plasticity than inherent variability between populations.

Genetic patchiness among recruits of *Girella elevata*: spatial and temporal variation in genetic composition

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Understanding the magnitude and pattern of connections among populations and the temporal variation in these patterns are essential for the design, implementation and administration of fisheries stock management and conservation strategies. Investigating the intra and inter year genetic variation of recruitment will increase our understanding of the repercussions of variation in recruitment success and yield important spatial and mechanistic insights into patterns of larval dispersal. To explore this, we examined the spatial and temporal variation in population genetic structure of adult and recently settled juvenile populations (from 3 years) of *Girella elevata* using microsatellite markers. *Girella elevata*, is a large (up to 76cm) long-lived species that has a range between 27°S and 39°S on the east coast of Australia which experiences considerable recreational fishing pressure throughout this geographical range and has recently been shown to have high levels of residency. The proportion of the total genetic variation attributable to differences between regions and locations (~800km) for the adults was effectively zero ($F_{st}=0.008$). In contrast, the juveniles showed significant heterogeneity in allele frequencies among years and in some cases reduced genetic diversity when compared to the adult populations indicative of sweepstakes recruitment. This result suggests that the adults, with several year-classes, are capable of maintaining a panmictic population over large spatial scales despite the genetic distinctiveness of individual year-classes at fine spatial scales. This result has implications for the management of marine populations as temporal variability in recruitment may act to promote long term stability of populations, it is therefore essential that management strategies account for this variability.

A biophysical model to assess trade-offs in larval recruitment and catch in Southern Australia's largest Prawn fishery

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Data from stock assessment surveys, published research, and climate and ocean sensors was linked to model the

interaction between fishing, physical-oceanographic processes, and spatial patterns of larval settlement for western king prawn (*Penaeus (Melicertus) latisulcatus*). This information was used to evaluate the trade-off between larval recruitment and catch by the Spencer Gulf Prawn fishery (SGPF) during pre-Christmas fishing periods that demand high prices but coincide with spawning. Total rates of larval settlement were maximised when tidal currents and atmospheric physical-forcing components were coupled with simulations of larval swimming behaviour under average gulf temperatures. Average gulf temperatures sustained longer larval durations and increased larval settlement rates by over 12% compared to warmer gulf conditions simulated under a scenario of global warming. Reproductive data coupled with outputs from the biophysical model identified consistent inter-annual patterns in the areas contributing to larval settlement success. Areas located in the north-east, and central-west of the fishery, consistently contributed to over 40% of all larvae reaching settlement in each year. Harvest sensitivity analyses indicated that changes in the spatial patterns of pre-Christmas fishing could lead to improvements in overall rates of larval settlement while maintaining or improving the levels of catch. Real time application of the biophysical model in the future could allow target exploitation rates to be capped within the areas that contribute most to larval settlement, thereby helping to maximise rates of larval settlement and catch across the fishery. This approach could augment current management strategies for pre-Christmas fishing in the SGPF and help to manage the potential threats of recruitment overfishing.

Expatriation of tropical reef fish recruits along the EAC

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Tropical reef fish recruits have been recorded along the southeast coast of Australia, particularly in New South Wales since early 2000. Reef fish recruits are 'hitching a ride' with the East Australian Current (EAC) as far south as Merimbula NSW. Our aim was to determine the connectivity of tropical vagrant fish along the SE coast. A total of 629 individual samples for 3 species were collected, sequenced for three mitochondrial loci (cytochrome b, control region and cytochrome oxidase I) and analysed. The range of sampling includes Lizard Island, One Tree Island (Capricorn bunker) on the GBR and south along the NSW coast to Merimbula. Here we present the first comprehensive molecular results for all three species.

Oral Session 36 – ASFB - 1315 – 1500

Fish Energ. Behav.

Fish energetics from the lab to the field: respirometry, tagging technologies, and understanding the impacts of climate change

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The foundation of ecologically-relevant experimental research begins with accurate and robust measurements. Failure to achieve this initial benchmark produces a chain of events leading to significant wastage of time and money, as scientists try to pursue previous claims that ultimately prove to be misleading and non-replicable. Once accurate and replicable data have been established under controlled conditions, the data may then be used to formulate hypotheses and parameterise models, such as those used to understand and forecast the impacts of climate change. The field of ecological energetics has the potential to contribute significantly to our understanding of how fishes respond to natural and anthropogenic environmental challenges. A critical step in this process is to apply data from controlled experiments to fishes in their natural environment, yet this step often represents a significant challenge. Bio-logging and bio-telemetry offer opportunities to bridge the gap between lab- and field-based research, test lab-derived hypotheses, and gain a more comprehensive understanding of animal-environment interactions. Fish energetics encompasses the acquisition and usage of energy, the former via food and the latter via several pathways including activity, digestion, reproduction and growth. Single-sensor technology is unlikely to provide a complete picture of the energy budget, whereas a combination of sensors (e.g., heart rate, acceleration, temperature, pressure) may enable a more comprehensive and accurate assessment. In this presentation, I will discuss (1) proper respirometry techniques in fishes, (2) calibrating and validating metabolic data against measurable proxies, (3) available technologies for measuring key proxies of energetics, and (4) how energetics can provide insight into the impacts of climate change on fishes.

The unthinking depths: Energetic constraints on encephalization in marine fishes

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Several hypotheses have been proposed to explain the limitation of brain size in vertebrates. Here we test three hypotheses of brain size evolution using marine teleost fishes: the direct metabolic constraints hypothesis, the expensive tissue hypothesis, and the temperature-

dependent hypothesis. Our analyses indicate that there is a robust positive correlation between encephalization and basal metabolic rate that spans the full range of depths occupied by teleosts from the epipelagic (< 200m), mesopelagic (200-1000m), and bathypelagic (> 4000m). Our results disentangle the effects of temperature and metabolic rate on teleost brain size evolution, supporting the direct metabolic constraints hypothesis. Our results agree with previous findings that teleost brain size decreases with depth, however, we also recover a negative correlation between trophic level and encephalization within the mesopelagic zone, a result that runs counter to the expectations of the expensive tissue hypothesis. We recommend that comparative encephalization studies control for basal metabolic rate in addition to controlling for body size and phylogeny.

Swimming speed and oxygen consumption of adult King George whiting: influence of temperature

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There has been considerable interest in how temperature influences the metabolic rate (oxygen consumption) and swimming speed of fish, as most of the biological activities of fish are dependent of their ability to move. These two parameters were measured in adult King George whiting (*Sillaginodes punctatus*), a temperate reef fish, under two temperature regimes (16 and 26 °C). Fish were swum in a Brett-type swim chamber respirometer until they reached maximum swimming capacity, whereby the critical swimming speed was calculated. Subsequently, fish were immediately transferred into a resting chamber where maximum and minimum metabolic and the aerobic scope of activity were calculated. At higher temperatures, fish swam longer, consumed more oxygen, recovered quicker, and had a higher aerobic scope of activity compared to fish at lower temperatures. Increased activity and metabolism of fish at a higher temperature may mean that under increasing temperatures, associated with climate change, fish may be able to move more easily to avoid predators and find food.

Improving consumption rate estimates by incorporating wild activity into bioenergetics models

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Consumption is the basis of metabolic and trophic ecology and is used to assess an animal's trophic impact. The contribution of activity to an animal's energy budget is an

important parameter when estimating consumption, yet activity of wild animals has not yet been incorporated into estimates of consumption rates. We calculated the consumption rate of a free-ranging marine predator (yellowtail kingfish, *Seriola lalandi*), by integrating the energetic cost of free-ranging activity into bioenergetic models. Accelerometry transmitters were used in conjunction with laboratory respirometry trials to estimate kingfish active metabolic rate in the wild. These field-derived consumption rate estimates were compared to those estimated by two traditional bioenergetic methods. The first derived routine swimming speed from fish morphology as an index of activity (a 'morphometric' method), and the second considered activity a fixed proportion of standard metabolic rate (a 'physiological' method). The mean consumption rate for free-ranging kingfish measured by accelerometry was 152 J g⁻¹ d⁻¹, which lay between the estimates from the morphometric method ($\hat{\mu} = 134$ J g⁻¹ d⁻¹) and the physiological method ($\hat{\mu} = 181$ J g⁻¹ d⁻¹). Incorporating field-derived activity resulted in the smallest variance in log-normally distributed consumption rates ($\hat{f} = 0.31$), compared to the morphometric ($\hat{f} = 0.57$) and physiological ($\hat{f} = 0.78$) methods. Incorporating field-derived activity into bioenergetics models likely provided more realistic estimates of consumption rate compared to the traditional methods, which may further our understanding of trophic interactions that underpin ecosystem-based fisheries management. These methods could be extended to examine ecological energetics and trophic interactions across aquatic and terrestrial ecosystems.

The response of juvenile Eastern King Prawns (*Melicertus plebejus*) to rapid changes in salinity associated with flooding of estuarine nurseries

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Anecdotal reports from fishers in the Eastern King Prawn (*Melicertus plebejus*; EKP) fisheries of QLD and NSW coupled with catch data have alluded to the potential existence of a relationship between declines in EKP landings and significant rainfall events. Juvenile EKP reside in estuaries which are subject to large and rapid changes in salinity associated with rainfall. While EKP are relatively stenohaline, their capacity to adapt and tolerate salinity changes may depend on the rate of decline and the salinity reached. Changes in physiology, behaviour or survival due to drops in salinity may impact the numbers and the size of individuals recruiting to the fishery. This study manipulated the rate and magnitude at which salinity changed and assessed mortality, behaviour, and metabolic rates of EKP. Juvenile EKP were exposed to salinity decline over 24 hours to concentrations covering the range possible within an estuary setting (36-0), with the salinity then maintained for 5 days to emulate an extended period of freshwater flow. Survival was 100% at salinity >16. Mortality increased below this point with the LC50 reached at a salinity of 8. At salinities <20, prawns had a reduced appetite and altered

metabolic rates, which would likely result in reduced growth. Prawn activity was also different at low salinities, potentially exposing them to increased risk of predation. This experiment provides an explanation for reduced catches of EKP as a function of greater mortality and slower growth of juveniles as a result of changing physico-chemical conditions within the estuarine nursery.

Bioenergetics modelling of the fish and shark population dynamics to environmental fluctuations in SE Australia

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Individual-level bioenergetics processes are important to understand for fisheries management as they influence population and ecosystem dynamics. We developed an individual-based bioenergetics and coupled population dynamics model's (IBM) for tiger flathead and dogfish within the southeast fishery. The models were implemented to examine the effects of food and temperature fluctuations on various population parameters, including size and maturity-at-age. The models were developed within the framework of the Dynamic Energy Budget theory and parameterised using local biological datasets and unique energetics measurements. Reference simulations used temperature and prey density forcing variables based on remote sensing data and outputs of biogeochemical models. For both species, model simulations successfully captured ontogenetic and seasonal growth patterns with inter-individual variability in life-history characteristics well represented. These models provide powerful tools, in which we exploit, to test hypotheses concerning population responses to short and long-term environmental and climatic variance.

Oral Session 37– ASFB - 1530 – 1715

Artificial Habitat

UTS Decommissioning Ecology group: filling science gaps in evaluating oil and gas infrastructure options

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Worldwide, more than 6000 oil rigs are set to be decommissioned in the next decade. Options include total removal, toppling in place and towing to deeper water. Opportunities include artificial reef fish attraction/production and consequent commercial or recreational fisheries. However, ecological understanding of options is surprisingly limited, as are rigorous protocols that evaluate options against ecological, societal, engineering and business benefits. I will discuss these issues with examples from our research into fish residency, infrastructure biodiversity value, and biological connectivity, and our development of a decision method. We urge an evidence-

based approach to oil rig decommissioning, and the objective evaluation of the ecological costs and benefits of all decommissioning options.

Righting the wrong: fish habitat enhancement of Harbour pontoons

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Since the time of the first European settlement, natural foreshore in Sydney Harbour and surrounding estuaries has been heavily developed. Urban estuaries are commonly flanked by built structures such as seawalls wharves, and large numbers of public and private pontoons which replace natural habitat. Pontoons may shade previously-existing seagrass beds and so negatively impact fish assemblages, however, they can also attract fishes. We tested the effectiveness of adding small structures under estuarine pontoons to enhance fish species richness and abundance in 4 Sydney estuaries. Compared to control pontoons, enhanced pontoons showed elevated species richness, including several species not previously seen on the pontoons. Some fish species responded directly to complexity of added habitat. We suggest that small increases in pontoon complexity may be beneficial and partly offset pontoon effects on natural habitat.

Multi-purpose Marine Farm

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Purpose-built artificial reefs that have been deployed in Australian waters over the past decade have shown their effectiveness as fisheries enhancement tools. Overseas, modern day marine farms (also known as sea ranches) are created by careful design using a range of different purpose-built artificial reef complexes in mostly coastal waters to collectively form a broad, complex breeding ground to sustainably conserve and increase aquatic resources and restore marine habitat, mainly for the purposes of fisheries enhancement, sea re-forestation, and to increase tourism revenue. The purpose-built artificial reefs must be designed for the prevailing wave, current, water depth, sediment conditions and weather, including cyclonic events and for the target species. Reef designs can be categorized into those for seaweed, shellfish and fish species in general. They are an eco-sustainable fisheries management tool that contributes to direct and long-term ecological and economic benefits. Multi-purpose marine farms enable us to restore natural resources and increase biodiversity, and also to generate a stable supply of marine products, increased carbon absorption, diverse leisure activities and eco-tourism.

Estimating fish production on an artificial reef using Ecopath with Ecosim

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Australia

The ability of artificial reefs to produce new fish biomass is uncertain. It is difficult to distinguish redistributed biomass from new biomass, and production is generally inferred for single species. We developed an ecosystem model for a temperate coastal system, using Ecopath with Ecosim (EwE), to determine the ecosystem's response to additional reef habitat. This model contained 37 trophic groups, multiple fishing fleets, and a small spatial extent of 3x3 km to represent a typical temperate coastal area out to the 50 m isobath. It combines multiple sources of data, including reef fish biomasses estimated in the Reef Life Survey, and commercial catch data. The ecosystem model shows that increasing reef habitat does increase biomass, although much is non-fish biomass, such as macroalgae. The model also shows that the amount of new biomass produced is non-linear with amount of reef area. Given the small size of this ecosystem, the net import of energy is a key process that greatly alters model outputs. In particular, the import of plankton into the system is an essential (and probably real) process maintaining the high fish biomass observed in coastal regions. Further use of mass-balanced models will provide much clarity to the artificial reef 'production vs attraction' debate.

Considerations of tidal flow for enhancing coastal and estuarine fisheries

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Flow of current is an essential consideration for marine fisheries enhancement. Since most commercial fish spawn in coastal waters, then a prime justification for restocking is when the estuarine population is recruitment limited by a berm or sand-bar, preventing tidal flow. Three recent examples reveal how flow has surprising influence on restocking and designed artificial reefs. We have discovered recruitment hotspots in 2 estuaries correspond to seagrass beds with low flow, adjacent to channels with a large tidal volume. Therefore enhancement of natural recruitment could be made in degraded or urbanised estuaries by deploying artificial seagrass adjacent to major tidal channels. We have also found that the passage of juvenile fish (mostly mullet, estimated from a Didson acoustic camera) in and out of an estuary is correlated with current velocity, and only occurs during tidal flow. During period of slack tide no fish movements are observed. Off Sydney, coastal currents transport many kilograms of zooplankton per day past the sessile invertebrates and planktivorous fish covering an offshore artificial reef. Around this 12x15x12 m reef we estimate planktivorous fish alone harvest ~1% of zooplankton per day, which was produced 40 to 80 km upstream over the continental shelf. We have found the recreational fishery over a year harvests approximately 3 kg per day. Coastal flows and zooplanktivory are important considerations in the deployments of more designed reefs off an urbanised coast.

Southwest habitat enhancement structure trial: A work in progress

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Habitat enhancement structures (HES) have been used throughout the world over many years for a number of purposes including enhancing habitat for target species, creating recreational fishing and tourism opportunities, aquaculture and restoring or mitigating pressure on natural areas. In 2013 two purpose built recreational fishing HESs were deployed in the Geographe Bay area, off Bunbury and Dunsborough as part of a dedicated trial to investigate their effectiveness in south western WA. The 3x3 m reinforced concrete fish boxes were thought to be suited to the target species of Samsonfish (*Seriola hippos*), snapper (*Chrysophrys auratus*) and silver trevally (*Pseudocaranx dentex*) and were located to be accessible to smaller recreational vessels. The installations are to be assessed to meet the broad management objectives of increased accessibility to the resource for recreational fishers and their effectiveness in the Geographe Bay region. The monitoring plan for the southwest HES trial was developed over a 12 month period with input from a scientific reference group considering objectives and regulatory requirements along with budgetary, logistical, and OSH constraints. The result was a comprehensive plan covering biological, ecological, social and structural aspects of the trial. Details of the monitoring for the biological and ecological components along with preliminary results from the first 2 years of the Southwest HES trial will be given in the presentation.

Oral Session 38 – ASFB - 1530 – 1715

Environmental Flows

eFlows and physical barriers to catadromous downstream spawning migration

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Facilitating fish migration along regulated river networks has progressed rapidly in Australia through improved fishway design and knowledge of environmental flow needs. Barrier mitigation measures generally focus on facilitating upstream passage for the majority of migratory species, however less is known of the environmental flow needs and fishway designs that enable downstream passage of adult catadromous species for spawning. We observed the migratory behaviour of three catadromous species: *Percolates novemaculeata*, *Mugil cephalus* and *Trachystoma petardi*, over 24 months using passive acoustic telemetry and RFID technology to determine downstream migration queues, movement patterns and the effect of barriers in the Logan River, a moderately regulated system in south-east Queensland. We found that for all three species, adults commenced downstream migrations

during pre-spawning periods on relatively small natural flows. However, fish were often delayed by barriers despite the presence of fishways that have proven effective for upstream passage. Successful downstream movement past barriers over the crest of the weir typically only occurred once river levels surpassed a height and flow threshold. The reluctance of fish to utilise fishways during downstream movements could potentially lead to population level impacts as significant as ineffective upstream passage. We argue that current mitigation measures to facilitate upstream migration past barriers may not be effective to facilitate movements downstream for spawning and research is required into the specific environmental flow and fishway design needs to cater for downstream migrating adults of catadromous species.

The ecology of Lake Eyre basin fishes: Hydro-climatic drivers and fish assemblage dynamics in Australia's desert river basin

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Lake Eyre Basin (LEB) is the largest endorheic basin in Australia. Its catchment is entirely arid or semi-arid with all major rivers either disappearing completely beneath desert sands or draining into ephemeral salt lakes. During large floods, however, the system is flushed with enormous volumes of fresh water enabling biota to reconnect across landscapes from critical aquatic refuges such as deep waterholes or artesian springs. Fish, being entirely aquatic, are an excellent indicator of the climatic and hydrological drivers that control ecosystem dynamics in this unique, unregulated and largely unimpacted Basin. Over the past decade, fish surveys have been conducted at multiple scales across the LEB by regional, State and cross-jurisdictional projects using common methodologies and sites. Data from Lake Eyre Basin Rivers Assessment (LEBRA), SA Aridlands NRM Board projects and ARIDFLO data to enable a Basin-wide assessment of the relationship between climate, hydrology, refuge habitat and fish population dynamics in the LEB. This project has enabled the analysis of a unique combination of broad scale spatial and temporal data. Data analysis was undertaken as part of the Goyder Institute for Water Research's GLEB project to investigate approaches for assessing environmental condition and help inform the LEB Ministerial Agreement. Analysis of data revealed discrete functional zones across the Basin where fish assemblage dynamics responded in similar and potentially predictable ways to environmental drivers. Functional zones correspond closely with patterns in hydrology, fluvial geomorphology and refugial dynamics and provide an opportunity for using long-term monitoring data to assess Basin-scale environmental condition within the hydro-climatic context of LEB.

Monitoring environmental flows in Queensland: The next generation

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Like many other areas of Australia, water planning in Queensland has evolved into an adaptive management framework. Many of the water resource plans, which provide the framework for allocation and management of water, have been in existence for nearly a decade and a number have been through a formal review process. Initial ecological monitoring focussed on 'condition and trend' type assessments. In 2005, monitoring changed direction and began to focus on 'ecological assets': species, processes or places of value that have a critical link to flow. This monitoring program, the Environmental Flows Assessment Program (EFAP) focussed on individual assets, their flow requirements and finally risks posed by change in flow regime. EFAP monitoring and research findings have resulted in a change to environmental flow releases and management in a number of river basins. The next generation of monitoring will be used to determine the success of these new rules in providing for stated ecological outcomes. This 'confirmation monitoring' will be testing whether specific environmental flow rules mimic the natural system and are continuing to provide the outcomes for the environment. This type of monitoring aligns to the adaptive management process and is focussed on continual learnings and improvement.

Oral Session 39 – ASFB - 1530 – 1715

Tech. Ecol. Telemetry

Multi-year movements of juvenile white sharks in eastern Australia

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Satellite telemetry of juvenile white sharks, *Carcharodon carcharias* (1.7 - 2.8 m), shows that they are wide-ranging similar to larger conspecifics in Australian waters. Tracking has shown movements from southern temperate to tropical waters, open ocean excursions and dives to 1000 m. Individual sharks, monitored for up to five years via acoustic telemetry, show movements of equivalent scale to that indicated by satellite telemetry, with sharks travelling up to 2000 km north and south along the east coast and crossing the Tasman Sea to New Zealand. Acoustic telemetry confirmed the repeated annual occupancy of two discrete nursery areas in eastern Australia, 800 km apart, where sharks remain resident on average for periods of 60-70 days. Although a general seasonal pattern of nursery area occupancy was indicated, individual sharks showed considerable variability in their range movements both within and between years. However, their overall annual fidelity to predictable locations within nursery areas combined with monitoring individuals via a broad-scale coastal receiver network provide opportunities to estimate abundance and population parameters such as growth rate and survival. These data highlight the value of national-

scale acoustic receiver networks and long-term monitoring of individual animal movements.

Where do the fish go? Acoustic tracking of brown trout in relation to increased summer water temperatures

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A Wild Trout Fisheries Management Plan has been put in place by Fisheries Victoria to address angler concerns about the status of trout fishing in Victorian rivers. The management plan has ten components, ranging from assessing 12 'priority' rivers (identified by anglers), success of stocking, fishing pressure and the movement of trout in response to increased summer water temperatures. This talk will focus on the movement of brown trout in response to increased summer water temperatures. One hundred wild brown trout were captured and acoustically tagged in the Delatite river, a feeder stream of Lake Eildon. An acoustic listening array (loggers) was installed from Lake Eildon to the upstream section of the Delatite river to detect movement of tagged fish over time. At each logger a temperature probe was installed to monitor the temperature when a fish was detected. The outcomes of this project will lead to increased understanding of trout behaviour in response to summer conditions; Anglers may be able to adapt their fishing practices in response to trout movement, while fisheries managers in conjunction with climate experts will better understand how changing summer conditions may affect the fishery in the future.

Movement and habitat use of the threatened Australian Grayling

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Riverine fishes are among the most threatened fauna in the world, but many species remain poorly studied or are managed with little understanding of their ecological requirements. In this study, a novel radio-telemetry technique, as well as a recently developed small, lightweight acoustic tag, was used to investigate the day-to-day activity, habitat use, and spawning season movement behaviours of the nationally threatened Australian grayling in the Tarago-Bunyip River system. The results showed that Australian grayling were often located within glide habitats, but also used a range of other mesohabitats (pool, riffle and run), and moved over larger ranges at night. The study also demonstrated synchronised migratory behaviour to specific locations during the spawning season, including movement responses to targeted environmental flows. This information has the potential to improve our capacity to provide the conditions required to conserve and restore Australian grayling populations.

Movement of introduced Goldfish *Carassius auratus*: implications for control

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2 CSIRO, Atherton TropWATER, James Cook University, Townsville, Australia

Goldfish *Carassius auratus* has been widely introduced across the globe and feral populations are known to have considerable ecological impacts within the receiving environments. Despite centuries of domestication and its current widespread distribution, there is a dearth of information on the spatial and temporal movement patterns of this species, which limits the understanding of the impacts of introduced populations and hampers the development of effective control measures. The current study examined the movement patterns of an introduced population of *C. auratus* in a regulated south-western Australian river using passive acoustic telemetry. The species had a high residency index within the array (mean 0.64 ± 0.06 S.E.). Mobility was high, with the mean minimum distance travelled within the array for individuals over the study period equalling 81.5 rkm (linear river kilometres, which was the sum of the distances of all movements between receivers and an underestimation of actual distances travelled); with one fish moving 231.3 km (including 5.4 km in a 24 hour period). Importantly, *C. auratus* displayed notable seasonal movement patterns including a clear shift to certain habitats during its breeding period; with most individuals being detected in an off-channel wetland during that time. The results of this study have considerable implications for developing control programs for the species, such as targeting connections to off-channel lentic systems during the breeding period. Finally, the presentation will touch on the subsequent study that tracked the movements of Black Bream in the heavily modified estuary habitat downstream of the Goldfish acoustic array that aimed to refine the operation of floodgate barriers.

Integrating telemetric and biochronological data to elucidate movement patterns of riverine fish

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All methods for studying fish movement have strengths and limitations. For example, fixed array acoustic telemetry allows continuous monitoring of fish for months to years, but the spatial grain is often coarse. Whilst spatially dense acoustic arrays can provide continuous fine-scale data, it is usually impractical to conduct such studies over large areas. Radio-telemetry, on the other hand, allows fish to be located at high resolution over very wide areas (e.g. using

helicopters or planes). However, collection of fine-scale data from radio-telemetry generally requires manual tracking that is time consuming and costly. Radio-transmitters are also unsuitable for tracking fish in estuarine and marine environments due to signal attenuation in saline water. Non-telemetric methods, such as otolith chemistry and stable isotope analysis, provide an entirely different suite of data attributes with their own strengths and limitations. Otolith chemistry, for example, provides the capacity to trace individual migration histories (e.g. across salinity gradients) throughout the life history, but does not provide geospatial information and relies on inference rather than direct observation of movement. Integration of multiple methods has the potential to allow researchers to exploit the strengths of each method and greatly improve the inference obtained from fish movement studies. In this presentation, we use a study of barramundi *Lates calcarifer* and forktail catfish *Neoarius leptaspis* in the South Alligator River, Northern Territory, to illustrate how integration of acoustic telemetry, radio-tracking and otolith chemistry were used to develop a comprehensive understanding of the movements of both species across the life history.

Oral Session 40 – ASFB - 1530 – 1715

Est. Coast Con. Hab

Eastern king prawn dispersal in eastern Australia: new information from particle tracking

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The eastern king prawn (EKP) is found from Queensland down to Gippsland Lakes in Victoria, and evidence of spawning females suggest that these individuals are largely supplied from Queensland. Lagrangian particle tracking experiments were undertaken using the OFES ocean model from 1980-2008 and have allowed us to explore the inter-annual variability in EKP transport and quantify the source populations of larval EKPs along the east coast of Australia. Larval EKPs were tracked from release through to settlement. Settlement time was based on growth-degree-days, and larvae were thinned according to negative exponential mortality. Both forward and backward simulations were done. Forward simulations had release locations between Fraser Island and Port Stephens to assess dispersal and backward simulations had arrival locations between Clarence River and Gabo Island to quantify the origin of EKP from known adult populations. Modelling revealed EKP larvae typically settle after 19-21 days in the plankton, and will disperse at a rate of 36-55 km/d. Both forward and backward simulations showed that southern Queensland can supply EKP larvae for the entire NSW coast, but supply to southern NSW is highly variable due to variability in the strength and eddies of the EAC. This variability means that spawning sites in northern NSW are an important source of EKPs, as a higher proportion of larvae released at these sites reach southern NSW. Our modelling also showed that many larvae do not make it to coastal areas at all, with larvae a mean distance of 300 km from the coast at time of settlement.

The fish faunas of an intermittently-open, seasonally inverse estuary

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Among the many environmental conditions that structure estuarine fish assemblages, salinity is perhaps the most influential. While most estuaries have a positive salinity gradient, where salinity declines in an upstream direction, and several exhibit the reverse pattern, very few experience both salinity regimes within a typical year. One estuary that does, however, is the shallow Vasse-Wonnerup Estuary, which receives no freshwater discharge during summer. In this system, salinity ranges from 0 (upstream) to 15 (mouth) during winter and 130 (upstream) to 35 (mouth) in summer. The fish faunas of the shallow and deeper waters were sampled on a seasonal basis for two years. The nearshore fish fauna was dominated by atherinids and gobies, which complete their life cycle within the estuary and are highly euryhaline, but also included 18 species of marine-spawning fish that utilise the system as a nursery area. Species richness and density decreased with increasing distance from the ocean and faunal composition changed markedly seasonally, in response to massive changes in salinity. The fish of the deeper waters comprised predominantly marine-spawning species, with the notable exception of Black Bream, which is solely estuarine. This species, together with two mugillids, largely dominated these deeper waters and their abundances remained relatively consistent. However, the prevalence of other species varied with changes in salinity and/or the frequency and duration of bar openings. This estuary is used as model for predicting the impact of climate change on seasonally-open estuaries in southern Australia, which will become more saline in the future.

Oral Session 41 – ASFB - 1530 – 1700

Fish Energ. Behav.

Maximum swimming speeds of five finfish bycatch species from north-eastern Tasmania

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Of the three types of swimming speeds in finfish (sustained, prolonged and burst), burst speeds are the most difficult to estimate. Swimming speeds of bycatch finfish species are less studied than those of commercial importance. However, to design Bycatch Reduction Devices (BRDs), it is critical to study the swimming ability of bycatch species. Five teleost species of north-eastern Tasmanian waters were studied: sand flathead (*Platycephalus bassensis*), jack mackerel (*Trachurus declivis*), Degen's leatherjacket (*Thamnaconus degeni*), silver biddy (*Parequula melbournensis*), and roundsnout gurnard (*Lepidotrigla mulhalli*). Stride lengths and minimum muscle contraction times were recorded while at sea on a research vessel and used to estimate the maximum swimming speed. The maximum swimming speeds of *L. mulhalli*, *P. melbournensis*, *P. bassensis*, *T. degeni* and *T. declivis* were

1.71, 4.17, 4.80, 3.19 and 6.40 m s⁻¹, respectively. *Trachurus declivis* had the longest stride length and maximum swimming speed. Therefore, it is predicted that of the five species studied, *T. declivis* would be most likely to avoid capture by a trawl net. The method of measuring stride length and muscle contraction times required healthy fish post-capture, and would not be suitable for species with high mortality rates. The approach to estimate the maximum swimming speed of fish demonstrated in this study, could be adopted by commercial vessels to guide tow speeds based on species present to minimise by-catch, and is a requisite to the process of designing effective BRDs.

Swimming activity and energetic costs of adult lake sturgeon during fishway passage

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Migrations through riverine systems can be energetically demanding and the presence of fishways to facilitate upstream passage past barriers can add an additional energetic cost that may directly affect fitness. Triaxial accelerometers were used to estimate location-specific swimming activity of sturgeon during fishway passage, to determine whether individual behaviour or path selection, resulting in differences in cumulative energy use, explain fishway passage success. Most individuals attempted to pass the fishway ($n=30/44$; 68%), although successful passage only occurred for a subset of those attempting ($n=7/30$; 23%). High speed swimming was rarely observed during upstream passage through fishway basins, and was of short duration. The rate at which the estimated energy was expended did not differ among successful and unsuccessful individuals, although successful sturgeon exhibited higher costs of transport per unit distance. Energy expenditure metrics were not predictive of successful fishway passage, leading us to conclude that other endogenous or exogenous factors influence passage success.

It eats, sits and that's about it: the bioenergetics of iconic sit-and-wait predator, the Murray cod

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The operation of hypolimnetic impoundments can profoundly impact downstream flow and temperature regimes, which these impacts diminishing with downstream distance. Environmental gradient theory intimates that inter- and intra-specific variation in the bioenergetic responses of individuals, manifesting as differential rates of growth, should mediate the reproduction, survival and ultimately fitness of fish communities along disturbance gradients such as these. Here we present a validated bioenergetics model, where consumed energy is allocated to

metabolism, wastes and growth, for the iconic main channel species, Murray cod, to explore the influence of the downstream flow velocity and temperature regimes imposed by Hume Dam on the River Murray. The model is parameterised using a combination of laboratory experiments, Monte Carlo filtering, and parameter borrowing from published literature, and then evaluated by sensitivity analysis, and laboratory validation. Modelling simulations suggest that the growth of the species may not occur directly downstream of the impoundment, due largely to the energetic costs associated with active and, to a lesser extent, standard metabolism outweighing the energetic benefits achieved through food consumption. As flow velocity and temperature regimes improve downstream along the river, so did the growth potential of the species. From 239 km downstream, flow velocities are sufficiently low and temperature sufficiently high to allow substantial final weights to be achieved during modelling simulations. The model presented here will also be beneficial to assess changes in the operation of hypolimnetic impoundments that act to restore more natural flow and temperature regimes.

Seasonally contrasting physiological and ecological performance question the ‘warmer-is-better’ hypothesis for juvenile fish

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Temperature affects most physiological processes which in turn impact animal behaviour and ecology. In ectotherms, both short- and long-term variations in temperature impact physiological (i.e. locomotor and metabolic capacity) and ecological (i.e. body condition and growth) performance and thus affect survival. It is therefore critical to understand the mechanisms driving these relationships. Here, we investigated the impact of seasonally changing temperature on the ecological and physiological performance of juvenile free-ranging largemouth sawfish (*Pristis pristis*) in its riverine nursery in North Western Australia. Animal-attached accelerometers, revealed that despite a 10°C increase in temperature, sawfish were active and displayed substantial burst-swimming capacity. Physiological performance, as ascertained by locomotory capacity, increased in the warmer late dry season conditions, whereas timing and duration of activity did not. Contrary to the physiological performance, late season sawfish were poorer condition than those in the early season. Activity was primarily crepuscular, irrespective of the season. This suggests that even though locomotory performance of juvenile sawfish increased at greater temperature, foraging activity and thus energy intake was not sufficient to maintain body condition, resulting in declining growth. Contrary to popular belief, seeking warmer temperatures can represent a disadvantage for juveniles under certain scenarios. Especially for individuals that are intake limited, greater temperatures and associated metabolic rates are

disadvantageous and can result in lower growth rates and potentially starvation. Physiological and ecological performances may thus respond differently to warming temperatures, emphasizing that ‘optimal’ temperatures may be highly context dependent. Ecological scenarios responsible for mediating growth performance are discussed and integrated into a classic bio-energetics framework.

Poster Overview

Poster Board	First Name	Last Name	Theme	Poster Title
1	Elodie	Ledee	ASFB	Movement Patterns Of Two Carangids Species In Inshore Habitats
2	Xavier	Hoenner	ASFB	The Australian national database for acoustic monitoring of marine species
3	Leanne	Currey	ASFB	"Some Like To Move It, Move It: Multiple Techniques Reveal A Complete Picture Of Fish Movement At Different Scales"
4	Kye	Adams	ASFB	Fiddler On The Reef: Movement And Abundance Of Fiddler Rays
5	Teagan	Marzullo	ASFB	"Shedding light on the spatial ecology of the Estuary Stingray, <i>Dasyatis fluviorum</i> ."
6	Krystle	Keller	ASFB	"Site Residency, Movement and Behaviour of the Port Jackson Shark (<i>Heterodontus portusjacksoni</i>), Banjo Ray (<i>Trygonorrhina fasciata</i>) and the Eastern Blue-Spotted Flathead (<i>Platycephalus caeruleopunctatus</i>) associated with a Designed Artificial Reef"
7	Mario	Espinoza	ASFB	Contrasting movements and connectivity of reef-associated sharks: implications for management
8	Christopher	Izzo	ASFB	Patterns of Habitat Use and Population Structure of a Large Pelagic Elasmobranch: Based on Vertebral Chemistry
9	Ruan	Gannon	ASFB	Effect Of Environmental Variables On The Movements Of Dusky Flathead
10	Steve	Hoseck	ASFB	Artificial reefs in Queensland
11	James	Smith	ASFB	Modelling fish attraction to artificial reefs – not always a fatal attraction
12	Ruby	Garthwin	ASFB	"Fish community composition and herbivory on tropical seagrass meadows in the remote Kimberleys, Western Australia"
13	Stacy	Bierwagen	ASFB	Bluespine Unicornfish (<i>Naso unicornis</i>) are both natural control agents and mobile vectors for invasive algae in a Hawaiian Marine Reserve.
14	Daniel	Yeoh	ASFB	"Diel, seasonal and regional variation of fish communities in the nearshore waters of a permanently open south-coast Australian estuary"

Poster Board	First Name	Last Name	Theme	Poster Title
15	Hayden	Schilling	ASFB	Estuarine Marauders? The Ecosystem of Tailor in Eastern Australia
16	Stephen	Beatty	ASFB	Mitigating Historical Management Actions To Preserve Fish For The Future
17	Gary	Jackson	ASFB	Breathing life into fisheries stock assessments with citizen science
18	Chris	Hallett	ASFB	The Fish Community Index - a simple and robust tool for monitoring and reporting estuarine health
19	Joanne	Langstreth	ASFB	The value in a long term time series of biological monitoring information in sustainability assessment of Spanish mackerel (<i>Scomberomorus commerson</i>)
21	Michael	Bertram	ASFB	Impacts of Exposure to 17-beta-trenbolone on Mating Preferences in Fish
22	Culum	Brown	ASFB	Life skills training in hatchery reared fish
23	Takeshi	Tomiya	ISSESR	"Optimum Stocking Density of Japanese Flounder in Fukushima, Japan"
24	Daisuke	Katamachi	ISSESR	Identification of Offspring of Hatchery-produced Tiger Puffer in the Wild
26	Gavin	Partridge	ISSESR	Development of Culture Methods for the Production of Western School Prawns (<i>Metapenaeus dalli</i>) for Release Into the Swan and Canning Rivers to Enhance the Community Values of the Recreational Prawn Fishery
27	Neil	Loneragan	ISSESR	Assessing The Sediment Preference Of A Penaeid Prawn To Inform Release Strategies
28	Jon	Altamirano	ISSESR	Restocking of giant clams to increase protection of MPAs
29	Joel	Williams	ISSESR	Performance and Contribution to Commercial Catches and Egg Production by Restocked <i>Acanthopagrus butcheri</i> in the Blackwood River Estuary
30	Daiko	Ando	ISSESR	Development of the System for Sibship Reconstruction to evaluate Genetic Effects of Stock Enhancement Program of Japanese Flounder
31	Beero	Tioti	ISSESR	Sea-ranching and farming of Sandfish in the Pacific Islands

[1] Movement patterns of two carangids species in inshore habitats

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4 Inland Fisheries Service Tasmania, New Norfolk, Australia

Passive acoustic monitoring was used to track the movements of 16 Giant Trevally (*Caranx ignobilis*) and 20 Golden Trevally (*Gnathanodon speciosus*) in Cleveland Bay, Queensland from 2011 to 2014. Acoustic monitoring allowed long-term observation of behaviour and movement via a network of moored listening stations recording the presence of tagged animals. Sixty-five listening stations were deployed in the bay; 28 in the western section and 37 in the eastern section. Network analysis (NA) determined temporal movement patterns and habitat use. NA is a novel and alternative approach to conventional movement analysis that treats listening stations as network nodes and analyses fish movement based on travel between nodes. Tagged individuals were present in the study region between 30 to 394 days (mean \pm SD = 166 \pm 116) with a mean residency index of 0.7 (\pm 0.1 SE). Preliminary findings showed that individuals were detected on more days, visited more receivers, moved more frequently, and were more resident in 2011 than in 2013 and 2014. An analysis of environmental variables is currently underway to explore these annual differences. In addition, movement patterns between species significantly differed with *C. ignobilis* being detected on fewer days, using less receivers and moving less than *G. speciosus*. A combination of factors including ontogeny, foraging niche, and habitat/tidal influences may explain differences in space use between species. These results highlight unique behaviours between co-occurring and closely related species, and enhance our understanding of animal interactions in inshore habitats.

[2] The Australian national database for acoustic monitoring of marine species

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5 Macquarie University, NSW, Australia

The Australian Animal Tracking and Monitoring System (AATAMS) is part of the Integrated Marine Observing System (IMOS), a national collaborative research infrastructure program to monitor the open oceans and coastal waters around Australia and off Antarctica. IMOS facilities continuously deploy a wide range of state-of-the-art observing equipment to collect long time-series of key physical, chemical and biological variables, which ultimately

help quantify the impacts of climate variability and ocean processes on marine ecosystems. AATAMS supports a national acoustic tracking and monitoring network covering a wide array of marine species in pelagic, coastal, and estuarine ecosystems. The AATAMS national database currently holds data from 34 organisations that have deployed receivers at over 2000 locations nationwide. More than 4000 individually identified animals have been tagged generating over 60 million tag detections. Those unprecedented volumes of acoustic telemetry data are subsequently made freely and openly available through the IMOS portal (<http://imos.aodn.org.au/>), an open source information infrastructure that allows users to search, subset, and download aggregated data in three simple steps. A test case will illustrate how the IMOS portal can be used to study animal behaviour and investigate migratory patterns of marine species.

[3] Some like to move it, move it: Multiple techniques reveal a complete picture of fish movement at different scales

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4 Secretariat of the Pacific Community

Movement of fishes occurs at multiple temporal and spatial scales, including long-distance migration over multiple years, and daily activity in a home range. A better understanding of spatial ecology can be gained by using multiple methods to study movements of fishes at different scales. This PhD research utilised novel techniques to identify the scales at which movements of exploited reef fish (adult redthroat emperor, *Lethrinus miniatus*) occurred, and identified the factors that influenced movement patterns. Movement of adult individuals were investigated in three ways: at a broad spatial scale (regions separated by 100s of km) with ontogeny (4 years); among reef platforms (160 km²) over periods of up to 12 months; and among habitats from the reef crest to sandy bottom (1 km²) over 3 months. Isotope ratios in otolith carbonate inferred broad-scale migration, while acoustic telemetry was used to monitor movements among reefs and finer-scale reef habitats. Individual variability in movement patterns was observed, with evidence for long-distance migration for a proportion of *L. miniatus*, characteristics of both mobile and sedentary lifestyles around reef platforms, and fine-scale space use which reflects the nocturnal nature of the species. This research highlights the need for investigation across multiple spatial and temporal scales, and emphasises that no single management strategy can ensure sustainability of a species. These methods can be applied to other fishes of importance to gain a complete picture of movement patterns at multiple scales, which is essential for the knowledge of species-specific spatial ecology.

[4] Fiddler on the reef: Movement and abundance of Fiddler Rays

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2 NSW Department of Primary Industries, NSW, Australia

Skates and rays play key ecological roles in shallow waters, but their patterns of movement are poorly understood. This study focuses on a common endemic species found along the east coast of Australia - the Eastern Fiddler Ray (*Trygonorrhina fasciata*). To date there have been no known studies that target the ecology and movement behaviour of this endemic ray species. Our overarching aim was to understand the site fidelity and relative abundance of these rays. We use of a fine scale acoustic receiver array deployed on soft sediment in Jervis Bay to track movements at scales <1m. Preliminary data confirms high levels of site fidelity in this species with several individuals being resident within the array for several months. Broad scale patterns of movement will be determined using the larger network of receivers deployed around the Bay, including a receiver gate across the Bay entrance, as well as the AATAMS database. Relative abundance of Fiddler Rays is being assessed with Baited Remote Underwater Video sampling on soft sediments within Jervis Bay, drawn from a multi-year data set. This study will provide important baseline data and contribute to improved management of the NSW marine estate.

[5] Shedding light on the spatial ecology of the Estuary Stingray, *Dasyatis fluviatorum*

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Space use and movement patterns underpin the behavioural ecology of a species and are key to identifying valuable habitats. To predict the dissemination of animals within available habitats, it is necessary to observe individuals living freely under natural conditions. We used passive acoustic telemetry to monitor the ecology of a euryhaline stingray, *Dasyatis fluviatorum*. Here we investigate the spatial ecology of this species using two distinct acoustic receiver arrays; (1) a linear array, which detects presence/absence data, and (2) a Vemco Positioning System (VPS), which provides positional data within the confines of the set up. The sampled population displayed low residency values over the winter period. There was no relationship between sex or size and for total estuary residency. Yet, there was a significant difference between male and female summer residency. There was no relationship between size (disk width) and core-range or home-range derived from the kernel density estimates. However, there was a relationship between size and modal distance-to-sea, where larger animals were more likely occur further upstream than smaller animals. On average females have a larger core-use area and home-range than males, however, further analysis showed that these differences were not significant. We also found distinct differences in seasonal habitat use, where core-range and

modal distance-to-sea were significantly different across seasons. On average stingrays used 0.25 km² per day within the VPS. In addition to this, movement activity index (a proxy for activity) and displacement from sea were significantly correlated with discharge, water temperature and size.

[6] Site residency, movement and behaviour of the Port Jackson Shark (*Heterodontus portusjacksoni*), Banjo Ray (*Trygonorrhina fasciata*) and the Eastern Blue-Spotted Flathead (*Platycephalus caeruleopunctatus*) associated with a designed artificial reef

Krystle Keller¹, Iain Suthers¹, Michael Lowry², James Smith¹

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2 Port Stephens Fisheries Institute, Nelson Bay, Australia

The movement patterns of fish associated with artificial reefs (ARs) is important for examining the degree of residency, and the potential for fish production in the AR vicinity. I tagged 10 Banjo rays (*Trygonorrhina fasciata*), 17 Port Jackson sharks (*Heterodontus portusjacksoni*) and 32 Eastern blue-spotted flathead (*Platycephalus caeruleopunctatus*) by surgically implanting a VEMCO acoustic tag to record the movements, activity, behaviour and residency around a designed AR located 1.5 km off the Sydney coast in 38 m depth. Connectivity of the AR with surrounding natural reefs was determined by comparing data from the AR receiver with those from 10-15 existing VEMCO receivers. Initial results show that individuals of all three species spend between 10-50% of their time within the detection range of the AR (~300 m), and move frequently between the AR and nearby natural reefs. Banjo rays were mostly active during daylight hours, whereas the Eastern blue-spotted flathead were mostly nocturnal, and the average activity of both species was found to increase with water temperature. In contrast, Port Jackson sharks were generally nocturnal and showed no correlation between temperature and activity. These results suggest that the AR does have partially-resident fish, and residency by the recreationally important flathead suggests that 50% of their biomass production is likely to be derived from this reef.

[7] Contrasting movements and connectivity of reef-associated sharks: implications for management

Mario Espinoza¹, Michelle Heupel², Andrew Tobin¹, Colin Simpfendorfer¹

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Understanding the efficacy of marine protected areas (MPAs) for wide-ranging predators is essential to designing effective management and conservation approaches. The use of acoustic monitoring and network analysis can improve our understanding of the spatial ecology and

functional connectivity of reef-associated species, providing a useful approach for reef-based conservation planning. Acoustic telemetry was used to examine the movement, connectivity and MPA utilization of grey reef (*Carcharhinus amblyrhynchos*), silvertip (*C. albimarginatus*) and bull (*C. leucas*) sharks monitored in the central Great Barrier Reef (GBR). Grey reef and silvertip sharks were detected most days at their tagging reef, but silvertip sharks moved more frequently (between reefs and management zones) and also exhibited lower residency to the array than grey reef sharks. Bull sharks were detected less than 20% of the time in the array, and 42% of the population undertook long-range migrations along the East coast of Australia. Networks derived for bull sharks were larger and more complex than the other species. Our findings suggest that increasing the level of protection to include closely-spaced reefs (< 20 km) may perform better for silvertip sharks than having a single and/or a network of isolated MPAs. This design would also provide protection for larger male grey reef sharks, which tend to disperse more than females. For wide-ranging species like bull sharks, other alternative measures are needed. Our findings demonstrate that acoustic monitoring can serve as a useful platform for designing more effective MPA networks for reef predators displaying a range of movement patterns.

[8] Patterns of habitat use and population structure of a large Pelagic Elasmobranch: Based on vertebral chemistry

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Analyses of the elemental composition of teleost otoliths (and other calcified tissues) are frequently employed to delineate movements and population structuring of wild fish, and are highly informative for fisheries management. Elasmobranch vertebrae provide an analogous, yet largely underutilised structure to better understand patterns of habitat use in cartilaginous fishes. Using laser ablation inductively coupled plasma mass spectrometry, we quantified the vertebral elemental composition of bronze whalers from five locations throughout South Australia. Elemental data at the marginal edge was used to derive a multi-element region of capture signature and optimised to identify spatial differences among samples. Boosted regression tree analysis indicated that variability in multi-element vertebral signatures were largely due to differences among individuals and size cohorts, with a lesser spatial component. These findings suggest that the two South Australian gulfs are utilized by individuals from different size cohorts, and are reflective of the migratory nature of this cosmopolitan species. These findings form the basis for element profile (transect) analyses to examine age-resolved patterns of movement and connectivity of individuals throughout their lifetimes.

[9] Effect of environmental variables on the movements of Dusky Flathead

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Dusky flathead (*Platycephalus fuscus*) are a large predatory estuarine teleost with a broad geographic range extending through temperate and tropical regions of Australia. Within their range *P. fuscus* tolerate fluctuations of an array of environmental factors throughout various habitats. The extent to which individual biotic and abiotic factors drive estuarine fish activity and space use is generally poorly understood. To identify primary factors influencing the movement and activity levels of wild *P. fuscus*, acoustic telemetry was used throughout alternate seasons to assess fish activity and space use in the Georges River estuary NSW Australia. In conjunction with monitoring fish activity and movements, hydrological variables were recorded throughout the study area via a subsurface logger. Observations of fish activity suggest *P. fuscus* is heavily influenced by diel period, tidal phase and water temperature. Primary factors influencing *P. fuscus* space use and movement were fish length, water salinity and temperature. Investigating the influence biotic and abiotic factors have on *P. fuscus* activity levels and spatial occupancy increases our understanding of the spatial requirements and behavioural response of this fish across a range of habitats of differing hydrological and seasonal variability.

[10] Artificial reefs in Queensland

Steve Hoseck¹

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The poster outlines the detail of artificial reefs installed by the Queensland Government in marine protected areas of Queensland. There are a total of nine artificial reefs, with reef material ranging from 'materials of opportunity' to purpose built modules.

[11] Modelling fish attraction to artificial reefs - not always a fatal attraction

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The debate on whether artificial reefs produce new fish or simply attract existing fish biomass continues, and there remains considerable doubt as to whether artificial reefs are a harmful form of habitat modification. The harm typically associated with fish attraction is that fish will be easier to exploit due to the existing biomass aggregating at higher densities on an artificial reef. This outcome of fish attraction has never developed past an anecdotal form, however, and is always perceived as a harmful process. We present a numerical model that simulates the effect that a

redistributed fish biomass, due to an artificial reef, has on fishing catch per unit effort (CPUE). This model can be used to identify the scenarios (in terms of reef, fish and harvest characteristics) that pose the most risk of exploitation due to fish attraction. Simulations revealed that attraction is not always harmful, because it does not always cause increased fish density. Rather, attraction sometimes disperses existing fish biomass, making them harder to catch. Therefore some attraction can be ideal, with CPUE lowest when attraction leads to an equal distribution of biomass between natural and artificial reefs. This simulation also highlights that the redistribution of fishing effort is as important as the redistribution of fish biomass for estimating the risk, effects, and impacts of artificial reefs.

[12] Fish community composition and herbivory on tropical seagrass meadows in the remote Kimberleys, Western Australia

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1 Evolution & Ecology Research Centre, Centre For Marine Bio-Innovation, University of NSW, Sydney, Australia

Herbivorous fish are known to play an important role in the control of primary producers in coral reef systems. Less is known about the ecological role of herbivorous fish in seagrass systems, particularly in remote tropical regions. To address this, a study was undertaken to quantify the diversity, abundance and feeding patterns of herbivorous fish associated with tropical seagrass meadows in the remote Kimberley region, WA. Underwater video cameras were deployed in meadows of two dominant seagrass species, *Thalassia hemprichii* and *Enhalus acoroides*, at three different sites on the Dampier Peninsula. The video footage was analysed to characterise fish community composition and quantify species-specific consumption rates of seagrass. Habitat traits such as turbidity, temperature, seagrass and epiphyte cover were also examined to determine what might predict fish activity or herbivory on seagrass. A number of species of herbivorous fish were observed feeding on both the epiphytes growing on the seagrass leaves and the leaves themselves. Two species that were particularly abundant were the rabbitfish, *Siganus lineatus*, and the surgeonfish, *Acanthurus grammoptilus*. Previous anecdotal evidence has indicated that *S. lineatus* frequently consume seagrass, and gut contents analyses has found that half to three-quarters of the stomach was comprised of seagrass tissue. Data will be presented that contrasts the rates of fish herbivory across the two species of seagrass and environmental variables that best predict the intensity of grazing will be discussed. These results will contribute to a better understanding of the role of herbivorous fish in ecologically important tropical seagrass meadows.

[13] Bluespine Unicornfish (*Naso unicornis*) are both natural control agents and mobile vectors for invasive algae in a Hawaiian Marine Reserve

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Blooms of non-indigenous marine macroalgae have been reported throughout the Hawaiian Islands over the past 40 years. In Kaneohe Bay, Oahu, a rhodophyte, *Gracilaria salicornia*, has successfully monopolized macroalgal communities throughout the Southern portion and is currently distributed to the most Northern regions of the bay. While there is an assumption that Marine Reserves protect overgrowth of algae by boosting populations of resident herbivorous fish, few empirical studies address species-specific residency within reserve boundaries, consumption of the invasive algae, and whether herbivorous grazers hold the capacity to disperse viable propagules. A 46-year-old Marine Reserve (Hawaii Marine Laboratory Refuge) in Kaneohe Bay provides habitat for herbivorous bluespine unicornfish (*Naso unicornis*) and is also affected by *G. salicornia*. Five unicornfish were captured within the reserve, implanted with an acoustic transmitter, and released where they were tracked using acoustic telemetry from June–August 2013. Observers would locate tagged individuals and track movements continuously for up to 24 hours each tracking period using a submerged hydrophone fixed to the tracking vessel (predominantly kayak). Logged coordinates from tracking were later used to outline the home ranges of each individual. Habitat composition, invasive algal cover, and grazing activities were observed using underwater videography and benthic survey within home ranges of the tagged individuals. Results showed residency of unicornfish to the Marine Reserve during the tracking period and also exhibited grazing of *G. salicornia*. While unicornfish select for habitats covered with invasive algae, movements were not uniform across reef habitats and most unicornfish used the outer crest of the reef more frequently than in shallow reef flats where the largest portion of invasive algal cover remains. We also showed that unicornfish ingest viable fragments of *G. salicornia* where a portion resume vegetative propagation within a few weeks. Chlorophyll fluorescence was measured through use of a pulse amplitude modulation fluorometer to statistically support growth after egestion. We conclude that *N. unicornis* may act as a controlling factor for Marine Reserves but may also be a disperser of invasive algae for this Hawaiian reef system.

[14] Diel, seasonal and regional variation of fish communities in the nearshore waters of a permanently open south-coast Australian estuary

Daniel Yeoh¹, Fiona Valesini¹, Chris Hallett¹, Joel Williams¹, David Abdo²

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Fish communities in the shallow (<1.5m) nearshore waters of the Walpole-Nornalup Estuary, on the south-coast of Western Australia, were sampled seasonally over a twelve month period using beach seine nets. Sampling was undertaken at a comprehensive range of sites throughout five regions of the system, during both day and night. Thirty-eight fish species from 24 families have been recorded, with the most abundant taxa being the atherinids *Leptatherina presbyteroides* and *L. wallacei*, and the gobiid *Favonigobius lateralis*. The characteristics of the ichthyofauna differed substantially between regions of the estuary, seasons and between day and night. The lower regions of the estuary were dominated by marine spawning species (e.g. *Arripis georgianus*, *Sillaginoides punctata* and *L. presbyteroides*), while the upper reaches contain a high proportion of solely estuarine species (e.g. *Acanthopagrus butcheri*, *Afurcagobius suppositus* and *L. wallacei*). Seasonal variation is most likely attributed to cyclic variation in physico-chemical water quality parameters, particularly salinity and temperature. Notably, abundances of the four gobiids *Arenigobius bifrenatus*, *Pseudogobius olorum*, *A. suppositus* and *F. lateralis* were far higher in summer than any other season.

[15] Estuarine Marauders? The ecosystem of Tailor in Eastern Australia

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Pomatomus saltatrix (tailor) is a globally important commercial and recreational fish species which has a large predatory impact. The species appears to be in decline along the east coast of Australia. Despite this decline, there is little data on the ecology of tailor in Australia and yet each year an estimated 550 tonnes of tailor are harvested by recreational anglers across NSW and Queensland with an additional 170 tonnes landed by the commercial sector. The juvenile estuarine phase of tailor were sampled from 10 estuaries along the NSW coast to investigate their growth, condition, diet and ecosystem impact; adult tailor were obtained from the markets to determine the age structure and growth rates. The otolith chemistry of juvenile tailor from different estuaries (as the source population) will be compared to that of adults sampled in coastal waters by the fishery. These estuary specific signatures remain in the core of adult tailor otoliths and will be used to assess the contribution of specific estuaries to the spawning biomass of tailor along the coast. The ecosystem impact of tailor particularly on the baitfish population will be calculated through dietary analysis of both juvenile and adult tailor, thereby linking the juvenile and adult stages and separating the impacts upon estuarine and coastal baitfish.

[16] Mitigating historical management actions to preserve fish for the future

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Estuaries are widely regarded as the most degraded of all aquatic ecosystems, largely due to their exposure to a range of deleterious anthropogenic influences. In the case of the Vasse-Wonnerup, such impacts have included, land clearing for agriculture and associated severe eutrophication, the diversion of river flow and the construction of barriers (floodgates) to prevent the intrusion of saltwater into the estuary. Although the prevention of flooding and maintenance of surrounding pastoral land has been achieved, the Vasse-Wonnerup now suffers from regular fish kills and algal blooms. Current managers are thus faced with the problem of managing the legacy of historical decisions, while also being under community and political pressure to introduce additional (but non-compromising) measures to reduce the frequency and severity of deleterious events. This poster details the anthropogenic changes that have occurred in the Vasse-Wonnerup over the last 120 years and describe the resultant changes in environmental conditions and how these influence the fish community. For example, fish faunal composition undergoes marked seasonal and regional changes in response to changes in dramatic changes in water quality and there is the seasonal expatriation of fish from particular regions of the estuary at times during the year. Moreover, growth rates and condition of the key recreational species Black Bream *Acanthopagrus butcheri* are poor in comparison to nearby systems. Ways to ensure the maintenance of a viable fish population in this estuary are discussed.

[17] Breathing life into fisheries stock assessments with citizen science

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Citizen science offers a potentially cost-effective way for researchers to obtain large data sets over broad spatial scales. However, it is not used widely to support biological data collection for fisheries stock assessments. Recently, significant management controls were introduced to recover stocks of demersal fishes from overfishing along the west coast of Australia. This diminished opportunities for Department of Fisheries' scientists to collect the required biological samples essential for stock assessment of key species using traditional fishery-dependent sampling methods. In addition, concerns about an effort shift onto nearshore species as a result of management changes required a greater understanding of the stock status of these species. As fishery-independent methods would be too expensive and logistically-challenging to implement for a diverse number of species, a citizen science program, Send Us Your Skeletons (SUYS), was developed. SUYS asks recreational fishers to voluntarily donate fish skeletons of key demersal and nearshore species from their catch to help monitor these stocks. After three years of the SUYS

program in operation, large increases occurred in recreational fisher involvement, sample sizes and spatial and temporal representativeness. Additionally, SUYS has allowed scientists to more cost effectively monitor the status of these stocks than through traditional methods of sampling recreational catches. This program is therefore ensuring sampling objectives for stock assessments are achieved via fishery-dependent collection. This has led to more comprehensive information for management of these resources and importantly, improved knowledge among the fishing community as well as developed a sense of stewardship of the local resource.

[18] The Fish Community Index - a simple and robust tool for monitoring and reporting estuarine health

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We outline the rationale, methodology and applications of the multimetric Fish Community Index (FCI), which was developed for monitoring and communicating the ecological health of the Swan Canning Estuary, Western Australia. Previous investigations have demonstrated the sensitivity of the FCI to environmental perturbations, including algal blooms of differing severity, and shown it to be sufficiently sensitive and robust to quantify and communicate spatial and temporal differences in the ecological condition of the system, thus helping to inform management actions. We describe the recent implementation of an annual FCI monitoring and reporting regime for the Swan Canning Estuary, and present an overview of spatial and temporal trends in the condition of this estuary in recent years. The capabilities of the FCI and the ecological implications of our results to date are also highlighted, using examples from both previously published and unpublished studies. Finally, we consider some potential applications and extensions of the FCI, and propose avenues for further research and investigation that could help to better understand the ecological responses of Western Australian estuaries to natural and anthropogenic stressors.

[19] The value in a long term time series of biological monitoring information in sustainability assessment of Spanish mackerel (*Scomberomorus commerson*)

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Fisheries Queensland conducts a comprehensive program to monitor and assess the status of key fishery resources in Queensland waters. A long-term monitoring program for Spanish mackerel (*Scomberomorus commerson*) along the east coast of Queensland, began on the key commercial fishing grounds in 1999. This program expanded in 2004 to monitor the commercial and recreational harvest on the east coast of Queensland. Annual structured fishery dependent sampling collects length, sex and age

information to construct length and age frequencies and total mortality estimates (derived from catch curve analysis). The main uses of the monitoring program data is to feed into regular stock status assessments and periodic stock assessments. Spanish mackerel captured along the east coast of Queensland have been aged up to 26 years, although fish over 10 years are rare in the catch. One of the key strengths of the monitoring program is in the long-term times series of information that identifies and tracks cohorts, particularly for a relatively long-lived species such as Spanish mackerel and can help to interpret annual trends in commercial catch rates. We highlight the strengths and weaknesses of a long-term monitoring Spanish mackerel biological dataset and its effectiveness in providing evidence for stock status determination and its contribution to stock assessments.

[20] The plight of the Weedy Seadragon, *Phyllopteryx taeniolatus*

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The endemic and iconic flagship species, *Phyllopteryx taeniolatus*, listed as Near Threatened and Data Deficient on the IUCN Red List, is examined to determine its true status. The species is protected in NSW (since 1994), and tissue was collected in situ without harming individuals, with the aid of the Underwater Research Group (URG) in a Citizen Science Project. We examined the population structure and genetic diversity of 30 individuals (Sydney region and Eden) using three mitochondrial DNA loci (cyt b, COI and control region). Preliminary results suggest that this species has very low genetic diversity, and thus may be in danger of local extinction.

[21] Impacts of exposure to 17-beta-trenbolone on mating preferences in fish

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Endocrine Disrupting Chemicals (EDCs) now occur in all environments worldwide. Despite this, understanding of how these hormonally active pollutants impact processes of sexual selection in wildlife is rudimentary. Further, the vast majority of existing ecotoxicological studies on sexual selection have focussed on estrogenic endocrine disruptors, while the impacts of androgenic EDCs are less well understood. One androgenic EDC of particular concern is 17 β -trenbolone. This chemical is a metabolite of the hormonal growth promotant trenbolone acetate, which is used globally in beef cattle production. Prior research has repeatedly identified 17 β -trenbolone in the environment, and has established its ability to disrupt development and reproduction. The consequences of exposure to 17 β -trenbolone on processes of sexual selection are, however, poorly understood. In the present

study, we investigated the effects of EDC-exposure on both pre-and post-copulatory aspects of sexual selection in guppies (*Poecilia reticulata*), including the consequences of exposure on reproductive behaviour, morphology, colouration and sperm performance.

[22] Life skills training in hatchery reared fish

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Releasing hatchery reared fish into wild habitats is a common strategy for bolstering fish stocks. However, hatchery fish suffer a high rate of mortality upon release often attributed to underdeveloped behavioural traits, particularly predator recognition. There is increasing interest in applying remedial steps before the release of hatchery fish to improve the survival rate of the fish post-release. This often involves conditioning via predator exposure. This research examined life skills training in three iconic Australian, golden Perch (*Macquaria ambigua*), trout cod (*Maccullochella macquariensis*) and Australian bass (*Macquaria novemaculeata*). The relative roles of visual and chemical cues in learned predator recognition were investigated in each species, followed by a behavioural interaction experiment with a live predator at liberty in semi-natural conditions. A range of graded responses were observed, however, the intensity of response and preferences for different sensory modalities varied for each species and in different tests. The results suggest the use of chemical and visual cues to enhance predator recognition may be successful in modifying the behaviour of hatchery reared fish in all three study species, however, these appear to be both context and species specific. These results indicate that the use of tailored life skills training programs in these species could potentially improve post-release survival of hatchery reared juveniles.

[23] Optimum stocking density of Japanese Flounder in Fukushima, Japan

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Stocking density (amount of release) is one of the important factor for successful stock enhancement. Excess release of hatchery-reared fish, i.e. overstocking, would increase the competition for prey among released fish, wild counterpart, and other predators, resulting in the reduced production of fishes. The maximum stocking density within the carrying capacity, that can be defined as optimum stocking density, is a target for optimizing the release strategy. Here, we tried to assess optimum stocking density of Japanese flounder *Paralichthys olivaceus*, released in the coastal waters off Fukushima in Japan. In this area, ca. one million hatchery-reared juveniles had been released annually from 1996 to 2010. This amount of release was determined empirically

without taking the carrying capacity into consideration. Nevertheless, the recapture rates of 1996-2006 year classes were high (7-17%), indicating the available carrying capacity in this area was sufficient for the release. We constructed the Ecophysiology Model, using the five years dataset. Growth of wild counterpart was used as the outcome and the water temperature, prey (mysids) density, consumption of prey by competitors, and the amount of release were used as the input variables. The optimum stocking density will be discussed from the response of wild-fish growth to changes in the amount of release through the model simulation.

[24] Identification of offspring of hatchery-produced Tiger Puffer in the wild

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Stock enhancement programs that release hatchery-produced fish in the wild are widely used for restoration of declining marine fish resources. However, little is known about the reproduction of these hatchery-produced fish stocked in the wild. The tiger puffer *Takifugu rubripes* is an economically important species that is distributed in the northwestern Pacific. Recently, the *T. rubripes* resource has progressively declined in the sea around Japan; therefore, about two million hatchery-produced juveniles are released annually to restore the population. In particular, between 28,000 and 1,280,000 hatchery-produced juveniles have been released into Ariake Sea every year since 2000. Mark-recapture studies revealed that these stocked juveniles mature in the wild and homing after migration. The aim of this study was to identify wild juveniles in the Ariake Sea that are related to mature hatchery-produced fishes using DNA analysis. A total of 154 mature hatchery-produced fishes and 276 wild juveniles collected from Ariake Sea in 2012 were genotyped using 16 microsatellite loci. We performed sibship analysis, and not parentage analysis, because most of the mature hatchery-produced fishes were collected before spawning. A total of 182 half-sib dyads composed of 50 wild juveniles were detected among 42,504 dyads of mature hatchery-produced fishes and wild juveniles, suggesting the possibility that these juveniles are descendants of mature hatchery-produced fishes, and that hatchery-produced fishes certainly reproduce in the wild. This is the first report to identify offspring of hatchery-produced tiger puffer in the wild.

[26] Development of culture methods for the production of Western School Prawns (*Metapenaeus dalli*) for release into the Swan and Canning rivers to enhance the community values of the recreational prawn fishery

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The Western School Prawn (*Metapenaeus dalli*) (WSP) was once abundant in the Swan and Canning Rivers, supporting productive commercial and recreational fisheries, however stocks have been declining since 1959. A three year collaborative project was initiated to pilot the production and release of WSP. The culture of this species was a world first and major bottlenecks were identified in the first year that limited our ability to follow established protocols for the culture of other prawn species. The most significant of these were fecundity and larval size. The WSP grows to a total length of ca. 100mm and gravid females spawn only 30,000 - 60,000 eggs. Although WSP larvae go through the same developmental stages at around the same speed as other commercially cultured species, they are significantly smaller at each life stage and therefore require a different approach to feed management. This paper describes how these bottlenecks were overcome and the new methods developed for the successful spawning and culture of WSP during the hatchery phase. As a result of these bottlenecks, the first season resulted in four spawning events with only 1,000 post larval prawns produced (PL15). In the second season, eight successful spawnings were achieved and 639,000 PL15s released. With the new methods developed, the third season produced over 1.9 million PL15s from 6 spawning events.

[27] Assessing the sediment preference of a Penaeid Prawn to inform release strategies

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The abundance of the Western School Prawn (*Metapenaeus dalli*) declined markedly in the Swan-Canning Estuary after the 1960s, resulting in the initiation of a restocking program in 2012. Further to the decline in abundance, anecdotal evidence from recreational fishers indicated that there had been a spatial shift in the distribution of this prawn. To test the hypothesis that a change in sediment composition may be responsible, the density of *M. dalli*, recorded monthly between October 2013 and August 2014, was correlated against sediment organic matter content and grain size distribution. Densities of *M. dalli* were found to differ among sediment types in summer, but not winter. Controlled laboratory experiments were used to investigate whether *M. dalli* exhibited a preference for sediments from either the upper or lower reaches of their distribution within the estuary. Prawns

exhibited a preference for nearshore and offshore sediments that contained a lower percentage contribution of larger grain sizes and/or a higher percentage contribution of finer grain sizes, i.e. sediments from the lower rather than upper reaches. These experiments also revealed that emergence and activity rates of *M. dalli* are strongly related to photoperiod, with individuals preferring to remain buried during daylight hours and become active during darkness. Visual observations also indicated that the prawns were able to bury more rapidly in finer than coarse sediments, thus reducing their length of exposure to predators. The implications of these findings on the current restocking program for *M. dalli* in the Swan-Canning Estuary are discussed.

[28] Restocking of giant clams to increase protection of MPAs

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The Municipality of San Joaquin in Iloilo has one of the most attractive coastlines in southern Panay Island of central Philippines characterized by majestic rock formations and crystal clear waters. Coral reefs show an abundance of life and diversity, although some areas show signs of degradation. To protect and rehabilitate this natural resource, the municipality has created three Marine Protected Areas (MPA) where fishing activities are limited. Maintaining MPAs require both environmental management and sustained livelihood for fishers. This study aims to promote awareness to protect coral reefs through restocking of giant clams *Tridacna gigas* while supporting livelihood through ecotourism. This project benefited from a strong cooperation among local government, research institutions, and local communities. Aside from some unfortunate clam mortality caused by incidents of typhoons, and an unexpected high predation on some clams, the project was still able to elicit positive impacts in promoting protection of the coral reefs as a whole. More and more fish and wild clams were observed in the past two years of the project, indicating success in environmental protection. Visitors who snorkel around the clams and reefs were also observed to increase, providing some extra income to local guides and fishers. Our presence in the area enhanced the awareness of local communities on the benefits of MPAs and the value of a healthy coral reef to sustain both marine diversity and local livelihood.

[29] Performance and contribution to commercial catches and egg production by restocked *Acanthopagrus butcheri* in the Blackwood River Estuary

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This study has explored whether restocked fish of a species perform as well as its wild stock, and has estimated their contribution to the fishery and egg production. Approximately 220,000 juvenile *Acanthopagrus butcheri*, whose otoliths were stained purple with alizarin complexone, were released into the Blackwood River Estuary in 2002/03. The purple stain in their otoliths was still clearly visible in 2014. Data on the biological characteristics and annual contributions to the small commercial fishery of restocked and wild stock *A. butcheri* were analysed. The growth of restocked fish was only slightly less than that of the wild stock and the differences between their maturity schedules were relatively small. As increasing numbers of restocked *A. butcheri* attained the MLL of 250 mm for retention by the commercial fisher, their contribution to the fishery increased progressively from 6% in 2005 to 74% in 2010. That contribution subsequently declined to 39% in 2012 and to 10% in 2014, due predominantly to the introduction of the very strong 2008 year class in the commercial catches, the first substantial recruitment of wild stock fish into the population since 1999. Restocked fish were estimated as contributing ~55% to the eggs produced in 2008, suggesting that substantial numbers of the 2008 year class were derived from spawning by restocked fish. The results of this and a previous genetic study imply that restocking is an effective and appropriate way for replenishing stocks of an estuarine species such as *A. butcheri*.

[30] Development of the system for sibship reconstruction to evaluate genetic effects of stock enhancement program of Japanese Flounder

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Sibship reconstruction using DNA markers is useful for monitoring the reproductive success of the broodstock in hatchery and the offspring stocked in the wild. We prepared a highly polymorphic DNA marker sets of 12 microsatellites DNA and 1,873 nucleotides in mitochondrial DNA (concatenating the first half of control region and entire of ND2 gene sequences) of Japanese flounder *Paralichthys olivaceus*, and tested the power for sibship reconstruction by comparing the sibship estimated by likelihood method without parental information and 'true sibship' among offspring produced from same broodstock. At first, we screened 120 captive wild broodstock without tags for their sex and the 192 offspring using both of the microsatellite and mitochondrial DNA markers. All of the offspring were completely assigned to

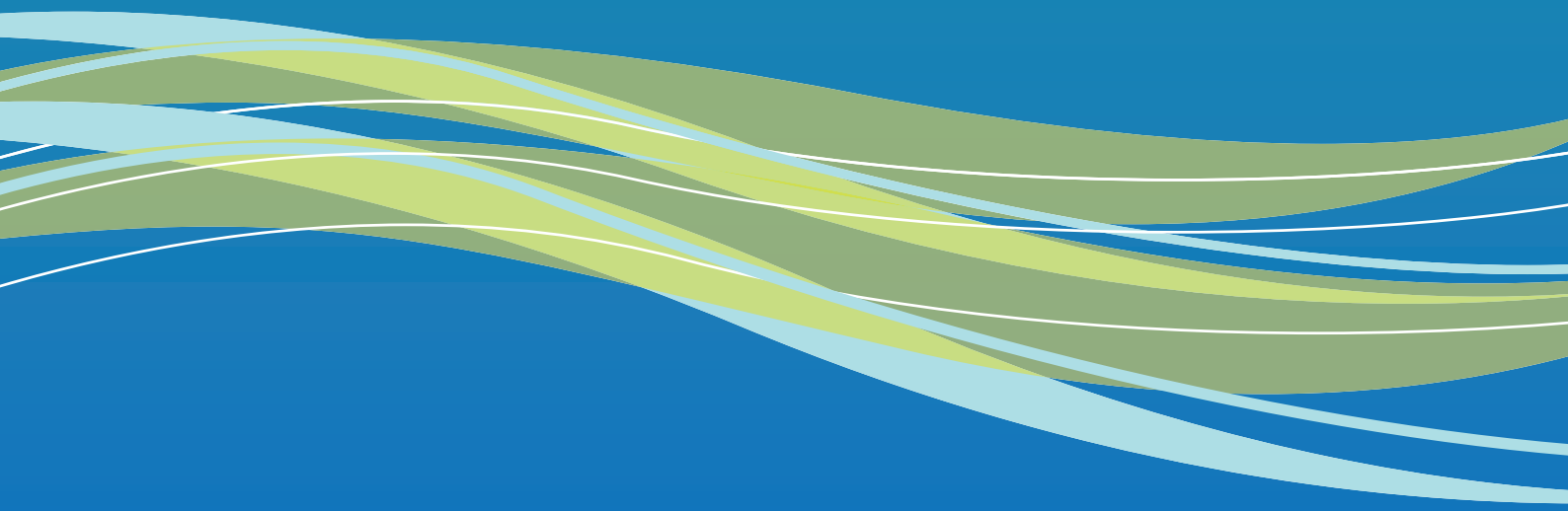
27 sires and 37 dams, and the number of full- and half-sib dyads were 357 and 1,960 respectively. The results of likelihood estimation using COLONY program (Jones & Wang, 2010) without parental information showed 357 full- and 1956 half-sib dyads. The value of type I and II errors, precision recall, and F-measure on full-sib was 0.000% and 0.000%, 1.000, 1.000, and 1.000, respectively. On half-sib, those were 0.000% and 0.365%, 0.842, 1.000, and 0.914. These results indicate that a combination of the DNA marker sets we prepared and COLONY program can reconstruct sibship among individuals without their parental information, and would contribute to evaluate genetic effect of stock enhancement program of this species.

[31] Sea-ranching and farming of Sandfish in the Pacific Islands

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The SPC - led ACIAR Community-based Aquaculture Project is being implemented to develop profitable aquaculture systems that would target improving resilience of fisheries systems to improve better resource management. The project will also assist in improving food security (nutrition) and livelihoods of communities in Fiji, Samoa, Vanuatu and Kiribati. The outcome of country consultations during project formulation has put focus on sandfish (*Holothuria scabra*) sea-ranching and farming as the basis of integrating sandfish aquaculture with coastal fisheries to strengthen community based fisheries management in Fiji and Kiribati. The lack of proper management has resulted in the decline of major harvested commercial sea-cucumber species. To provide alternative livelihoods, the project is exploring sea-ranching and farming of sandfish reared from hatcheries. This has led to hatchery trainings conducted in earlier 2015 for Fisheries officers including the private sector from several Pacific Island countries. The key constraints lie in the high mortality of sandfish juveniles in the early hatchery and nursery culture stages. The project will explore ways of improving early nursery culture techniques and lessons learnt from other countries will be considered. What remains unclear also is how benefits from released sandfish will flow back to those who invested in the technology and those with rights over the marine space. It is hoped that communities will have an alternative source of income and therefore improve their livelihoods after completion of this project. It is also anticipated that women and the children will benefit from this activity, and that sea-ranching will contribute to better community-based coastal fisheries management.



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