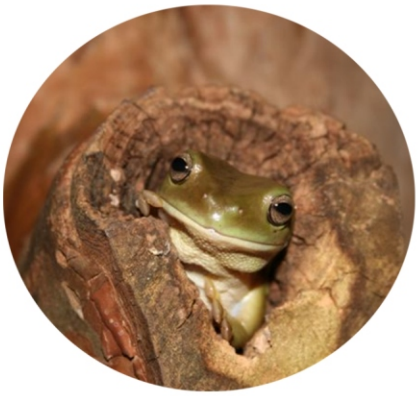
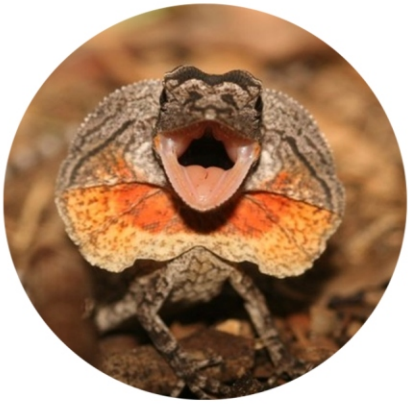
enviroTox 2011

SHARING KNOWLEDGE FOR A HEALTHIER ENVIRONMENT

THE ROYAL AUSTRALIAN CHEMICAL INSTITUTE INC.

Hosted by SETAC Australasia





Sharing knowledge for a healthier environment

Darwin Convention Centre
Darwin, Northern Territory
17 April – 20 April 2011

www.envirotox2011.org

Contents

Welcome

EnviroTox 2011

17th April – 20th April, 2011

Darwin Convention Centre

Dear colleagues,

On behalf of the Royal Australian Chemical Institute (RACI) and the Society for Environmental Toxicology and Chemistry – Australasia Chapter (SETAC-AU; formerly Australasian Society for Ecotoxicology, ASE), it gives us great pleasure to welcome you to Darwin for EnviroTox 2011! This conference aims to promote the sharing of knowledge to gain a better understanding of the environmental risks, impacts and management of contaminants to ensure a healthier environment.

Darwin represents a fitting location for the conference – the aquatic and terrestrial ecosystems of northern Australia are recognised as being amongst the least impacted and most diverse in the world, but are under increasing pressure due to the abundance of natural resources such as minerals, oil, natural gas and freshwater and the tourism and pastoral industries. There is an opportunity in northern Australia for sustainable development without repeating the mistakes made elsewhere in Australia and the world. For this to be realised, development must be underpinned by sound scientific knowledge. The generation and sharing of such knowledge, not just in northern Australia, but globally, is the key theme of this conference.

EnviroTox 2011 continues the tradition of joint meetings of RACI and SETAC-AU / ASE. The conference represents the 6th such joint meeting, the 2nd conference of the Northern Territory Branch of RACI and the inaugural conference of SETAC-AU. These joint conferences have a reputation for bringing together a strong mix of relevant environmental disciplines, and are recognised as being the premier, industry-wide gathering of environmental researchers, practitioners and other professionals in the Australasian region working or involved with the harmful effects of contaminants on ecosystems.

EnviroTox 2011 features a group of nine internationally-recognised invited Plenary and Keynote speakers, over 120 general platform and poster presentations. In addition, we have planned a series of formal and informal social events that should keep those interested in after-hours networking well occupied.

We would like to take this opportunity to thank the two Societies, RACI and SETAC-AU, and the conference sponsors (listed elsewhere in the conference program book), for the support they have shown for the conference. We would not have been able to hold this event without this support.

We hope you also take the opportunity to stay a little longer in this unique part of the world, and explore some of the most highly valued ecosystems and cultural settings in the world, including the iconic Kakadu and Kimberley regions.

Enjoy your conference!

Michelle Iles and Rick van Dam
Conference Co Chairs, EnviroTox 2011

Organising Committee

ENVIROTOX 2011 ORGANISING COMMITTEE

Co-chair (SETAC-AU)

Rick van Dam (Environmental Research Institute of the Supervising Scientist (ERISS), SETAC-AU)

Co-Chair (RACI)

Shelly Iles (Energy Resources of Australia (ERA), RACI)

Treasurer

Nicole Jacobsen (Energy Resources Australia ERA, RACI)

Secretary

Alicia Hogan (ERISS, SETAC-AU)

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Andrew Harford (ERISS, SETAC-AU)
Mel Trenfield (ERISS, SETAC-AU)
Claire Costello (ERISS,SETAC-AU)
Kim Cheng (ERISS, RACI)
Paul Davey (Sinclair Knight Merz, RACI)
David Parry (Australian Institute of Marine Science (AIMS), RACI)
Sue Codi-King (AIMS, SETAC-AU & RACI)

Society representatives

Munro Mortimer (SETAC-AU)
Jan Hosking (RACI)

Sponsors and Supporters

The organising committee for EnviroTox 2011 acknowledges with gratitude the generous support received from the following sponsors:

GOLD SPONSORS

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Delegate Information

THE VENUE
The venue has two levels. The ground level is known as Level 1 and the first floor as Level 2. Sessions can be found in the Waterfront Rooms 1 and 2 (level 2), and Meeting Rooms 2 and 3 (level 1). All breaks and poster displays occur on the ground floor in Exhibition Hall 2 (level 1). The speaker preparation room is immediately behind the registration counter (level 1)

NAME TAGS
Delegates are required to wear their name tags to all scientific and catered sessions.

ORAL PRESENTERS- SPEAKER PREPERATION ROOM
The presentations need to run on MS PowerPoint. There is a speaker preparation room behind the registration desk and you should go there to load your talk and check it runs to your satisfaction at least an hour before your session starts. There will be a technician in attendance. There is no facility to use your own laptop.

POSTER PRESENTERS
Your poster can be on display throughout the whole conference. Delegates with posters can place their poster by finding the appropriate abstract number on the display panels in the exhibition area. The maximum size of posters allowed is 1 metre wide by 1.2 metres high. It should be attached by velcro which can be obtained from the registration desk on arrival.

REGISTRATION DESK
The North West entrance lobby gives direct access to the Registration Desk. The registration desk will be open during the day on Sunday (after 3pm), Monday, Tuesday and Wednesday.

INTERNET ACCESS AT THE CONFERENCE
Wireless internet is available to all delegates on Monday, Tuesday and Wednesday for no charge. In addition there will be two workstations connected to the internet in the exhibition hall.

SOCIAL FUNCTIONS

- **WELCOME RECEPTION – SUNDAY 17TH APRIL**
  The conference acknowledges the support of NTEL

Delegates are invited to the Welcome Function to be held at the Darwin Convention Centre (Waterfront Foyer, level 2) on Sunday evening, 6pm – 8pm. The opening formalities will be conducted along with drinks and finger food..

- **MONSOONS PUB NIGHT - MONDAY 18TH APRIL**

All delegates are welcome to attend the conference social event being held at Monsoons bar and restaurant on Monday 18th of April from 6:00 pm. The night will include beverages at hospitality rates; $4.00 house wines & sparkling, $5.50 basic spirits, $4.00 schooners and $5.00 - $5.50 pints .To take advantage of these special rates please ensure that wear your EnviroTox name tag. Monsoons also have a choice of food specials; $15.00 - Burger and a schooner (tap beer), $20.00 - Any pizza & a carafe of Sangria and 2 for the price of 1 pizzas.

- **CONFERENCE DINNER – TUESDAY 19TH APRIL**
  The conference acknowledges the support of Energy Resources of Australia

All delegates and accompanying persons are invited to attend the Conference dinner to be held in the Exhibition Concourse on Wednesday evening, from 7pm. Dress is smart casual and socialising is the focus after the day's academic proceedings. Tickets are required to gain admission and need to be purchased separately; they are not included in your registration fee. Delegates will find their pre-paid tickets with their name tags at the registration desk. Additional tickets are limited and can be purchased separately from the registration desk for $75.00. Enjoy the night dancing away to 'The NEO', who will entertain you with a mix of funk, ska, blues and rock, with elements of cabaret and circus.

- **DARWIN HARBOUR CRUISE – WEDNESDAY 20TH APRIL**

For a great way to finish the conference on Wednesday 20th of April, enjoy 2.75 hours cruising Darwin Harbour aboard the 'Alfred Nobel' for the 'Seated Sunset Dinner Cuise'.The cruise boards at 5:15 pm for a 5:45pm departure. To attend the cruise, you will need to book directly with the company at http://www.darwinharbourcruises.com.au or on 8942 3131. A special conference rate of $88.00 per person (normally $110.00) is being offered for EnviroTox delegates so make sure you mention that you are attending the conference. Note that in the case of wet weather our group may be transferred to a larger vessel, the 'Charles Darwin'. More information is provided in your conference satchel.

The conference acknowledges the support of the silver sponsors

Plenary Speakers

Dr Tracy K. Collier
Science Advisor
Oceans and Human Health Initiative, National Oceanographic and Atmospheric Administration, U.S.A
Topic: Organics and micropollutants in the marine environment

Dr Tracy Collier currently serves as the science advisor to NOAA's Oceans and Human Health Program, where he provides science direction in the areas of chemical contaminants, pathogens, and algal toxins and their effects on human and ecosystem health. Until recently, Dr. Collier was Director of the Environmental Conservation Division of NOAA's Northwest Fisheries Science Center, where he supervised a research enterprise comprised of approximately 90 scientists. Dr. Collier received his PhD from the University of Washington in 1988, and he holds faculty appointments at Oregon State University and Washington State University. He is a post-doctoral advisor to the National Research Council, serves on a number of regional, national, and international panels and committees, and has over 125 scientific publications.
Dr. Collier's research interests over the years have covered some of the first work on metabolism of PAHs by fish, studies of the impacts of oil spills on marine fish and mammals, the enzymology of carcinogen activation and detoxication, and assessing overall effects of contaminants on fish populations through the use of field investigations. His current personal research interests are in the areas of environmental toxicology, field investigations of causality, the use of marine mammals and fish as sentinel species for assessing relationships between oceans and human health, and the ecological consequences resulting from exposure to sub-lethal levels of chemical contaminants.

Dr Samuel N. Luoma
Emeritus Professor, - U.S. Geological Survey and John Muir Institute of the Environment, University of California, Davis
Chief Advisor Environment - Rio Tinto Mineral Technology Services, Richards Bay, South Africa
Topic: Metals bioavailability and ecological effects
Dr Samuel N Luoma spent 34 years as a senior research scientist with the U.S. Geological Survey and has held roles as Research Professor in the John Muir Institute of the Environment at the University of California, Davis, Editor-in-Chief of San Francisco Estuary & Watershed Science and Scientific Associate with The Natural History Museum in London, UK.
Dr Luoma's specific research interests are bioavailability and ecological effects of metals in aquatic environments as well as water resource management in arid and semi-arid climates. He is an author on more than 200 peer-reviewed publications. Developing interests include work with metallo-nanoparticles, and in 2008 he worked with the Woodrow Wilson International Center for Scholars to write a report on the state of knowledge with regard to nanosilver: Silver Nanotechnologies and the Environment: Old problems or new challenges. With co-author Philip Rainbow, Dr Luoma recently published the highly regarded book, Metal Contamination in Aquatic Environments: science and lateral management (Cambridge University Press). He is an editorial advisor for Marine Ecology Progress Series, and is on the editorial board of Oceanologia. He was a W.J. Fulbright Distinguished Scholar in the UK in 2004 and is a Fellow in the American Association for the Advancement of Science. He has served nationally and internationally as a scientific expert or advisor on issues at the interface of science and environmental management, including sediment quality criteria (USEPA SAB Sub-committee), Bioavailability of Contaminants in Soils and Sediments (Canadian National Research Council, 1987; US National Research Council sub-committee, 2000-2), mining issues (UNESCO, Global Mining Initiative), selenium issues, environmental monitoring, and metal effects.
Sam recently joined Rio Tinto's Mineral Technology Services as Chief Adviser, Environment where his close ties with academic institutions supports links between industrial practices and environment protection.

Mary Reiley
Water Research Coordinator
Office of Water & Office of Science and Technology
U.S. Environmental Protection Agency

Mary Reiley is an Environmental Biologist. She has worked over the years to communicate environmental science between interested organizations in the US and abroad. Ms. Reiley is frequently a speaker both state-side and internationally at workshops, seminars and conferences on bringing strong science to environmental decisions.

Mary recently completed her first tour and is starting her second as a member of the Society of Environmental Toxicology and Chemistry-North America Board of Directors. As a member of SETAC she has chaired many North American annual meeting sessions on the use of risk assessment information. Mary has chaired, been a steering committee member, and participant in several SETAC Pellston Workshops and been a steering committee member for the SETAC-NA Metals Advisory Group.

Beyond her professional life, Mary lives in Virginia with her husband and three kids. She camps, hikes, and teaches environmental science to her youngest's Girl Scout Troop and elementary school class, participates in middle school environmental science fieldtrips, and moonlights as her children's chauffeur. On the rare occasion she finds herself with nothing to do, Mary paints murals and is an accomplished do-it-yourselfer.

Keynote speakers

Professor Jack Ng
Professorial Research Fellow
EnTox (National Research Centre for Environmental Toxicology)
The University of Queensland

Professor Jack Ng is a certified toxicologist (DABT - Diplomate of the American Board of Toxicology) who is a Professorial Research Fellow at the National Research Centre for Environmental Toxicology, the University of Queensland where he leads the Metals and Metalloids Research. He is also a Program Leader for Risk Assessment for the CRC-CARE (Cooperative Research Centre of Contamination Assessment and Remediation of the Environment). His major research themes include chemical speciation of metals in environmental and biological media, bioavailability in relationship to toxicities, carcinogenicity and mechanistic studies using various in-vitro and in-vivo models.

Mr Jon Brodie
Senior Principal Research Officer
Australian Centre for Tropical Freshwater Research
James Cook University
Jon Brodie is a Research Scientist with the Catchment to Reef Research Group of the Australian Centre for Tropical Freshwater Research, James Cook University. His area of interest is research and management of water quality issues for the iconic Great Barrier Reef (GBR) – specifically, the sources and dispersal of pollutants in catchments and their transport to, and effects on, the marine environment. He has published over 60 peer-reviewed articles and 80 technical reports in this field, and in 2008 was the lead author of the Scientific Consensus Statement documenting the status of knowledge and management for water quality issues affecting the GBR.

Dr Donald Baird
Research Professor
Environment Canada and the Canadian Rivers Institute
University of New Brunswick, Canada.
Dr Donald Baird is a Senior Research Scientist working in the Water Science and Technology Directorate of Environment Canada, and is co-located at the Canadian Rivers Institute at the Fredericton campus of the University of New Brunswick. His principal research focus is on the development of diagnostic approaches to assess impacts of multiple stressors on freshwater

ecosystems. Current research focuses on two main areas: the development of traits-based ecological risk assessment approaches and the application of high-throughput genomics in biodiversity discovery and ecosystem biomonitoring. He has previously organized and co-chaired 3 SETAC Pellston workshops focusing on ecological aspects of ecotoxicology.

Dr Stuart Simpson
Principal Research Scientist
Centre for Environmental Contaminants Research
CSIRO Land and Water, Sydney, Australia
Dr. Stuart Simpson is a Principal Research Scientist at the Centre for Environmental Contaminants Research, CSIRO Land and Water, and has more than 15 years experience in water and sediment quality assessments. His main research interests involve the development of cause-effect relationships between contaminants and biological/ecological effects and the development and application of sediment quality guidelines and assessment tools. In addition he has a broad interest in the analytical and environmental chemistry of contaminants in aquatic environments, in particular, the reactivity of metal pollutants and processes controlling metal speciation and bioavailability in both surface waters and sediments.

Professor Louis J. Guillette
Professor, Obstetrics and Gynecology;
CoEE Endowed Chair of Marine Genomics;
Marine Biomedicine and Environmental Sciences Center
Medical University of South Carolina
Louis J. Guillette, Jr., Ph.D., holds a Professorship in Obstetrics and Gynecology at the Medical University of South Carolina, a professorship at the Howard Hughes Medical Institute and the CoEE Endowed Chair in Marine Genomics at the Hollings Marine Laboratory. Prof Guillette was, until recently, a Distinguished Professor of Biology at the University of Florida. He is internationally recognized for his research examining the role of environmental contaminants as inducers of birth defects in various wildlife species and children which has been published in almost 300 papers and edited five books. His current work examines the molecular, cellular and endocrine mechanisms associated with genital and gonadal development and contaminant-induced abnormalities.

Professor David Fox
Director, Australian Centre for Environmetrics
Prof. Fox is one of Australia's leading environmental statisticians. He holds a Masters and PhD in statistics and has professional accreditation from the Science Council (UK), American Statistical Association and the Royal Statistical Society (London). He has held academic positions at universities in Australia, the U.K. and the United States. During nearly 15 years with CSIRO he held a number of senior appointments including Project Leader, Program Manager, and Business Director. He was joint recipient of CSIRO's Chairman's Gold Medal in 1997 for his role in the Port Phillip Bay Environmental Study. He currently chairs a working group and statistics sub-group as part of the revision of Australia's National Water Quality Guidelines. His research interests include ecotoxicology, spatial-temporal statistics, and methods for improved water quality monitoring and assessment.

Program

Sunday, 17 April 2011

Welcome Reception
6:00 PM - 8:00 PM Conference Centre Waterfront Foyer (Level 2)
The conference acknowledges the support of NTEL

Monday, 18 April 2011

Opening Ceremony
8:15 AM - 8:50 AM Waterfront 1 & 2
Chair: Rick Van Dam

DonnaJackson, Larrakia Nation
Dr Andrew Tupper, Chair of the Northern Territory Environment Protection Authority

Plenary session
8:50 AM - 9:50 AM Waterfront 1 & 2
The conference acknowledges the support of the Australian Institute of Marine Science
Chair: David Parry

Dr Tracy Collier
Emerging concerns about the effects and fate of chemical contaminants in marine biota *abs#001*

Keynote session
9:50 AM - 10:30 AM Waterfront 1 & 2
The conference acknowledges the support of Agilent Technologies
Chair: Sue Codi King

Professor Louis J. Guillette
New Views on Environmental Health and Disease: Aquatic Contaminants and Lessons from Wildlife *abs#002*

Keynote session
9:50 AM - 10:30 AM Meeting Room 2
The conference acknowledges the support of Charles Darwin University
Chair: Rick Van Dam

Professor David Fox
Statistics and Ecotoxicology: Past, Present and Future *abs#003*

Morning Tea (Poster viewing)
10:30 AM - 11:00 AM Exhibition Hall 2

The conference acknowledges the support of Agilent Technologies

Micropollutants and emerging contaminants 1
11:00 AM - 12:20 PM Waterfront 1 & 2
Chair: Tracy Collier

11:00am **Kavitha Chinathamby**
An assessment of *Gambusia holbrooki* for Freshwater Biomonitoring of Estrogenic Endocrine Disruptors in Melbourne *abs#004*

11:20am **Alexis Marshall**
Quantitative assessment of endocrine disruption in a native Australian fish (*Tetractenos glaber*) using gonad histopathology techniques *abs#005*

11:40am **Minna Saaristo**
Effects of 17α - ethinyl estradiol on the reproductive behaviour of a marine fish sand goby (*Pomatoschistus minutus*) *abs#006*

12:00am **Anu Kumar**
Murray rainbowfish (*Melaotaenia fluviatilis*): small fish model for identifying and assessing the effects of endocrine disrupting chemicals in the Australian riverine environment *abs#007*

Environmetrics
11:00 AM - 12:00 PM Meeting Room 2
Chair: Michael Warne

11:00am **Ross Smith**
Variance – the neglected parameter in ecotoxicology *abs#008*

11:20am **Duncan Buckle**
Comparison of ANOVA and PERMANOVA analysis techniques to stream community data for BACI-type impact detection designs *abs#009*

11:40am **David Fox**
Time-dependent SSDs *abs#010*

Integrated monitoring and assessment 1
11:00 AM - 12:20 PM Meeting Room 3
Chair: Vin Pettigrove

11:00am **Rick van Dam**
Integrated assessment of discharges from two mining operations into a tropical freshwater stream *abs#011*

11:20am **David Jones**
Integrated water quality monitoring for an Australian uranium mine – a best practice case study *abs#012*

11:40am **Kyla Clark**
Wetland Function and the Role of Ecology in the Removal of Contaminants *abs#013*

12:00pm **Lisa Golding**
Impacts on freshwater macroinvertebrates from pesticides used to control locusts in Victoria, Australia *abs#014*

Lunch (poster viewing)
12:20 PM - 1:20 PM Exhibition Hall 2

The conference acknowledges the support of Charles Darwin University

Micropollutants and emerging contaminants 2
1:20 PM - 2:40 PM Waterfront 1 & 2
Chair: Dayanthi Nugegoda

1:20pm **Susan Codi King**
Micropollutants and their potential impact in Darwin Harbour *abs#015*

1:40pm **Heather Hamlin**
Nitrate as an endocrine disrupting contaminant in American alligators (*Alligator mississippiensis*) *abs#016*

2:00pm **Admane Shanthanagouda**
Responses of the aromatase genes in the Murray River rainbowfish, *Melanotaenia fluviatilis* exposed to xenoestrogens *abs#017*

2:20pm **Fiona Young**
Comparative *in vitro* assessment of the cytotoxic and endocrine disrupting effects of glyphosate and Roundup *abs#018*

Mining/oil and gas impacts 1
1:20 PM - 3:00 PM Meeting Room 2
Chair: Karen Hughes

1:20pm **Raijeli Taga**
Evaluation of environmental risks from metals and metalloids in historical wastes at the Wainivesi Gold Mine, Fiji *abs#021*

1:40pm **Alison Frostick**
Trace metal and lead isotope dispersal from a decommissioned gold mine in the Northern Territory, Australia *abs#022*

2:00pm **Sheila (Shamsa) Syeda**
Metal and sulfate pollution of riverine surface sediments caused by Acid Mine Drainage *abs#023*

2:20pm **Barry Noller**
Evaluation of a DGT approach to develop toxicity models of metal speciation in shallow seepage from a rehabilitated lead-zinc mine to an ephemeral tropical creek *abs#024*

2:40pm **David Everett**
Cumulative Impacts of Mines on Water Quality in the Fitzroy Basin: Risk Assessment and Licensing Review *abs#019*

Integrated Assessment and Monitoring 2
1:20 PM - 3:00 PM Meeting Room 3
Chair: David Everett

1:20pm **Beate Escher**
Assessing removal efficiency of organic contaminants during advanced water treatment by combining passive sampling with chemical analysis and bioanalytical tools *abs#025*

1:40pm **Kathryn Hassell**
Identification of pollution sources and biological effects in an urban stream in Victoria: a CAPIM case study *abs#026*

2:00pm **Katherine Dafforn**
Bang for buck, the challenge of choosing between chemical and biological monitoring tools for assessing the health of estuaries *abs#027*

2:20pm **Ross Smith**
Providing better linkages between ecotoxicity testing and field biomonitoring - why don't we at least use the same species? *abs#028*

2:40pm **Steve Marshall**
Ecological diagnosis of pesticide impacts by weight of evidence *abs#029*

Afternoon Tea (Poster viewing)
3:00 PM - 3:30 PM Exhibition Hall 2

The conference acknowledges the support of Australian Institute of Marine Science

Micropollutants and emerging contaminants 3
3:30 PM - 4:30 PM Waterfront 1 & 2
Chair: Lou Guillette

3:30pm **Dayanthi Nugegoda**
The toxicity of Silver nanoparticles (AgNPs) to two Australian freshwater invertebrates, *Hydra vulgaris* and *Paratya australiensis* *abs#030*

3:50pm **Kenneth Leung**
Temperature-dependent Toxicities of Nano-Zinc Oxides on Three Marine Organisms *abs#031*

4:10pm **Mike McLaughlin**
Retention of metallic nanomaterials in soils *abs#032*

RACI Environmental Medalist
4:30 PM - 5:10 PM Waterfront 1 & 2
Chair: Di Jolley

Simon Apte
Confessions of an Environmental Chemist *abs#033*

Mining/oil and gas impacts 2
3:30 PM - 5:10 PM Meeting Room 2
Chair: Barry Noller

3:30pm **Howard Smith**
The stability of hydrotalcite as an environmental ameliorant: a molecular modelling approach to toxic anion bonding *abs#034*

3:50pm **Sajida Bakhtyar**
Closed-bottle biodegradation test for synthetic-based drilling fluids under Australian conditions *abs#035*

4:10pm **Fleur Pablo**
Investigations into the effects of common petroleum fuels to local soil organisms, plants and soil functions *abs#036*

4:30pm **Christopher Rawson**
Monitoring the impacts of the Montara well release using biomarkers of fish health *abs#037*

4:50pm **Niall Johnston**
Recent developments in fuels: environmental effects and implications for management of underground petroleum storage systems *abs#038*

Environmental Monitoring 1

3:30 PM - 5:10 PM Meeting Room 3

Chair: Graeme Batley

3:30pm **David Williams**
Fine Sediment Transport in Darwin Harbour *abs#039*

3:50pm **Grant Northcott**
Disappearance and transformation of triclosan, a common antimicrobial compound, in a New Zealand soil *abs#040*

4:10pm **Lili Yu**
Short-term Monitoring of Atmospheric Polycyclic Aromatic Hydrocarbons during a Haze Episode in the Pearl River Delta, South China *abs#041*

4:30pm **Katelyn Edge**
Non-destructive sampling for persistent organic pollutants in Australian white ibis (*Threskiornis molucca*) from Sydney *abs#042*

4:50pm **Ralph Alquezar**
Does Batman Influence Gotham City? *abs#043*

Poster viewing

5:10 PM - 6:00 PM Exhibition Hall 2

Informal social event - Monsoons, food and beverages

6:00 PM - 9:00 PM Monsoons restaurant

Tuesday, 19 April 2011

Student Breakfast (sponsored by SETAC AU)
7:15 AM - 8:30 AM Convention Centre Café
The conference acknowledges the support of SETAC AU

Metals speciation, bioavailability and effects 1
8:30 AM - 10:10 AM Waterfront 1 & 2
Chair: Sam Luoma

8:30am **Emma Johnston**
The role of contamination in facilitating invasion *abs#044*

8:50am **Melanie Trenfield**
The influence of dissolved organic carbon on the speciation and toxicity of aluminium to tropical freshwater organisms *abs#045*

9:10am **Ceiwen Pease**
Differential tolerance to metal contamination among populations of a marine herbivore *abs#046*

9:30am **Tom Cresswell**
Trace metal accumulation by the freshwater decapod *Macrobrachium australiense* exposed to metal-enriched sediments *abs#047*

9:50am **Marilyn Bennet-Chambers**
Cadmium and zinc uptake and efflux rates in the signal crayfish *Pacifastacus leniusculus* *abs#048*

Risk Assessment 1
8:30 AM - 10:10 AM Meeting Room 2
Chair: Donald Baird

8:30am **Adam Wightwick**
Environmental risks of fungicides used in horticultural production systems: current knowledge and research gaps *abs#049*

8:50am **Yin Latt Phyu**
A comparison of mixture toxicity assessment: examining the chronic toxicity of atrazine, permethrin and chlorothalonil in mixtures to *Ceriodaphnia* cf. *dubia* *abs#050*

9:10am **Chris Hickey**
Incorporating community level macroinvertebrate endpoints into guideline derivation procedures: application to several environmental stressors *abs#051*

9:30am **Des Connell**
Risk to breeding success of fish eating birds in Hong Kong due to persistent organic contaminants in eggs *abs#052*

9:50am **Julie Mondon**
Histological health indices: Linking complex pollutant exposure with tissue alteration in sand flathead *Platycephalus bassensis* *abs#053*

Environmental monitoring 2
8:30 AM - 10:10 AM Meeting Room 3
Chair: Leonie Andersen

8:30am **Susan Codi King**
The use of a socio-economically important species, the Indo-Pacific rock oyster (*Saccostrea* sp.), as a biomonitor for water quality in northern tropical Australia *abs#054*

8:50am **Christy Davies**
Drawing inference in in-stream toxicity monitoring tests used to assess mining impact in a tropical stream *abs#055*

9:10am **Katelyn Edge**
Evaluating the use of biomarkers as indicators of ecological stress *abs#056*

9:30am **Stuart Simpson**
DGT-copper flux predicts bioaccumulation and toxicity to bivalves in sediments with varying properties *abs#057*

9:50am **Anthony Roach**
Species Responses to Contamination: Insights from Sydney Harbour *abs#058*

Morning Tea (Poster viewing)
10:10 AM - 10:40 AM Exhibition Hall 2
The conference acknowledges the support of Vision Environment QLD

Plenary Session
10:40 AM - 11:40 PM Waterfront 1 & 2
Chair: David Jones

Dr Samuel Luoma
Whence metal ecotoxicology? Exploiting integrative concepts *abs#059*

Keynote session
11:40 AM - 12:20 PM Waterfront 1 & 2
The conference acknowledges the support of Energy Resources of Australia
Chair: Nicole Jacobsen

Professor Jack Ng
Environmental chemistry and toxicology of arsenic *abs#060*

Keynote session
11:40 AM - 12:20 PM Meeting Room 2
The conference acknowledges the support of NTEL
Chair: Karen Gibb

Dr Donald Baird
Biomonitoring 2.0: generating and harnessing data on an epic scale for ecosystem assessment *abs#061*

Lunch (poster viewing)
12:20 PM - 1:20 PM Exhibition Hall 2

Metals speciation, bioavailability and effects 2
1:20 PM - 3:00 PM Waterfront 1 & 2
Chair: Jack Ng

1:20pm **Yarong Li**
Microbially mediated chemical transformation of metal species in landfill leachate *abs#062*

1:40pm **Adam Wightwick**
Resilience of soil microbial function to a copper stress and heat disturbance *abs#063*

2:00pm **Dianne Jolley**
Cellular biomarkers in microalgal toxicity bioassays - unravelling physiological responses to metal exposure *abs#064*

2:20pm **Amie Anastasi**
Progress towards a dissolved Mn trigger value for subtropical waters *abs#065*

2:40pm **Enzo Lombi**
Speciation and bioavailability of arsenic along the soil-plant-human exposure pathway *abs#066*

Risk Assessment 2
1:20 PM - 3:00 PM Meeting Room 2
Chair: Kenny Leung

1:20pm **Michael Warne**
Species sensitivity distributions: how they can be improved? *abs#067*

1:40pm **Renee Dowse**
Salinity risk assessment: comparing guideline species sensitivity distributions with single-species studies *abs#068*

2:00pm **Eric Wolanski**
The possible threat of Lead pollution from atmospheric deposition in Townsville *abs#069*

2:20pm **Amanda Reichelt-Brushett**
Risk Assessment and Ecotoxicology -social and scientific contexts related to the ocean disposal of mine waste *abs#070*

2:40pm **David Perry**
Environmental Risk Assessment of Chemicals for Chemical Regulators *abs#071*

Aquatic toxicology
1:20 PM - 3:00 PM Meeting Room 3
Chair: Jenny Stauber

1:20pm **Alicia Hogan**
Toxicity of magnesium pulse exposures to tropical Australian freshwater biota *abs#072*

1:40pm **Scott Wilson**
Cladoceran behaviour as a sensitive indictor of water contaminants: Their potential use in a Biological Early Warning System *abs#073*

2:00pm **Jackie Myers**
Do pesticides in Victorian freshwaters affect microalgae: Development and validation of a microalgal bioassay *abs#074*

2:20pm **Anne Colville**
Development of oxidative response assays to measure stress in duckweed (*Lemna disperma*) *abs#075*

2:40pm **Khurshida Siddiqua**
Variations in tolerance to atrazine for the cane toad, *Rhinella marina* at different larval developmental stages *abs#076*

Afternoon Tea
3:00 PM - 3:30 PM Exhibition Hall 2

The conference acknowledges the support of Exotox Services

Extreme ecotoxicology 1
3:30 PM - 5:10 PM Waterfront 1 & 2
Chair: Jon Brodie

3:30pm **Cliff Seery**
Ecotoxicology & climate change: Using a sea urchin fertilisation bioassay to assess combined effects of climate change and pollution *abs#077*

3:50pm **Monique Binet**
The effect of seawater temperature on sea urchin sperm viability *abs#078*

4:10pm **Merrin Adams**
The effect of contaminants on maximum thermal tolerance limits of aquatic invertebrates *abs#079*

4:30pm **Joost van Dam**
Stressor interactions: symbiont-specific responses of marine invertebrates to PSII herbicides and high temperature *abs#080*

4:50pm **Andrew Negri**
Copper reduces the resilience of coral larvae to thermal stress *abs#081*

Risk Assessment 3
3:30 PM - 5:10 PM Meeting Room 2
Chair: Tim Canfield

3:30pm **Jennifer Gadd**
Use of the MAM-PEC model to predict antifoulant concentrations in New Zealand ports and marinas *abs#082*

3:50pm **Michelle Iles**
Risk assessment of soils and sediments for closure planning at Ranger Uranium Mine *abs#083*

4:10pm **Frank Harris**
A Risk Based Approach to Radio-Ecotoxicity *abs#084*

4:30pm **Bill Maher**
Sediment risk assessment: Using the exposure-dose-response paradigm *abs#085*

4:50pm **Rai Kookana**
Persistence, degradation, bioavailability and toxicity of triclosan and methyl-triclosan in biosolids and biosolids amended soils *abs#143*

Novel techniques in environmental chemistry and ecotoxicology
3:30 PM - 5:10 PM Meeting Room 3
Chair: Scott Wilson

3:30pm **Matthew Neave**
Marine polychaete responses to elevated levels of metals can be detected in the transcriptome and proteome *abs#086*

3:50pm **Sara Long**
Can metabolomics identify chemical-specific changes in *Chironomus tepperi* larvae exposed to metal and non-metal contaminants? *abs#087*

4:10pm **Niels Munksgaard**
Synchrotron X-ray mapping of bio-accumulated metals in a tropical sponge *abs#088*

4:30pm **Katherine Jeppe**
Induction profile of potential metal response genes in *Chironomus tepperi* *abs#094*

4:50pm **Shelley Templeman**
Development of a new and novel sub-lethal toxicity technique using the upside-down jellyfish, *Cassiopea* sp *abs#090*

Poster viewing
5:10 PM - 6:00 PM Exhibition Hall 2

SETAC-AU AGM
5:30 PM - 6:30 PM Meeting Room 3

Conference Dinner
7:00 PM - 11:00 PM Darwin Convention Centre, Exhibition Concourse

The conference acknowledges the support of Energy Resources of Australia

Wednesday, 20 April 2011

Extreme ecotoxicology 2

8:50 AM - 10:10 AM Waterfront 1 & 2

Chair: Cath King

8:50am **Kenneth Leung**
Temperature-dependent physiological responses of the marine medaka *Oryzias melastigma*: Implication on pollutant responses at thermal extremes *abs#091*

9:10am **Florita Flores**
Herbicides increase the vulnerability of corals to high sea surface temperature *abs#092*

9:30am **Pelli Malcolm-Howe**
Development of laboratory culturing and ecotoxicological testing methodologies for the sea anemone *Aiptasia pulchella* *abs#093*

9:50am **Michael Warne**
Real world conditions vs. Laboratory studies: How the tropical north differs from the laboratory *abs#094*

Sediment chemistry and ecotoxicology 1

8:50 AM - 10:10 AM Meeting Room 3

Chair: Bill Maher

8:50am **Tristan Stringer**
Acute effects of sediment-borne toxicants on a New Zealand Copepod: *Quinquelaophonte stringeri* *abs#095*

9:10am **Melanie Sun**
Fingerprinting bacterial communities in estuarine sediments: Identifying potential bioindicators of estuarine health *abs#096*

9:30am **Dianne Jolley**
A high resolution study of arsenic, selenium and phosphate fluxes from spiked marine sediment by simultaneous deployment of dgt and det probes *abs#097*

9:50am **Alyssa Cornall**
Bacteria and archaea as candidates for a rapid biological assay for metal-impacted coastal sediments *abs#098*

Morning tea (poster viewing)

10:10 AM - 10:40 AM Exhibition Hall 2

Plenary Session

10:40 AM - 11:40 AM Waterfront 1 & 2

The conference acknowledges the support of Crocodile Gold

Chair: Michelle Iles

Mary Reiley
The Science Policy Interface: "Never cut what you can untie; never nail what you can screw" *abs#099*

Keynote session

11:40 AM - 12:20 PM Waterfront 1 & 2

The conference acknowledges the support of Vision environment QLD

Chair: Ross Smith

Mr Jon Brodie
Effects of pollutants in tropical aquatic ecosystems: Are they different from temperate systems *abs#100*

Keynote session

11:40 AM - 12:20 PM Meeting Room 2

Chair: Andrew Harford

Dr Stuart Simpson

Emerging issues and key challenges in sediment chemistry and ecotoxicology *abs#101*

Lunch (Poster viewing)

12:20 PM - 1:20 PM Exhibition Hall 2

Extreme Ecotoxicology 3

1:20 PM - 3:00 PM Waterfront 1 & 2

Chair: Andrew Negri

1:20pm **M Josie Lategan**
Evaluating endpoints to determine metal toxicity of groundwater microbial communities *abs#102*

1:40pm **LeeAnn Woodward**
Extreme Ecotoxicology: Case Study of the Long Term Persistence of Carbofuran in the Dead Zone, Laysan Island, Hawaiian Islands National Wildlife Refuge, Papahānaumokuākea Marine National Monument *abs#103*

2:00pm **Thomas Mooney**
Effects of Special Antarctic Blend (SAB) diesel on survival and reproduction of the earthworm *Microscolex macquariensis* *abs#104*

2:20pm **Patricia Corbett**
Histological alterations in the Antarctic cod, *Trematomus bernacchii* from Davis Station, East Antarctica *abs#105*

2:40pm **Catherine King**
Environmental Impact Assessment of the sewage outfall at Davis Station, East Antarctica *abs#106*

Sediment chemistry and ecotoxicology 2

1:20 PM - 3:00 PM Meeting Room 2

Chair: Stuart Simpson

1:20pm **Daniel Ward**
The response of marine epibenthic fauna to short exposures to contaminated sediment: a study of avoidance and toxicity *abs#107*

1:40pm **Vimlesh Chand**
Distribution, chemical fractionation and potential ecological risk assessment of arsenic and heavy metals in surface sediments from a contaminated coastal environment in Fiji *abs#108*

2:00pm **Stephanie Gardham**
Establishment of freshwater communities in mesocosms with copper contaminated sediment for research into climate change effects *abs#109*

2:20pm **David Spadaro**
Relative sensitivities of whole-sediment toxicity test protocols with the amphipod *Melita plumulosa* and copepod *Nitocra spinipes*. *abs#110*

2:40pm **Andrew Harford**
Effects of uranium spiked sediments on bacterial, microinvertebrate and macroinvertebrate benthic communities *abs#111*

Policy and regulation

1:20 PM - 3:00 PM Meeting Room 3

Chair: John Chapman

1:20pm **Michael Warne**
Contaminant soil-specific quality guidelines for ecosystem protection: The proposed Australian National Environment Protection (Assessment of Site Contamination) Measure *abs#112*

1:40pm **Jon Brodie**
Pesticide risk assessment, monitoring and management in Australia: Using the 'iconic' Great Barrier Reef as a case study *abs#113*

2:00pm **Kenneth Leung**
The challenges in search of the "Holy Grail" for protecting aquatic ecosystems from chemical pollutants *abs#114*

2:20pm **Tarah Hagen**
Incorporation of ecotoxicology into dangerous goods classification of metals and sparingly soluble inorganic substances *abs#115*

2:40pm **Sneha Satya**
Management of Prospective and Retrospective Generations of Industrial Chemicals *abs#116*

Afternoon Tea (poster viewing)

3:00 PM - 3:30 PM Exhibition Hall

Water Quality Guidelines Special Session

3:30 PM - 5:00 PM Waterfront 1 & 2

Chair: Mary Reiley

3:30pm **Chris Humphrey**
An overview of key features of the revision of the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* affecting aquatic ecosystems *abs#117*

3:50pm **Graeme Batley**
Recommended Revisions of the Australian and New Zealand Water Quality Guidelines for Toxicants *abs#118*

4:10pm **Michael Warne**
Proposed Changes to Methodology for the Derivation of Toxicant Guideline Trigger Values *abs#119*

4:30pm **Questions & Answers**

Conference close

5:00 PM - 5:15 PM Waterfront 1 & 2

Darwin Harbour Cruise

5:15 PM - 8:30 PM Stokes Hill Wharf

001

EMERGING CONCERNS ABOUT THE EFFECTS AND FATE OF CHEMICAL CONTAMINANTS IN MARINE BIOTA.

D. K. Collier

Oceans and Human Health Initiative, NOAA, Silver Spring, MD, United States

In recent years there has been great interest in determining which 'new' chemical contaminants should be classified as 'contaminants of emerging concern', or CECs. Common classes of compounds considered as suspects in these discussions include pharmaceuticals and personal care products, endocrine disruptors, nanomaterials, halogenated flame retardants, hormones, plasticizers, and current use pesticides, to name a few. Obviously this discussion suffers from a lack of consistent nomenclature and classification, at least in part because modes of action are mixed in with classifications of use. In this presentation I posit that it is the biological effect of chemicals that should be of primary concern, rather than simply detection in biological or physical matrices. Moreover, some chemicals which have been around for a very long time can also be considered as CECs, because new information on their effects is raising new concerns for agencies responsible for protection of the marine environment.

Notable among these 'old' chemicals that pose new concern are the polycyclic aromatic hydrocarbons (PAHs). High molecular weight PAHs (e.g. those with > 3 aromatic rings) have long been of concern because some of them are known to cause cancer in vertebrates, including fish and humans. A review of the literature shows that the vast majority of studies of PAHs have focused on their carcinogenicity. PAHs are also believed to be the most toxic component of petroleum, and many of the concerns following oil spills are related to the potential carcinogenicity of oil exposure, as is demonstrated in guidance for determining seafood safety following oil spills. However, a series of recent studies has shown that some low molecular weight non-carcinogenic PAHs are exquisitely toxic to fish eggs and larvae, and these findings may have substantial implications for oil spill response planning.

002

NEW VIEWS ON ENVIRONMENTAL HEALTH AND DISEASE: AQUATIC CONTAMINANTS AND LESSONS FROM WILDLIFE

Louis J. Guillette Jr.

Department of Obstetrics and Gynecology, Medical University of South Carolina, Hollings Marine Laboratory & Howard Hughes Medical Institute

Many chemicals introduced into the environment by humans adversely affect embryonic development of animals, including humans. It has been hypothesized that many developmental alterations are due to the endocrine disruptive effects of various environmental contaminants as the endocrine system exhibits an organizational effect on the developing embryo. Thus, a disruption of normal hormonal signals can permanently modify the organization and future function of the reproductive system. Over the last 20 years, we have performed a series of studies, some experimental, examining animals, including embryos, exposed to various environmental contaminants in aquatic ecosystems. We have examined the health of wildlife species, especially the American alligator, in wetland systems, including freshwater and coastal ecosystems in Florida, USA with various pollutant histories (e.g., Lake Apopka – agricultural chemical with high pesticide and nutrient levels; Kennedy Space Center, with industrial chemicals and metals). Using the American alligator (*Alligator mississippiensis*), wild caught animals and egg dosing studies have produced data indicating alterations in gonadal hormone production, secondary sex characteristics and gonadal anatomy. We have found alterations in the structure of the developing ovarian follicle that have been associated with high infertility and early embryonic loss. These experimental studies have begun to provide the causal relationships between embryonic pesticide exposure and reproductive abnormalities that have been lacking in pure field studies of wild populations. Moreover, at the gene expression level, the changes we have observed in wildlife are similar to changes described in the human ovary that are associated with several prevalent diseases (e.g., premature ovarian failure, polycyctic ovary syndrome, polyovular follicle syndrome). An understanding of the developmental consequences of endocrine disruption in aquatic wildlife can lead to new indicators of exposure and a better understanding of the most sensitive life stages and the consequences of exposure during these periods for wildlife and humans.

003

STATISTICS AND ECOTOXICOLOGY: PAST, PRESENT AND FUTURE

P. Fox

Australian Centre for Environmetrics, University of Melbourne, VIC, Australia

In this talk I shall briefly trace the origins of statistical science and (eco)toxicology before examining the interplay between the two disciplines and discussing some of the significant advances in quantitative methods of ecotoxicology.

While the early challenges associated with the statistical estimation and inference in 'bioassay' problems received a good deal of attention from eminent statisticians/biometricians such as Chester Bliss, Ronald Fisher and Joseph Berkson it would appear that the level of interest has waned over the years. Nevertheless, the drivers for robust and credible statistical inference are perhaps even greater today than they were in the 1960s when the Water Quality Act was first introduced.

The talk will review the role and place of statistical methodology in the context of identifying 'safe' concentrations of chemicals in aquatic environments and highlight opportunities and threats for statistical ecotoxicology.

004

AN ASSESSMENT OF *GAMBUSIA HOLBROOKI* FOR FRESHWATER BIOMONITORING OF ESTROGENIC ENDOCRINE DISRUPTORS IN MELBOURNE

K. Chinathamby[1,2], D. Nugegoda[1,2], A. L. Lopata[1], V. Pettigrove[2,3]

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Streams and rivers in Melbourne receive a number of estrogenic pollutants from various land uses such as livestock farming, sewage and human activity. Effects of estrogenicity from exposure to endocrine disrupting chemicals (EDCs) in the water have been shown on freshwater fish both in the field and in the laboratory. Most of the research on estrogenic endocrine disruption in freshwater fish has been conducted in Europe and America (Lavado *et al*, 2004; Desantis *et al*, 2005; Bjerregaard *et al*, 2006), while few studies have been conducted in Australia (Batty and Lim, 1999; Game *et al*, 2006; Leusch *et al*, 2006) and none in Melbourne. Indicator species relevant to Australia need to be identified for biomornitoring purposes. *Gambusia holbrooki* has been selected for evaluation because they are commonly found throughout a broad range of aquatic habitats in Melbourne and have been shown to be sensitive bioindicators of exposure to estrogenic EDCs. This paper presents results on the assessment of gonopodia (anal fin) in mosquitofish collected from urban-industrial, agricultural and sewage effluent discharge sites and reference sites around Melbourne from 2007 to 2009. Comparisons are made between gonopodial measurements and total estrogens in water from those sites. The objective of this work is to understand the effects of estrogenic EDCs in effluents in Melbourne's water bodies on freshwater fish and to assess the suitability of *Gambusia holbrooki* as a bioindicator for freshwater systems around Melbourne. The data could be extrapolated to native fish species also inhabiting the waterbodies that may be subjected to similar stresses from EDCs.

(1) Batty, J., and Lim, R. 1999. Morphological and reproductive characteristics of male mosquitofish (Gambusia affinis holbrooki) inhabiting sewage-contaminated waters in New South Wales, Australia. Arch

(2) Bjerregaard, Lisette B., Madsen, Allan H., Korsgaard, Bodil., Bjerregaard, Poul. 2006. Gonad histologyand vitellogenin concentrations in brown trout (Salmo trutta) from Danish streams impacted by sewa

(3) Desantis, S., Corriero, A., Cirillo, F., Deflorio, M., Brill,R., Griffiths, M., Lopata, A.L, de la Serna,Bridges, C.R., J.M, Kime, D,E., De Metrio, G. 2005. Immunohistochemical localization of CYP1A,

(4) Game,C., Monique, G., Webb, D., Lim, R. 2006. Endocrine disruption in male mosquitofish (Gambusia holbrooki) inhabiting wetlands in Western Australia. Ecotoxicology 15:665-672

(5) Lavado, R., Thibaut., R, Raldï¿½a, D., Martï¿½n, R and Porte, C. 2004. First evidence of endocrine disruption in feral carp from the Ebro River. Toxicology and Applied Pharmacology 196 (2):247-257.

(6) Leusch, F.D.L., Chapman, H.F., Kay, G.W., Gooneratne, S.R., Tremblay, L.A. 2006. Anal fin morphology And gonadal histopathology in mosquitofish (Gambusia holbrooki) exposed to treated municipal sewage

005

QUANTITATIVE ASSESSMENT OF ENDOCRINE DISRUPTION IN A NATIVE AUSTRALIAN FISH (*TETRACTENOS GLABER*) USING GONAD HISTOPATHOLOGY TECHNIQUES.

A. Marshall[1], K. Hassell[1], S. Swearer[1], V. Pettigrove[1], A. Roach[2]

[1]Victorian Centre for Aquatic Pollution Identification and Management (CAPIM), The University of Melbourne, Department of Zoology, Parkville, VIC, Australia
[2]Centre for Ecotoxicology. Ecotoxicology and Environmental Contaminants Section, Department of Environment, Climate Change and Water (DECCW), Sydney, NSW, Australia

Chronic exposure to hormonally active contaminants in laboratory conditions has been repeatedly shown to induce adverse reproductive effects in fishes. Fish captured from areas close to human activity are often reported to display comparable signs of reproductive abnormalities. However, the level of reproductive alteration seen in the natural environment can be difficult to assess, as unlike laboratory conditions, fish are exposed to complex mixtures of low dose contaminants for long periods of time.

The aim of this study was to assess if histological methods could be developed as an accurate tool for determining 1) endocrine disruption in natural populations and 2) if image analysis could be used as a quantitative tool for measuring endocrine disruption through assessment of gonad histopathology.

Smooth toadfish (*Tetractenos glaber*) are a demersal feeding species that are widely distributed throughout the major estuarine systems and embayments of coastal Australia. These characteristics make them an ideal candidate as a potential model for detecting endocrine disruption. Fish were collected from known contaminated sites as well as from sites considered to be free from human impact in central New South Wales. All fish examined were considered to be sexually mature or maturing and the gonads were examined histologically in Haematoxylin and Eosin (H&E) or Mallory's triple stain (MT). To determine the level of reproductive dysfunction the image processing program Image J (NIH Image) was used to quantify the number and size of different cell types.

Differences were observed between the contaminated and control sites. At contaminated sites higher levels of cell apoptosis and plaques occurred. Males displayed a higher degree of germ cell breakdown and females contained higher ratios of atretic follicles and

perinucleolar vacuoles. This study indicates that the smooth toadfish is a good candidate species and that quantitative histopathological analysis is a valuable tool for biomonitoring purposes.

006

EFFECTS OF 17A - ETHINYL ESTRADIOL ON THE REPRODUCTIVE BEHAVIOUR OF A MARINE FISH SAND GOBY (*POMATOSCHISTUS MINUTUS*).

M. Saaristo[1], J. A. Craft[2], K. K. Lehtonen[3], K. Lindström[4]

[1]School of Biological Sciences, Monash University, Clayton, VIC, Australia
[2]Biological and Biomedical Sciences, Glasgow Caledonian University, Glasgow, Scotland, United Kingdom
[3]Marine Centre, Finnish Environment Institute, Helsinki, Finland
[4]Environmental and Marine Biology, Åbo Akademi University, Turku, Finland

Endocrine disrupting chemicals (EDCs) interfere with the endocrinology of individuals and form a threat to the reproduction of populations. With regard to fish, despite the extensive literature on physiological effects of EDCs on individuals, very little is known about potential population level effects, which may result – among other factors – from disturbances in the patterns of reproductive behaviour. In my PhD, I examined how 17α- ethinyl estradiol (EE2), a synthetic estrogen used in oral contraceptive pills, affect the reproductive behaviour of a marine fish sand goby. First, I investigated how exposure to EE2 affects the courtship and parental care of sand goby males. Secondly, I looked at effects on mating system and sexual selection. In the third study, I observed the effects of exposure in a social context: exposed male had to compete for resources and mates. Finally, I studied the effects of exposure to the male-male competition and aggressive behaviour of males.This thesis revealed that EE2 exposure impairs the ability of males to acquire and defend a nest, as well as diminish the attractiveness of males to females by decreasing their courtship and aggressive behaviour. Furthermore, selection towards male size was relaxed after exposure and females were no longer able to distinguish the differences among males. These effects are harmful for a male whose reproductive success is determined by the ability to compete for limited resources and to attract mates. This thesis shows that exposure to environmentally relevant level of EDC clearly reduces the chances of an individual to reproduce successfully. Furthermore, it demonstrates that severe behavioural effects can be seen before any effects are detectable at the molecular or morphometric level. Behavioural assays should be considered as important complementary tools for the standard ecotoxicological tests, because observed behavioural changes have direct and negative effects on fitness.

007

MURRAY RAINBOWFISH (MELAOTAENIA FLUVIATILIS): SMALL FISH MODEL FOR IDENTIFYING AND ASSESSING THE EFFECTS OF ENDOCRINE-DISRUPTING CHEMICALS IN THE AUSTRALIAN RIVERINE ENVIRONMENT

A. Kumar, M. Woods, H. Bhatia, H. Doan

Urrbrae, CSIRO Land and Water, SA, Australia

In recent years, evidence has been mounting that very low concentrations of specific contaminants in wastewater, including hormones (from animal husbandry and residue from human hormonal contraception methods) and synthetic chemicals that mimic hormones in their action, can have unpredictable adverse impact on the aquatic organisms including fish and frogs. Discharges from sewage treatment plants (STPs) are increasingly being seen as a potential source of environmental flows in riverine systems. Endocrine disrupting chemicals (EDCs) and other micropollutants (pharmaceuticals) are of particular concern as these are not fully removed by existing treatment technologies, and these have been found to be present in the Australian environment at ecologically relevant concentrations. Currently, we have little understanding of what impact the range of micropollutants present in STP effluent have on the aquatic ecosystem. Endocrine-disrupting chemicals (EDCs), particularly those that affect the hypothalamic-pituitary-gonadal (HPG) axis of vertebrates, have become a focus of regulatory screening and testing throughout the world. Small fish species, principally the fathead minnow (*Pimephales promelas*), Japanese medaka (*Oryzias latipes*), and zebrafish (*Danio rerio*), are recommended as model organisms under the OECD testing programs. The potential of molecular screening approaches has been recognised as a valuable tool in regulatory applications, and has led to the development of fish screening assays for compounds interfering with reproductive hormones. The strong correlation between xenoestrogen exposure and reproductive impairment allows for the establishment of simple but integrative screening assays for regulatory purposes. Currently, in Australia there are no standard molecular biomarkers for native fish species to assess impacts of estrogenic and androgenic chemicals in the freshwater environment. In response to growing concerns regarding endocrine disrupting chemicals (EDCs) in the Australian riverine environment, the Murray rainbowfish (*Melanotaenia fluviatilis*) has been identified as a small fish model for testing compounds that have the potential to adversely affect reproduction. Examples of results with specific chemicals in tests with the Murray rainbowfish will be presented and discussed in terms of sensitivity and specificity for different classes of EDCs.

008

VARIANCE – THE NEGLECTED PARAMETER IN ECOTOXICOLOGY

R. Smith[1], D. Fox[2]

[1]Hydrobiology, Milton, QLD, Australia

[2]Australian Centre for Environmetrics, University of Melbourne, Melbourne, VIC, Australia

As ecotoxicologists we are all aware from our basic training that sensitivities to toxicants within populations are variable. This variation arises from many sources, although principally among these are: Variability in motility of individuals and different life stages within a population; Incomplete or turbulent mixing of a waste stream; Spatial and temporal variability of distribution of individuals and inputs of toxicants; Random or stochastic variation; and Combinations of these factors combined with pulsed toxicant inputs or variability of concentrations and/or fluxes of toxicants.

Therefore, it is evident that, except where the concentration of the toxicant is such that it is effectively equally toxic to all of the exposed population or in unusual circumstances of essentially steady-state exposures of large numbers of individuals and high intensity of sampling of the population, a feature of population responses to toxicant exposure will be variation in the response. Despite this, most assessments of toxicity response remain focussed on changes to the mean response and we seem to devote extraordinary effort to maintaining equivalence of variance within test populations. In some cases this is counter-productive, since the assumed statistical model guarantees that the variance will change as the mean response changes. This mean-variance relationship is a characteristic of the binomial, poisson, and gamma distributions – to name a few.

Few ecotoxicologists in either field or laboratory situations seem to appreciate the value of examining change of variance as a viable, informative and sensitive statistical parameter to measure. In this paper we will give examples of how this can provide an early warning of population response to toxicants, of long-established statistical procedures to test for it, and how its value can be communicated to stakeholders at least as readily as that of the mean.

009

COMPARISON OF ANOVA AND PERMANOVA ANALYSIS TECHNIQUES TO STREAM COMMUNITY DATA FOR BACI-TYPE IMPACT DETECTION DESIGNS

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[2]Charles Darwin University, School of Environmental & Life Sciences, Faculty of Education, Health & Science, Darwin, NT, Australia

The Supervising Scientist Division (SSD) develops and implements monitoring techniques that are used to identify potential mining impact upon receiving-water streams. The experimental designs used for biological monitoring are based upon the BACI (Before-After-Control-Impact) class and have evolved to include difference values in responses between Paired sites (BACIP designs) measured through time, as well as Multiple control sites (MBACI(P)), that collectively provide data that best meet statistical assumptions and enhance statistical inference.

Macroinvertebrate sampling is included in the SSD's monitoring with underpinning research (since 1990) extending the BACI approach to sampling design and analysis of ensuing data. In one of these enhancements, MBACIP designs were modified to include multivariate (community-level) responses using dissimilarity indices as the measure of paired-site difference. Data are analysed using a four-factor ANOVA based upon replicate, paired-site dissimilarity values and using the factors Before/After (BA), Control/Impact (CI), Year and Site.

The PERMutational ANOVA (PERMANOVA) technique has the potential to supersede current community-level analysis methods by enabling complex analysis of assemblage data without the model assumptions typically required for alternatives, including BACIP-style ANOVA based upon paired-site dissimilarity values. A fundamental difference between PERMANOVA and ANOVA using BACIP dissimilarities is that the latter greatly minimises temporal and spatial variation. PERMANOVA retains the original temporal and spatial information for sites and partitions the variation by way of factors, thereby providing, potentially, more statistical power as well as greater interpretation of the sources of variation other than the key BA*CI effect.

We explore these different techniques and discuss the results from an MBACIP macroinvertebrate community monitoring study in tropical seasonally-flowing streams around the Ranger uranium mine (NT). The results indicate that while PERMANOVA identifies significant temporal and spatial variation within the data (not apparent using a dissimilarity approach), the key BA*CI interaction for impact detection does not differ between methods.

010

TIME-DEPENDENT SSDS

E. Billoir[1,2], D. R. Fox[2]

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[2]Australian Centre for Environmetrics, The University of Melbourne, Parkville, VIC, Australia

In ecotoxicology, endpoints are generally estimated at the end of some pre-determined exposure period (eg. 4-day fish survival, 21-day *Daphnia magna* reproduction, etc). The analyses focus solely on the response as a function of concentration. However the response is generally a function of both time and concentration and ignoring the time dependency can lead to severe bias in environmental risk assessment (Baas et al., 2010, Heckmann et al., 2010). For aquatic organisms, it is usually possible to test its

response at intermediate points in time. For effects on mortality or reproduction, it is part of the standard protocol, however these data are usually not used in subsequent data analyses.

The species sensitivity distributions (SSDs) has become a key instrument in water quality guidelines. While the technique is regarded by most as a significant improvement on the use of safety factor, it is not without its problems and limitations. One of the most severe shortcomings is its reliance on the largely discredited NOEC. As an alternative to the conventional NOEC-based analyses, Fox (2010) has recently described a model-based Bayesian method for the estimation of no effect concentrations (NEC) and hazardous concentrations (HC). We extend this approach by adding the time dimension into the models. Using time-series data sets, we investigate the changes in NEC over time, and their impact on the HC value and uncertainty.

(1) Baas J, Jager T, Kooijman B. 2010. Understanding toxicity as processes in time. Science of the Total Environment 408: 3735-3739.

(2) Heckmann L-H, Baas J, Jager T. 2010. Time is of the essence. Environmental Toxicology and chemistry 29: 1396-1398.

(3) Fox DR. 2010. A Bayesian approach for determining the no effect concentration and hazardous concentration in ecotoxicology. Ecotoxicology and Environmental Safety 73: 123-131.

011

INTEGRATED ASSESSMENT OF DISCHARGES FROM TWO MINING OPERATIONS INTO A TROPICAL FRESHWATER STREAM

R. Van Dam[1], A. Harford[1], C. Humphrey[1], S. Barber[2], K. Hughes[2]

[1]Environmental Research Institute of the Supervising Scientist, DSEWPaC, Darwin, NT, Australia
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Assessments of water quality and aquatic ecosystem health are best undertaken using an approach that integrates physico-chemical, ecotoxicological and biological measurements. Such a program was undertaken to assess effects of water discharges from two mining operations, Cosmo Howley (CH) and Brock's Creek (BC), in the Howley Creek catchment, northern Australia. The assessment included: (i) detailed chemical characterisation; (ii) toxicity assessments of the key discharges from both mine sites; (iii) toxicity assessment of ambient waters from Howley Creek up- and downstream of both mine sites; and (iv) field survey of aquatic macroinvertebrates in Howley Creek at sites up- and downstream of both mine sites. Toxicity assessments focused on five tropical freshwater species (alga, macrophyte, cladoceran, hydra, fish).

The CH discharge adversely affected the alga (EC 10 – 6.5%), cladoceran (10%) and hydra (1.2%), although cause/s of toxicity were difficult to identify. The BC discharge adversely affected the alga and cladoceran, most likely due to arsenic. Toxicity observed in the Howley Creek waters due to the two mine discharges varied depending on the species. The alga and cladoceran were more affected by the BC discharge, whereas the hydra was more affected by the CH discharge. At the downstream-most site (~9 km from the mines), moderate to good recovery was observed for all affected species, although effects were still evident. In contrast to the toxicity data, field macroinvertebrate data suggested little in the way of reduced abundance and diversity in relation to mine discharge exposure. The site immediately downstream of BC displayed an enrichment in total abundance, potentially due to higher nutrient concentrations compared to the other sites. The results will be presented in a weight of evidence framework. The study demonstrated the importance of integrated assessment, and identified a need for future assessment of phytoplankton communities to better understand indirect effects and trophic interactions.

012

INTEGRATED WATER QUALITY MONITORING FOR AN AUSTRALIAN URANIUM MINE – A BEST PRACTICE CASE STUDY

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The Ranger Uranium Mine is surrounded by the World Heritage-listed Kakadu National Park. Thus the highest standards of aquatic ecosystem protection are applied. The objective of the Supervising Scientist Division's (SSD) stream monitoring program for Ranger is to provide independent assurance to the Australian community that the aquatic environment remains protected from detrimental mining-related impacts.

The techniques and indicators used in the monitoring program satisfy two key requirements for environmental protection assessment: (i) early detection of changes to minimise the potential for broader scale ecosystem impacts; and (ii) use of biodiversity indicators to provide ongoing information about the health of the aquatic ecosystems so as to be able to distinguish potential low level chronic impacts of mining from other (natural) regional ecological stressors.

The stream monitoring program comprises:

· multi-probe loggers for continuous measurement of water quality, telemetered to SSD offices (15 min frequency), and collection, by autosamplers, of event-based samples for chemical analysis;

· in situ biological toxicity monitoring using freshwater snails (fortnightly);

· annual measurement of concentrations of metals (including radionuclides) in the tissues of freshwater mussels downstream of Ranger;

· abundance and diversity of benthic macroinvertebrate and fish communities at stream sites or waterbodies (sampled at end of each wet season) .

Apart from real-time monitoring of water quality parameters, one of the key issues associated with the interpretation of the continuous data and its use for regulatory purposes, is the potential for short duration (pulse) exceedances of chronic toxicity guidelines. The SSD has been conducting an extensive program of research into this important aspect of guideline application. The findings from this work will be overviewed in this paper and reported in full in another paper (Hogan et al) at this conference.

The application of the integrated monitoring framework described above to environmental perfomance assessment will be discussed.

013

WETLAND FUNCTION AND THE ROLE OF ECOLOGY IN THE REMOVAL OF CONTAMINANTS

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Attenuation of metals in wetlands is dependent on the ability of the contaminant to attract to surfaces or form precipitates that will eventually report to the sediments. Water chemistry, speciation and the availability of compatible sorption sites will affect the rate of removal from the water column while biogeochemical factors specific to the wetland sediments will determine its storage capacity.

Artificial wetlands are commonly used to attenuate contaminants from stormwater as well as passively treat surficial mine waters. For many contaminants, however, remobilisation can occur post-desiccation therefore wetlands are preferentially kept wet. This requirement alone can threaten the wetland ecosystem if the hydrological regime is not compatible with vegetation selection and ecotoxicologically as contaminants accumulate within the sediments. The management of constructed wetlands therefore must incorporate a holistic approach to maintain the health of the ecosystem including the re-evaluation of performance and ecotoxicological risks as the pH and constituents of input water vary.

014

IMPACTS ON FRESHWATER MACROINVERTEBRATES FROM PESTICIDES USED TO CONTROL LOCUSTS IN VICTORIA, AUSTRALIA

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During the 2010/11 spring and summer, a major locust control program was managed by the Victorian Department of Primary Industries (DPI). The locust population size was predicted by DPI to be the largest in Victoria in the past 75 years and posed a major threat to agricultural production. As part of the control programme, fungal spores (Metarhizium *anisopliae* var. *acridum*), fenitrothion and fipronil were used on public land, and private landowners were recommended to use these chemicals as well as carbaryl or organophosphates depending on the crop being protected.

The Centre for Aquatic Pollution Identification and Management (CAPIM), Victorian Environment Protection Authority and Department of Sustainability and Environment conducted a major investigation of the health of aquatic ecosystems in the locust impacted region to determine whether pesticides were polluting inland waters and whether pesticides caused adverse impacts on the aquatic biota. Over 40 sites across Victoria were surveyed. Surface waters and sediments were collected before and after regional pesticide applications and analysed for 90 pesticides including those recommended for locust control. Sediment toxicity tests using the bloodworm *Chironomus tepperi* and macroinvertebrate surveys were also conducted. In addition, *in situ* toxicity tests were trialled whereby cages of amphipods (*Austrochiltonia sp.*) and freshwater snails (*Potamopyrgus antipodarum*) were deployed at three sites to determine acute effects of pesticides on survival and separate water versus sediment effects.

Pre-spray results indicate potential adverse biological effects currently exist at a limited number of sites related to sediment pollution levels. The presentation will relate the biological response of freshwater macroinvertebrates at the various levels of investigation mentioned to the measured concentration of pesticides in water and sediment before and after pesticides were applied to locust populations across Victoria.

015

MICROPOLLUTANTS AND THEIR POTENTIAL IMPACT IN DARWIN HARBOUR

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Micropollutants refers to low concentrations of organic compounds such as pharmaceuticals, petroleum compounds, pesticides, herbicides and insecticides, released into the aquatic environment, especially in surface waters. Many micropollutants have been found to interfere with the normal functioning of the endocrine (hormonal) system in both terrestrial and aquatic organisms, and for this reason are termed ‘endocrine disrupting chemicals' (EDCs). For temperate Australia, the public concerns about the presence of such EDCs in waterways are growing rapidly with increased reliance on recycled water. For Darwin Harbour, little data is available in relation to the presence of micropollutants, what level they are at in water and sediments, and their effects on aquatic organisms. In 2009 a collaborative research project was initiated with the aim of identifying and quantifying the presence of a number of micropollutants being released into Darwin Harbour at sewage, urban and industrial outfall sites and their potential impact on mud

crabs, (i>Scylla serrata). Dry season (October 2009) and wet season (March 2010) results have identified both natural and synthetic estrogens, pharmaceuticals, pesticides and some petroleum hydrocarbons as key contaminants in water and in sediments from sewage and urbanized sites. In addition, in vitro assays were used to screen effluent, water and sediments samples to determine total estrogenic and androgenic activities. The results of the recombinant yeast estrogen (YES) and recombinant androgen assays (YAS) independently confirmed the chemical analyses and highlighted that sewage effluent sites (Buffalo and East Point) were more significantly impacted as compared to our reference site (West Arm). These data provide significant baseline information on the overall health of the Darwin Harbour ecosystem, and will provide data vital to help make informed decisions regarding the future growth of the region.

016

NITRATE AS AN ENDOCRINE DISRUPTING CONTAMINANT IN AMERICAN ALLIGATORS (*ALLIGATOR MISSISSIPPIENSIS*)

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Humans have dramatically increased the amount of nitrogen released into the environment, either intentionally as fertilizer, or unintentionally by burning fossil fuels (Fields, 2004) . Humans have now altered the nitrogen cycle more than any other natural cycle. Nitrogen in river ecosystems across the world have increased 10 to 15 times in the last 10 years alone, and as human populations increase, it is likely the nitrogen burden will continue to increase. Nitrate, a principal form of environmental nitrogen, has not traditionally been considered a material water quality hazard in most aquatic ecosystems, despite a growing number of studies describing nitrate's ability to causes a variety of physiological dysfunctions. Crocodilians are ecologically important top predators that have been shown to be sensitive to environmental contaminants, and have long served as sentinels for contaminant exposure (Milnes and Guillette, 2008) . Understanding the vulnerability of these long lived reptiles to understudied, yet ubiquitous environmental pollutants is critical to understanding ecosystem health. We evaluated the effects of ecologically relevant concentrations of nitrate on female American alligators during their first 5 months of life. We found nitrate to alter circulating concentrations of sex steroids in the plasma in a non-monotonic fashion, but we found little change in circulating concentrations of thyroid hormones. Aquatic concentrations of nitrate were reflected in urine and blood. These data highlight the importance of furthering our understanding of nitrate in vulnerable ecosystem communities.

(1) Fields S. 2004. Global nitrogen: cycling out of control. Environ Health Perspect 112(10):A557-A563.

(2) Milnes MR, Guillette LJ. 2008. Alligator Tales: New Lessons about Environmental Contaminants from a Sentinel Species. Bioscience 58(11):1027-1036.

017

RESPONSES OF THE AROMATASE GENES IN THE MURRAY RIVER RAINBOWFISH, *MELANOTAENIA FLUVIATILIS* EXPOSED TO XENOESTROGENS

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Cytochrome P450 aromatase is the only key steroidogenic enzyme responsible for the synthesis of oestrogens from androgens. It plays a pivotal role in sex differentiation, sexual behaviour and in reproductive cycles. This study investigated the influence of exogenous oestrogen 17β-oestradiol (E2) and the oestrogen mimic nonylphenol (NP) on the mRNA expression of aromatase isoforms in both sexes of adult Murray River rainbowfish. Reproductively active male and female fish were exposed to either 1, 3, 5 µg /L of E2 or 100 µg/L, 500 µg/L of NP for 96 h. The expression analyses of cyp19a isoforms in the brains and gonads of both sexes of adult fish were studied using qPCR. cyp19a1b was significantly downregulated in the brains of male fish exposed to E2 and nonylphenol. Whereas expression of cyp19a1b in testicular, ovarian and brain tissues of female fish exposed to E2 was upregulated until 72 h of exposure and downregulated at 96 h. Expression of cyp19a1b in female fish brain was upregulated with exposure to 100 µg/L NP and downregulated with exposure to 500 µg/L NP. The exposure of rainbowfish to E2 and nonylphenol intriguingly resulted in significant reduction in the expression of cyp19a1a isoform in ovarian tissues at 1 µg /L of E2 and 100 µg/L of nonylphenol and was completely inhibited at 96 h. Further at higher concentrations of E2 and nonylphenol, cyp19a1a was completely inhibited in ovarian tissues throughout the exposure period. The observations support the hypotheses that E2 regulates expression of cyp19a1b via both positive and negative feedback mechanisms. In contrast both chemicals negatively regulate cyp19a1a expression in the ovarian tissues. Collectively the results suggest that, the xenoestrogens can have a disruptive effect on the steroidogenic pathways and hence sex differentiation, sexual behaviour and reproductive cycles in this fish.

018

COMPARATIVE *IN VITRO* ASSESSMENT OF THE CYTOTOXIC AND ENDOCRINE DISRUPTING EFFECTS OF GLYPHOSATE AND ROUNDUP .

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Glyphosate, the active component of the herbicide *Roundup*^{TM}, causes endocrine disruption (ED) by inhibiting uptake of substrate for steroid hormone biosynthesis, and by inhibiting CYP450 aromatase, which is required to synthesise estradiol (E), but not progesterone (P) [1]. The E-screen and other receptor reporter assays cannot detect ED that prevents hormone synthesis, necessitating the development of new methods for ED characterisation.

Seven 1:10 serial dilutions of 720mg/L glyphosate, or the same concentration of glyphosate in *Roundup*^{TM}, were added to human T47D breast cancer cells or to JAr choriocarcinoma cells *in vitro* for 24 or 72 hours. JAr cells synthesise P & E, and respond to dbcAMP, with increased synthesis. After exposure to glyphosate or *Roundup*^{TM} ± dbcAMP (1mM), P & E synthesised by JAr cells were measured using ELISAs, and the numbers of viable JAr cells were determined in an MTT assay. Surviving T47D cells were examined in a crystal violet assay and all results were expressed as mean ± stdev (n=3).

After 24h there were 15439±1185 T47D cells per medium-only control well, 13146±1469 cells/well after exposure to 720mg/L glyphosate, and 0 cells/well after exposure to 7.2mg/L glyphosate in *Roundup*^{TM} (LD50 2.2mg/L, $p<0.05$). Comparative results were obtained after 24h for JAr cells (LD50 1.3mg/L). After 72h, 0.0072mg/L *Roundup*^{TM} significantly reduced JAr cell viability (LD50 0.29mg/L, $p<001$). dbcAMP stimulated P & E synthesis as expected, and 0.72mg/L RoundUp reduced ($p<0.01$) basal (EC50 1.1mg/L) and dbcAMP-stimulated (EC50 1.4 mg/L) P production. Glyphosate alone had no effect on P synthesis. Preliminary analysis of E data suggests that *Roundup*^{TM} stimulated higher E synthesis than glyphosate alone.

A novel assay combining ED and toxicity detection was used to find that *Roundup*^{TM} toxicity and ED occurred at ~0.0072 microgram/L, orders of magnitude lower than the 370 microgram/L glyphosate guideline [2]. Ecotoxicity testing of RoundUp is therefore recommended.

(1) Benachour, N., et al., Time- and dose-dependent effects of roundup on human embryonic and placental cells. Arch Environ Contam Toxicol, 2007. 53(1): p. 126-33.

(2) Australian and New Zealand Guidelines for fresh and marine water quality. Australia and New Zealand Environment and Conservation Council, and Agriculture and Resource Management Council of Australi

019

CUMULATIVE IMPACTS OF MINES ON WATER QUALITY IN THE FITZROY BASIN: RISK ASSESSMENT AND LICENSING REVIEW

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In 2008, there was a significant flood event in the Fitzroy River Catchment in Queensland and as a result numerous Coal Mines had to discharge very large quantities of water. There were significant concerns about one particular discharge and the potential affects on water quality and downstream environmental values. As a result of this, a study was undertaken to review the approval conditions and potential cumulative impacts of mine discharges in the Catchment.

The major water quality contaminants of concern associated with the coal mines were salinity (based on electrical conductivity), heavy metal/metalloids and acidity/alkalinity. The study focussed mainly on salinity impacts as these were of most concern to the communities in the areas affected by the mine discharges in 2008. A broad-scale risk assessment was undertaken based on the available data.

The major findings of this study concluded that discharge quality limits and operating requirements for coal mine discharges in the Fitzroy River Catchment were inconsistent and for some coal mines did not adequately protect the downstream values of the environment. The background data relating to the quality of the waterways receiving the discharge water was extremely limited and there was insufficient data to quantify the cumulative impacts of mining water discharges. Nonetheless, based on a risk assessment using salinity, six mines were identified as being the highest contributors to potential cumulative impacts. The study recommended that additional and ongoing monitoring and analysis was needed for assessing cumulative impacts more quantitatively in the future. Since that time, new standardised conditions have been developed and implemented to these mines which have included more comprehensive monitoring

020

EFFECTS OF URANIUM SPIKED SEDIMENTS ON BACTERIAL, MICROINVERTEBRATE AND MACROINVERTEBRATE BENTHIC COMMUNITIES

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There are currently no robust national or international toxicity guidelines for uranium in sediments. Based on the limited published data, toxicity estimates vary by at least three orders of magnitude. This level of uncertainty represents a substantial gap in environmental management capacity given the major upswing in uranium exploration and mining activity. Sediment U toxicity guidelines are required for both the operating and closure stages of mine life. To address this gap a field-based approach combining various traditional biological assessment and emerging ecogenomic approaches is being used to quantify the toxicity of U to sediment-dwelling biota across multiple trophic levels. During the 2009-2010 wet season, a range finding pilot investigation was undertaken to test and optimise sediment spiking methods, U concentration range and experimental design required for a subsequent full scale assessment. U-spiked sediments (400 mg/kg and 4000 mg/kg) and appropriate control sediments were deployed in retrievable containers in a natural northern Australian waterbody for three months. Detailed chemical characterisation of the sediment was undertaken prior to deployment and on retrieval. At the end of the exposure period, the extent of re-colonisation of the sediment by macroinvertebrate, microinvertebrate, biofilm and bacterial communities was measured. Unfortunately, interpretation of results from the pilot study was potentially confounded by the inadvertent creation of highly compacted sediments that appeared to be unrepresentative of natural sediments, and especially inhibitory to macroinvertebrate colonisation. Notwithstanding this limitation biological effects of U in the sediments were able to be discerned from analysis of the bacteria data. Different methods of spiking to minimise physical disruption of the sediment structure will be trialled over the 2010-11 wet season. The application of ecogenomic assessment approaches to determine effects will be discussed.

021

EVALUATION OF ENVIRONMENTAL RISKS FROM METALS AND METALLOIDS IN HISTORICAL WASTES AT THE WAINIVESI GOLD MINE, FIJI

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Historical mine wastes at the Wainivesi Gold Mine, Fiji have been a source of heavy metal and metalloid contamination to the surrounding environment and downstream aquatic ecosystem. They are transferred into the surrounding environments via wind-borne dispersion, through water dissolution or particulate metal mobilisation. The geochemical characteristics of these waste materials, specifically size dependence and solid-phase speciation, indicate that the metals and metalloids are predicted to become more bioavailable and increase the potential to migrate offsite and expose humans, terrestrial and aquatic biota. This study seeks to distinguish different species of metals and metalloids at and downstream from the Wainivesi Gold Mine by characterising their bioaccessibilities (BAc) and exposure pathways.

Results from the study indicate a potential exposure pathway of metal and metalloid contamination through ingestion and inhalation. Lead had very high concentrations of up to 25000 mg/kg in the <2 mm soil fraction; the presence of the mineral plumbojarosite was confirmed by X-ray absorption spectroscopy using synchrotron technique and XRD. Total sediment (<63 µ m fraction) concentrations exceeded the ANZECC ISQGs for zinc (200mg/kg) and mercury (0.15mg/kg) . Further 1 M HCl extraction showed mine site sediments zinc and mercury concentrations for all sites also exceeded the ISQG-low trigger values. Sediment adsorption capacity analysis indicated that some of the sediments had very low adsorption capacity for heavy metals and posed a risk to aquatic biota and via the food chain to humans when these items are consumed. Bioaccessibility (BAc) measurements carried out for soil samples concur with the results of particle size distribution and presence of plumbojarosite. Soil samples had a maximum BAc of 55%. Taro samples grown on the mine site were analysed and contained up to 206 mg/kg Pb, which exceeded the FSANZ permissible level. Further studies are needed to quantify food chain transfer effects on the population.

022

TRACE METAL AND LEAD ISOTOPE DISPERSAL FROM A DECOMMISSIONED GOLD MINE IN THE NORTHERN TERRITORY, AUSTRALIA

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The rehabilitation of decommissioned and legacy mine sites can present organisations with a huge financial burden in order to prevent detrimental impact on the environment. Identification of the key contaminant sources on site can enable prioritisation of

rehabilitation needs and targeted use of limited resources to increase the efficiency of remediation and environmental protection. Results are presented for a study of trace metal concentrations and stable lead isotope ratios for and their dispersion from a decommissioned gold mine in northern Australia.

Samples of mining wastes, drainage channel and creek sediments were analysed for trace metal concentrations and stable lead isotope ratios (206 Pb/ 207 Pb and 208 Pb/ 207 Pb). Mining wastes and drainage lines from the heap leach pad, waste rock dump and low grade ore stockpiles were readily identified as highly polluted with Cu and Zn concentrations up to 637 and 5640 mg/kg respectively. The lead isotope ratios of these sediments are indicative of lead minerals such as galena, which are associated with the ore body. In contrast, samples taken from the Edith River and Stow Creek show trace metal concentrations similar to natural areas elsewhere in the Pine Creek Orogen and lead isotope ratios which exhibit a greater contribution of thoriferous 208 Pb. Results indicate that the containment of acid mine drainage, from stockpiles and waste rock dumps, poses the key management and rehabilitation priority on site.

Keywords: trace metals, stable lead isotopes, rehabilitation, mine sites, acid mine drainage

023

METALS, ARSENIC AND SULFATE POLLUTION OF RIVERINE SURFACE SEDIMENTS CAUSED BY ACID MINE DRAINAGE

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This study focuses on the metals, arsenic and sulfate concentration in surface sediments of the Dee River, central Queensland, Australia as a result of Mt. Morgan gold and copper mining activities in its catchment. The main objectives of this research were to determine the average regional concentration of metals (Al, Cd, Cu, Fe, Pb, Zn), arsenic (As) and sulfate (SO42-) that are associated with mining in the Dee River catchment in sediments; to identify the possible source(s) of contamination and also identify the level of contamination (i.e., high, medium or low impact) to inform Queensland Department of Mines and Energy and other similar environmental protection agencies for rehabilitation work; to investigate the seasonal affects on concentrations in sediments; and to utilise the information (for identifying high impacted areas for rehabilitation) obtained to assess the current extent of the area impacted within the Dee River catchment.

Sediments were collected from different sites of the river and analysed for metals and arsenic by ICPMS and sulfate by ICPOES. The results indicated a general decrease in concentrations with increasing distance downstream from the mine site.

Average concentrations of all elements assessed, except Cu, fell below ANZECC (2000) trigger (ISQG-low) values. The Cu levels in sediments exceeded the ANZECC (ISQG – high) value at all sites downstream of the mine with a trend of decreasing Cu concentrations with increasing distance downstream. Despite concentrations of Pb being below ANZECC (ISQG-low) values at all sites, high levels were observed at Kenbula and Possum street sites compared to other sites. Although there are no ANZECC values available for Al, Fe, and SO4, the highest concentrations were observed at the Kenbula. The canonical variates and cluster analyses of metals, arsenic and sulfate for sediments also indicated a separation of Kenbula as a high impacted site by mine pollution compared to the other sites of the Dee River.

The elevated concentrations of some elements like Al, Cu, and Fe in the top layer of the Dee River sediments may have harmful effects on the biota residing in the catchment and further downstream and need further investigations.

Key words: metal contamination, catchment, sediments, concentration, pollution, canonical variates analyses, cluster analyses

024

EVALUATION OF A DGT APPROACH TO DEVELOP TOXICITY MODELS OF METAL SPECIATION IN SHALLOW SEEPAGE FROM A REHABILITATED LEAD-ZINC MINE TO AN EPHEMERAL TROPICAL CREEK

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Monitoring of water quality in an ephemeral tropical creek lying within the lease of a rehabilitated lead-zinc mine has identified contributions from local seepage resulting in increased electrical conductivity (EC) and dissolved metal concentrations in the flowing creek water during and following cessation of the annual wet season. This study aims to evaluate the use of Diffusive Gradients in Thin-films (DGT) and ultra-filtration technique to determine discrete pathways of seepage from the former mine features and existing mineralisation that may induce metal toxicity to aquatic biota in the creek. The DGT technique provides measurement of soluble metal forms in water therefore estimating the toxicity response to aquatic biota. Following a preliminary trial of DGT deployment along the creek, a more precise delineation of seepage led to DGT placement during the early part of the dry season in 10 plastic tube lined holes to 0.5 m depth in the creek bed and tributaries from a former tailing dam. An increase in zinc concentration was accompanied by increases in EC and sulfate in water. For an observed hardness range of 800 -1500 mg/L $CaCO_3$ the zinc DGT concentrations, as an example, exceeded the adjusted ANZECC (2000) trigger value for 95% protection of aquatic species of 72 µg/L

Zn indicating that further investigation of actual ecotoxicity is warranted. Thus the DGT technique enables accurate location to be made of seepage predicted to exhibit toxicity of metals.

025

ASSESSING REMOVAL EFFICIENCY OF ORGANIC CONTAMINANTS DURING ADVANCED WATER TREATMENT BY COMBINING PASSIVE SAMPLING WITH CHEMICAL ANALYSIS AND BIOANALYTICAL TOOLS

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Advanced water treatment for recycling of secondary treated effluent to a standard suitable for augmenting drinking water supplies requires stringent quality control. Amongst other process parameters, the removal of micropollutants such as pesticides, industrial chemicals, endocrine disrupting chemicals (EDC), pharmaceuticals and personal care products (PPCP) is paramount. As the concentrations of individual contaminants are typically low, frequent analytical screening is both laborious and costly. We propose and validate an approach for continuous monitoring by applying passive sampling with EmporeTM disks in vessels that were designed to slow down the water flow and thus uptake kinetics. This design not only assured integrative sampling over 27 days for a broad range of chemicals but also permitted the use of bioanalytical tools as sum parameters representative of mixtures of chemicals with a common mode of toxic action. Bioassays proved to be more sensitive than chemical analysis to assess the removal of chemicals by reverse osmosis followed by UV/H2O2 treatment, when many individual chemicals fell below the detection limit of chemical analysis but still contributed to the observed mixture toxicity. The mass balance of the reverse osmosis process matched theoretical expectations. Overall the investigated treatment train removed >97% estrogenicity, >99% herbicidal activity and >96% baseline toxicity. The product water was indistinguishable from tap water in all three bioassays. This study demonstrates the suitability and robustness of passive sampling linked with bioanalytical tools for semi-continuous monitoring of advanced water treatment efficiency with respect to micropollutant removal.

026

IDENTIFICATION OF POLLUTION SOURCES AND BIOLOGICAL EFFECTS IN AN URBAN STREAM IN VICTORIA: A CAPIM CASE STUDY.

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Urban catchments are subject to a range of environmental stressors and often exhibit poor ecosystem health. The upper reaches of Dandenong Creek, located 30 km north-east of Melbourne, have been described in several studies as being in poor condition. The poor condition is attributed to the degraded physical condition of the stream and pollution, however, there is considerable speculation about which are the most important factors contributing to this.

The aims of this study were to provide an integrated environmental assessment of ecosystem health within the Dandenong Creek by identifying contaminants present in sediments and combining this with biological effects data in three species, and to determine if these organisms were showing signs of exposure to sewage–related contaminants (endocrine disrupting chemicals).

An *in situ* caging study using a gastropod mollusc (*Potamopyrgus antipodarum*) was conducted, by transplanting snails from a reference site to sites within the study area. The cages were deployed for one month, then survival, growth, and embryo counts were recorded. Morphological analysis was conducted on mosquitofish (*Gambusia holbrooki*) collected from multiple sites within the study area, and gonadal histology and vitellogenin analysis were conducted on goldfish (*Carassius auratus*) collected from a reference site and a site downstream of a sewerage discharge point.

Sediment analysis indicated high levels of several heavy metals (zinc, lead, copper, nickel, silver), as well as detectable levels of some synthetic pyrethroids and organochlorine pesticides. Sediment toxicity testing using *Chironomus tepperi* displayed varying degrees of toxicity between different sediments and w ater analysis for hormonal activity indicated both estrogenic and androgenic activity in certain parts of the system. This study comprised an integrated environmental assessment that provides multiple lines of evidence for identifying the specific types of pollution causing ecosystem stress within Dandenong Creek, which will help in establishing the most appropriate means of remediation.

027

BANG FOR BUCK, THE CHALLENGE OF CHOOSING BETWEEN CHEMICAL AND BIOLOGICAL MONITORING TOOLS FOR ASSESSING THE HEALTH OF ESTUARIES.

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The accurate assessment of ecosystem health requires that multiple lines of evidence (LOE) be collected and analysed to link exposure with effects. As minimal resources are often allocated to assessments, the comparison and prioritization of methods that provide strong LOEs, and exclusion of less effective tools, is often necessary. For seven estuaries that were either relatively unmodified, or heavily modified by urbanization and industrial activities, we surveyed concentrations of heavy metals and PAHs in benthic sediments, resuspended sediments and experimentally deployed oysters. Estuaries were divided into zones based on qualitative observations of grain size, wave exposure and flushing, and were further distinguished by quantitative measurements of water quality variables (e.g. salinity). Strong positive correlations existed for Cr, Cu, Ni, Mn, Pb and Zn between benthic and resuspended sediment compartments. However, low resuspended sediment sample masses prevented analysis of these relationships for PAHs. Copper was the only metal for which useful correlations existed between benthic sediment and oyster tissue concentrations, but useful correlations existed for several PAHs. For all estuaries, metal and PAH contaminant concentration increased proportionally with increasing of levels of silt and heavily modified estuaries had proportionally more fines content. In terms of assessing differences in ecosystem health between the heavily modified and relatively unmodified estuaries, analyses of benthic sediments and oyster tissues contaminant concentrations appeared equal as LOE. Estuarine health assessments that combine multiple LOE are expected to improve detection of broad-scale impacts on ecosystem health; we discuss the costs and benefits of utilizing total PAHs in place of individual PAHs, and the usefulness of combining copper with total PAHs as a ‘metric' to characterise the health of heavily modified and relatively unmodified estuaries. The identification of priority LOEs and useful ‘metrics' will assist in creating sensitive sampling programs to detect contaminant impacts where resources are limited.

028

PROVIDING BETTER LINKAGES BETWEEN ECOTOXICITY TESTING AND FIELD BIOMONITORING – WHY DON'T WE AT LEAST USE THE SAME SPECIES?

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The 2000 edition of the Australia and New Zealand Guidelines for Fresh and Marine Water Quality brought in two significant innovations. One was the use of species sensitivity distributions in the development of trigger values for both single toxicants and more complex mixtures such as via direct toxicity assessment and the other was a greater integration of biological monitoring into assessment of water quality. However, the laboratory-based ecotoxicology and the field-based biological monitoring disciplines have had different histories and have, therefore, developed largely independently of each other. The toxicity testing species that are commonly used in Australia for commercial and research purposes are rarely used for biomonitoring, and the standard biomonitoring approaches, where they have been standardised, rarely focus on taxa that have been found to be sensitive to the toxicants of concern or are amenable to laboratory sensitivity testing. Despite the rare exceptions to this, the most common biomonitoring protocols often target taxonomic groups such as that do not have established sensitivities, or even have been shown to be tolerant of toxicants. Conversely, the list of toxicity testing species commonly used in Australia has not been developed to aid in establishing the sensitivity of taxa with well-established biomonitoring protocols. This presentation will illustrate examples of these cases and demonstrate how these two fields could be better linked, for little additional cost or effort, and potentially lead to more informed environmental management decision making.

029

ECOLOGICAL DIAGNOSIS OF PESTICIDE IMPACTS BY WEIGHT OF EVIDENCE.

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A recent survey of sediment quality in Melbourne and the Yarra Valley found elevated concentrations of a range of pesticides(1). Because contaminants typically occur in combination, and guideline concentrations exist for few of the detected pesticides, predicting the ecological impact of contaminated sediment is a complex issue. We applied a weight of evidence approach to three complementary sediment toxicity bioassays to diagnose both the severity and type of ecological impact. We measured community compositional change in a field microcosm bioassay, deformity rates in wild *Chironomus* spp, and growth, emergence and survival in laboratory-reared *C. tepperi*. The field microcosm bioassay provided an ecologically relevant benchmark by estimating the impact of sediment pollution on invertebrate community composition. Pesticides and heavy metals were linked with two distinct types of microcosm community change. In wild *Chironomus* spp, heavy metals were specifically associated with mentum deformities, while pesticides were associated with deformities of the pectin epipharanges. Sites where impacts were identified by both laboratory *C. tepperi* bioassay and wild *Chironomus* spp deformity rates tended to also display community impacts in the field microcosm

bioassay. We conclude the *C. tepperi* test was the most sensitive of the three bioassays, deformities suggested more severe toxicity, and microcosm community change indicated the most severe toxicity. The combined bioassays provide useful evidence regarding the type of contamination responsible for the observed toxicity.

(1) Rose G, Allen D, Allinson G, Allinson M, Bui A, Wightwick A, Zhang P. (2009). Melbourne Water and DPI agrochemicals in Port Phillip catchment streams-project summary report on 2008-09. DPI Tech Rpt

030

THE TOXICITY OF SILVER NANOPARTICLES (AGNPS) TO TWO AUSTRALIAN FRESHWATER INVERTEBRATES, HYDRA VULGARIS AND PARATYA AUSTRALIENSIS

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Silver nanoparticles (AgNPs) are used in numerous consumer products mainly due to their antibacterial proprieties. The increasing production and use of these nanomaterials will inevitably lead to increased levels of their discharge into the environment. Soluble forms of silver are recognised as highly toxic to aquatic organisms; however, little information exists on the toxicity of AgNPs to aquatic species or on the behavior of these nanomaterials in aqueous environments. Thus it is unclear whether environmental release of silver nanoparticles poses a significant ecological risk. This research investigated the toxicity of silver (Ag) nanoparticles to two representative Australian freshwater invertebrates, Hydra vulgaris and Paratya australiensis. The study aimed firstly to examine whether AgNPs are toxic to freshwater invertebrates, using the selected species as model test organisms and if so, determine if the observed toxicity is solely due to dissolution of the nanoparticles. The behaviour of silver nanoparticles in natural water was examined and the acute toxicity of nanoparticulate silver was compared to that of soluble silver nitrate (AgNO3). The dissolution of AgNPs in each medium was determined using atomic absorption spectrophotometric analyses and the calculation of dissolution rates, to evaluate if the toxicity of AgNPs was related to the release of ionic silver (Ag+) from the AgNPs, or to the specific effects of AgNPs.

031

TEMPERATURE-DEPENDENT TOXICITIES OF NANO-ZINC OXIDES ON THREE MARINE ORGANISMS

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Nano zinc oxide (nZnO) is increasingly used in sunscreen products, with high potential of being released directly into marine environments. Our laboratory has previously demonstrated that toxicity of nZnO on marine organisms can be attributed to the release of metal ions and aggregate sizes (Analytical Bioanalytical Chemistry 396: 609-618; 2010). Other recent studies have further showed that different temperatures can alter the agglomerate sizes (Journal of Applied Toxicology, 30:276-285; 2010) and ion release rates (Environmental Science & Technology 44: 2169-2175; 2010) of nanomaterials in water. In this study we, therefore, hypothesize that the toxicities of nanomaterials on marine organisms are augmented with increasing temperature within their thermal tolerance ranges. Acute toxicity tests were conducted using the marine diatom Thalassiosia pseudonana, the amphipod Elasmopus rapax, and the fish Oryzias melastigma exposed to nZnO under various temperatures (i.e., 10°C, 15°C, 25°C, 30°C and 35°C). Our results showed that toxicity of nZnO generally increases with increasing temperature. For example, the LC_{50} values of nZnO on the amphipod decreased from 8.33 mg L^{-1} at 15°C to 0.10 mg L^{-1} at 30°C. To further elucidate the mechanism, we are currently investigating the interacting effect of temperature and nZnO on the expression of stress proteins such as heat shock proteins in the fish while we will examine the chlorophyll content and photosynthetic activity of the diatom. The results will be discussed with reference to the temperature-dependent physicochemical properties of nZnO.

032

RETENTION OF METALLIC NANOMATERIALS IN SOILS

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Environmental exposure to metallic nanoparticles (NPs) is predominantly to land in wastewater treatment solids (sludges/biosolids). The potential dissolution and/or transport of NPs in soils is therefore of interest to regulatory/chemical registration authorities. We examined the dissolution and retention/transport of silver (AgNP) and ceria (CeO_2) nanoparticles (CeNP) in a range of Australian soils, under a range of conditions including co-addition with biosolids. Behaviour was compared to bulk (>100 nm) Ag and CeO_2 and to dissolved ionic Ag (Ag^+) and Ce (Ce^{3+}/Ce^{4+}).

Dissolution of CeNP in model soil solutions was only significant at low pH where 2.5% of total Ce dissolved, but no CeNP dissolution was detected in soil suspensions. AgNP dissolution in solutions was found to be enhanced relative to bulk Ag at pH 4 but remained < 8 %. AgNP dissolution in soils after 24 h could not be detected in most cases possibly because ionic Ag was adsorbed by soil organic matter.

Retention of CeNP (termed K_r values) was low (median K_r= 9.6 L kg^{-1}) compared to soluble Ce(III) and Ce(IV) (median K_d= 1808 L kg^{-1} and K_d= 3763 L kg^{-1}, respectively). Retention of CeNP was greater as spiking rate increased suggesting homocoagulation of particles. AgNP retention was greater than for CeNP (589 L kg^{-1}), but lower than retention of bulk Ag (median $K_d \geq$ 100,000 L kg^{-1}), and not dramatically different to Ag^+ (median K_d = 1791 L kg^{-1}). Retention of AgNP and CeNP was found to be positively correlated with parameters that relate to clay, iron and aluminium oxide contents in soils, suggesting heterocoagulation with natural colloids plays a role in retention. The K_r values were found to increase (higher solid phase retention) in soils with the addition of biosolids. Heterocoagulation experiments confirmed that metallic NPs associate with natural colloids in soils.

033

CONFESSIONS OF AN ENVIRONMENTAL CHEMIST

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In this talk, I will give an overview of the thrilling scientific challenges faced when assessing the impacts of contaminants on aquatic systems. The environmental chemistry and ecotoxicology of various trace metals in aquatic systems will be discussed. The talk will describe investigations conducted in some exotic locations including crocodile-infested lakes in Papua New Guinea, the coastal waters of Australia and back in the laboratory in Sydney.

034

THE STABILITY OF HYDROTALCITE AS AN ENVIRONMENTAL AMELIORANT: A MOLECULAR MODELLING APPROACH TO TOXIC ANION BONDING.

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Hydrotalcite is an anionic layered double hydroxide having stoichiometry [Mg0.80Al0.20(CO3)0.3(Xy-)0.7 (OH)2.zH2O] that forms spontaneously as seawater is mixed with wastewater from the Bayer process. As it precipitates, it adsorbs anionic chemical species(Xy-) such as C2O42-, CrO42- and VO43- that may be harmful to or accumulate in marine biota. The stability of these anions within the interlamellar space is dictated by the manner in which they are bonded. Should the bonds be weak, then ion exchange may occur and harmful species released back into the environment.

Laboratory experiments show that while 60% to 70% of the CrO42- and VO43- adsorbed during precipitation of hydrotalcite (HT) remains locked within its molecular matrix, the remainder can be easily removed by leaching with water or by ion exchange with CO32-. This indicates that some species are not bonded strongly and that hydrotalcite may therefore not be as useful as an environmental ameliorant as originally thought. Computational modeling suggests that water creates a structured environment within the interlamellar space and that anionic species are held principally by hydrogen bonding with either the water molecules, or with the terminal –OH groups of the Mg/Al lamellae. Though electrostatic forces of attraction do exist between the anions and the metal hydroxide layer, they are weaker at pH<10 (i.e 4:1-HT) compared to pH >12 systems (2:1-HT).

The self-diffusion co-efficients of different anions in the interlamellar space of the HT models are measured and differences between them interpreted as a reflection of relative mobilities. Models correlate well with experimental data, indicating that while the bulk of the intercalated CrO42- and VO43- within the interlamellar space are stable, leaching and ion-exchange of less strongly bonded species can still occur. In turn, this suggests that hydrotalcite may not be as stable as previously thought and that its use as a long-term environmental ameliorant may be restricted.

035

CLOSED-BOTTLE BIODEGRADATION TEST FOR SYNTHETIC-BASED DRILLING FLUIDS UNDER AUSTRALIAN CONDITIONS

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Biodegradation rate, along with acute and chronic toxicity, is an important factor in determining the overall environmental performance of drilling fluids (SBFs) used in synthetic-based mud (SBM) formulations. The closed-bottle anaerobic biodegradation test (CBT) is one of the three criteria set by United States (US) Environmental Protection Agency that drilling fluids have to meet in order to be permitted for use in offshore exploration. This project, based on US methodologies, was aimed at optimising the CBT to Australian conditions. Phase one (CBT1) included a comparison study for the relative biodegradability of selected SBFs including esters, internal olefins (IO), linear alpha olefins (LAO) and paraffin in Australian and US sediments. Apart from dissimilar characteristics, Australian sediments demonstrated very high metabolic activity relative to US sediments, most likely due to the presence of higher levels of sulfate reducing bacteria (SRB) and organic content (% volatile solids, VS). The results suggested the relative ranking from fastest to slowest anaerobic biodegradation rates of SBFs as esters > LAO > IO > paraffin. CBT2, the second phase, focused on further refinement in the selection of marine sediment along with comprehensive characterization of five selected sediments and resulted in successful completion of CBT in two sediments among five inoculums. Results suggested that increasing number of microbes including SRB and VS correlate well with biodegradation rates. This study has shown that CBT has the capacity to provide information on the relative biodegradability of SBFs and sediment recovery period under marine conditions. CBT data may assist in improvements to SBM technology including the selection of SBFs, quality control of base fluid batches and subsequent minimization of environmental impacts associated with SBM discharge at sea under Australian conditions.

036

INVESTIGATIONS INTO THE EFFECTS OF COMMON PETROLEUM FUELS TO LOCAL SOIL ORGANISMS, PLANTS AND SOIL FUNCTIONS

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Petrol service stations provide the community with services and essential goods, particularly petroleum fuels. Large amounts of petroleum fuels are stored underground within these facilities, and these contain a range of petroleum aliphatic and aromatic hydrocarbons, oxygenate fuel additives and other compounds. If these chemicals are released into the environment such as by leakage from storage tanks or by runoff of road spills during rain events, they can potentially affect exposed soil organisms and consequently soil functions. These events account for a significant proportion of issues dealt by regulators and Contaminated Site managers such as in NSW DECCW. The purpose of this study was to investigate the effects of commonly used fuels, by two modes of application, to local species of earthworms & springtails, plants, and the soil microbial functions respiration and nitrification.

Common petroleum fuels (diesel, unleaded-98, unleaded E10) obtained from a local petrol station were applied onto soil either (i) directly using a solution of a fuel in an organic solvent; or (ii) indirectly by applying as water-accommodated fractions (WAF). The petrol-contaminated soils were tested on a range of endpoints for earthworm tests (survival, growth, avoidance behaviour, reproduction); survival of local springtail species particularly *Proisotoma minuta*; growth of seedlings of bottle brush *Callistemon* sp; and soil microbial functions respiration and nitrification. Preliminary results will be presented. Overall, preliminary results suggest that on a volume: volume basis, the unleaded E10 had least toxic effects of the three petroleum fuels studied. The relationship, if any, of the observed effects with the petroleum hydrocarbon fraction profiles, will be discussed.

037

MONITORING THE IMPACTS OF THE MONTARA WELL RELEASE USING BIOMARKERS OF FISH HEALTH

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In August 2009 an estimated 22,800 barrels of oil and gas condensate were accidentally discharged from the Montara well head to the Timor Sea raising immediate economical, political and environmental concerns. The spill was controlled after seventy-four days after which a monitoring program to assess the extent of environmental impacts of the well release was enacted. As part of this program, commercially important fish species were collected and a suite of physiological indices (condition factor, liver somatic index and the gonadosomatic index), biomarkers (biliary polycyclic aromatic hydrocarbon (PAH) metabolites, liver integrity measured by serum sorbitol dehydrogenase activity (SDH), oxidative DNA damage) and histological examination were used to evaluate the short and long-term impacts of exposure to petroleum hydrocarbons on fish health. Shortly following the control of the well release, fish exhibited evidence of exposure to petroleum hydrocarbons and were showing, in the short term, very limited adverse health impacts. An additional investigation conducted four months after the spill revealed continuing exposure to petroleum hydrocarbons in demersal species captured close to the rig, with associated alterations to physiological indices consistent with chronic exposure to petroleum compounds. Histological morphology of male and female gonads remained unaltered in all fish species from all locations. In presenting these results we discuss the continuing importance of ecotoxicology in establishing rapid methods for testing the short- and long-term impacts of acute exposure to industrial contamination events related to the expanding Australian resource sector.

038

RECENT DEVELOPMENTS IN FUELS: ENVIRONMENTAL EFFECTS AND IMPLICATIONS FOR MANAGEMENT OF UNDERGROUND PETROLEUM STORAGE SYSTEMS

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Leaking underground petroleum storage systems account for approximately 70% of all contaminated site notifications to the Environmental Protection Authority in NSW. Petroleum leakage is therefore a significant environmental, public health and financial issue. While legislation is in place to proactively prevent and identify this issue, changing fuel blends have the potential to increase the mobility of fuel leaks. For instance the increased water solubility of ethanol blends can result in accelerated plume spread in aquifers. Since 2007 the ethanol content of total fuel volume in NSW has been mandated, initially at 2%, and subsequently to a 10% mandate by 2011. Nationally, tax incentives also encourage the use of biofuels. This trend for increasing use of biofuels and subsequent reduction in imported petroleum is likely to continue. Fuel blends with up to 85% ethanol are now available with car makers producing local models that can use these blends. The replacement of petroleum with ethanol has a number of implications for the environment: preliminary results from current ecotoxicology investigations on earthworms, plants and soil function suggest that ethanol blends are less toxic on a volume:volume basis, however increased mobility may increase environmental consequences in groundwater. Preliminary chemical analyses have indicated that a 10% addition of ethanol to fuel increased the partitioning of

several non-polar compounds into an aqueous phase. In addition fuel additives such as methyl tertiary butyl ether (MTBE) also can result in additional impacts. This has implications for management and storage of fuel, fuel releases and the subsequent remedial approaches.

New diagnostic methods based on gas and liquid chromatography techniques are currently being developed that can identify the components, including additives of petroleum, in the environment, which will facilitate management of fuel releases and potentially assist regulators to apportion responsibility for remediation.

039

FINE SEDIMENT TRANSPORT IN DARWIN HARBOUR

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Darwin Harbour is a large macro tidal harbour with a tide range of up to 8 metres. The large tide range generates strong tidal currents in the order of 2 metres per second. The bed shear generated by the currents resuspends fine muddy sediments creating a turbid harbour. Over the past decade Darwin Harbour has had many large developments including marinas, wharfs, water front developents and liquified natural gas terminals. There are plans underway to increase the shipping in the harbour to accommodate Panamax class ships at all tide conditions and to construct another LNG terminal including berthing facilities. All these developments require a substantial amount of dredging and the disposal of the fine muddy sediments has created several issues relating to disposal. Fine sediment on its own can be considered a pollutant, especially when originating from dredge disposal, where it can be transported by the tidal currents to deposit over wide areas.

Several field data collection programs have shown that Darwin Harbour has a net fine sediment transport that results in sediment being imported into the upper harbour. These data have been used to construct a numerical hydrodynamic and sediment transport model. The model has been used to evaluate the fate of sediments from dredging projects and natural sediment transport. The model has also been extended to assist with tracking the fate of other contaminants such as sewage effluent. The field data and the model have quantified that Darwin Harbour has a high residence time for contaminants that are disposed of into the harbour and that the flushing rate is progressivelly lower in an upstream direction in the harbour arms.

The development of a field research program will be essential in making the the numerical model a reliable management tool for Darwin Harbour.

(1) Willams David, Wolanski Eric and Spagnol Simon (2006) Hydrodynamics of Darwin Harbour. In Environment of Asia Pacific Harbours. Wolanki E (ed) published by Springer Chapter 26 pp 461-476.

040

DISAPPEARANCE AND TRANSFORMATION OF TRICLOSAN, A COMMON ANTIMICROBIAL COMPOUND, IN A NEW ZEALAND SOIL.

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The antimicrobial chemical triclosan is a common ingredient in many household personal care products including toothpastes, liquid soaps, shampoos, lotions, and cosmetics. A considerable quantity of triclosan enters wastewater treatment plants (WWTPs) in domestic wastewater where it's removed by degradation and transformation processes, and sorption to sewage sludges. Triclosan partitions and concentrates in sewage sludge and it is a common contaminant in biosolids recycled to land. Contamination of soils by triclosan has raised several concerns, principally the potential development of cross-resistance to antibiotics, toxicity to soil organisms, and negative impact on soil microbes. The potential for triclosan to impact soil microbial communities is dependent upon its concentration and half-life. Upon mixing with soil triclosan is subjected to various abiotic and biotic loss mechanisms that act to reduce its concentration, and therefore the potential to negatively impact the soil microbial community. Published half-lives for triclosan in soil range from 12 to 107 days and there is no data on the half-life of triclosan in New Zealand soil.

Here we present the results of an experiment investigating the disappearance of triclosan in a common New Zealand agricultural soil. Triclosan was spiked into sterile and non-sterile soil treatments at a concentration of 0.1 mg.kg-1 and incubated at 15oC for a maximum of 112 days. Treated soils were sampled at predetermined intervals and analysed immediately for the biochemical parameters of microbial biomass, and dehydrogenase and sulphatase enzyme activity. Soil samples were analysed for residues of triclosan, the primary transformation product methyltriclosan, and degradation products 2,4-dichlorphenol and 4-chlorocatechol. We will present calculated kinetic parameters for the loss of triclosan and formation of methyl triclosan, 2,4-dichlorphenol and 4-chlorocatechol. We will discuss the relevance of these parameters to estimating the persistence of triclosan introduced to NZ soil under recommended biosolid guidelines.

041

SHORT-TERM MONITORING OF ATMOSPHERIC POLYCYCLIC AROMATIC HYDROCARBONS DURING A HAZE EPISODE IN THE PEARL RIVER DELTA, SOUTH CHINA

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Haze is primarily caused by the accumulation of fine particles in the near ground atmosphere. Haze particles are toxic because of the atmospheric pollutants they absorb, such as polycyclic aromatic hydrocarbons (PAHs) which are carcinogenic, mutagenic, and teratogenic. This study was the first to monitor the short-term variation of atmospheric PAHs during a haze episode. Atmospheric sampling was conducted simultaneously at 3 sites, namely Guangzhou (urban), Qingyuan (suburban) and TaiO (coastal background), in the Pearl River Delta of South China. Gaseous and particulate samples were collected by high-volume air samplers continuously at 12 hour (day/night) intervals. The sampling period was from the 8th to the 15th February 2007, covering a typical winter haze episode.

A gradient of PAH concentrations from the sites was observed in both gaseous and particulate samples. The total concentrations of gaseous and particulate PAHs were 562 and 35 ng m^{-3} in Guangzhou, 86 and 0.88 ng m^{-3} in Qingyuan, and 16 and 0.97 ng m^{-3} in TaiO, respectively. About 90% of the total PAHs existed in the gaseous phase and the particulate phase was relatively lower. From the haze formation to the stagnant period, concentrations in Guangzhou and Qingyuan increased sharply up to 4-6 times. During the fade-out period, they declined dramatically with the effective washout of rain. The secondary aerosols, which are more favorable to gaseous PAH absorption, may be responsible for the disequilibrium of gas–particle partitioning of PAHs in Guangzhou. At Qingyuan and TaiO, concentrations were mainly controlled by meteorological parameters such as wind direction/speed, which indicated that air mass movement played a significant role in the transportation of PAHs from the source areas to the suburban and coastal background sites. It was also found that secondary aerosols in TaiO were more aged than Guangzhou and Qingyuan during the atmospheric transportation process.

042

NON-DESTRUCTIVE SAMPLING FOR PERSISTENT ORGANIC POLLUTANTS IN AUSTRALIAN WHITE IBIS (*THRESKIORNIS MOLUCCA*) FROM SYDNEY

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Dioxins, furans, PCBs and brominated flame retardants are persistent and bioaccumulative substances which are toxic to humans and wildlife. There is significant concern about their presence in the environment both in Australia and overseas. Measuring their concentrations in the tissues of biota is problematic because this requires specimens to be sacrificed. For endangered bird species, this often means that assessment of their exposure cannot be assessed because they cannot be sampled without impacting their populations. Here we examine the use of non destructive media (i.e. feathers and eggs) as a surrogate for measuring levels in other tissues (i.e. muscle and liver) using a non-endangered and culled bird species the Australian white ibis.

Concentrations of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans, dioxin-like polychlorinated biphenyls (DL-PCBs) and polybrominated diphenyl ethers (PBDEs) were measured in liver, muscle, eggs and feathers of the Australian white ibis, an aquatic and terrestrial feeding bird, from south-western Sydney. Pico-gram level concentrations were obtained using high resolution gas chromatography-high resolution mass spectrometry (HRGC-HRMS), using isotopically labelled internal standards allowed accurate peak identification and quantification. Levels and congener profiles were compared among tissues to evaluate their usefulness as a monitoring media, not only for ibis, but also for other species. This is the first data on dioxins, furans, PCBs and PBDEs in eggs and feathers of a bird species from Australia. Levels and profiles were also compared with other bird species and wildlife from different parts of the world. High levels of BDE-209 were also detected in the birds from this study, which contrasts to concentrations found in other bird species from elsewhere. Risk assessment using the $WHO_{TEQ\text{-}avian}$ were compared among tissues. Values derived from feathers were comparable with those from muscle whereas eggs were more comparable to those from liver.

043

DOES BATMAN INFLUENCE GOTHAM CITY?

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Nutrient enrichment in aquatic and marine habitats can have an overlying effect on organism, population and community demographics. There are a number of flying fox roosting camps in intertidal mangrove habitats within north eastern Australia. Although flying foxes are important keystone species that play essential roles in pollination and seed transfer for a number of fruit crops, excess nutrient enrichment from guano can have an effect on overlaying mangrove intertidal communities.

This preliminary study investigated the potential effects of guano enrichment from flying fox roosting camps in mangrove intertidal ecosystems. Water and sediment nutrient concentrations were determined at roosting camps, abandoned roosting camps and at two reference sites within the Calliope River and Curtis Island, Queensland, Australia. Intertidal macroinvertebrate assemblages were

investigated to determine potential changes in community structure, attributed to enriched nutrient loading from guano. Further, stable isotope analysis was used to determine if guano derived nutrient enrichment was transferred through intertidal food chains.

Results from the study suggest that there was a two-fold increase in nutrient enrichment at the roosting sites attributed to guano runoff and to a lesser extent, at the abandoned roosting site compared to reference sites. Macroinvertebrate community assemblages were different at roosting and abandoned roosting sites compared to reference sites. Moreover, trophic transfer of guano enriched nutrients was observed in mangrove crabs and, is likely contributing to bottom-up trophic interactions of some food chains.

This study demonstrated that small new flying fox roosting camps in mangrove systems could potentially alter intertidal macroinvertebrate communities and influence energy transfer through food webs.

044

THE ROLE OF CONTAMINATION IN FACILITATING INVASION.

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The introduction and establishment of non-indigenous species (NIS) can have profound effects on the economic potential, social values and environmental stability of affected regions. As an ever increasing global population places more stress on coastal environments (e.g. poor water quality, habitat loss, climate change), and the reliance on shipping for the transport of goods and services worldwide increases, it becomes important to understand the links between disturbance and invasions. Ports and harbours are invasion 'hot-spots', and the proliferation of NIS occurs despite the fact these environments receive high levels of anthropogenic disturbance including chemical pollution. Antifouling biocides such as Cu exert very strong selective pressures on target and non-target organisms, favouring individuals that have increased tolerance. When combined with a common transport vector for marine NIS, such as hull-fouling, the potential for such biocides to create and transport tolerant and competitively superior organisms quickly becomes apparent. Through a series of novel laboratory and field experiments and broad-scale surveys we have gathered strong evidence that contamination facilitates marine invasions both directly (through differential tolerance) and indirectly (through disturbance). We present a growing body of evidence indicating that metal polluted source and recipient environments, connected by metal biocide affected transport vectors, is leading to the evolution of a pool of highly metal-tolerant non-indigenous organisms that are successfully out-competing less resilient native taxa. This transfer of metal-tolerant NIS is likely to continue into the near future, until: (1) alternative anti-fouling strategies, practices and regulations become more effective and widespread; (2) water quality issues (particularly concerning metal pollution) are addressed in ports, harbours and estuaries worldwide; and (3) a better understanding is gained of the nature and evolution of metal tolerance in marine fouling taxa, particularly with respect to differential tolerance among non-indigenous and native species.

045

THE INFLUENCE OF DISSOLVED ORGANIC CARBON ON THE SPECIATION AND TOXICITY OF ALUMINIUM TO TROPICAL FRESHWATER ORGANISMS

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Aluminium (Al) can be a contaminant of concern in the aquatic environment, particularly due to acid main drainage. Inputs of Al to surface waters can occur through acidic seepage or discharges from operating, closed or legacy mine sites. The ANZECC & ARMCANZ (2000) water quality guidelines provide a "low reliability" trigger value (TV) of 0.8 µg/L Al for freshwaters of pH<6.5. This value, however, is typically below natural Al concentrations in low pH freshwater streams in northern Australia. The TV also does not incorporate the influence of dissolved organic carbon (DOC), despite it being known to be an effective complexing agent for Al.

This study quantified the influence of two DOC sources on the toxicity of Al at pH 5 to three Australian tropical freshwater species - the cladoceran, *Moinodaphnia macleayi*, the green alga, *Chlorella* sp. and the green hydra, *Hydra viridissima*. The influence of a fulvic acid standard (SRFA) on Al toxicity was compared to that of local DOC sourced from a northern Australian billabong water (Sandy Billabong; SBW, 10mg/L DOC). Al exposures over a 1-10 mg/L DOC range were conducted firstly with SRFA in dilute creek water and secondly in SBW diluted with synthetic creek water lacking DOC.

Al toxicity was reduced up to 10-fold in water containing 10 mg/L DOC as SRFA, relative to test waters at background DOC. Al toxicity was reduced only up to 3-fold in SBW containing 10 mg/L local DOC, relative to test waters at background DOC. Geochemical speciation modelling confirmed the decreased Al toxicity in the presence of each DOC source was primarily due to lowering of $Al(OH)_2^+$ and Al^{3+} concentrations through complexation with DOC. SRFA's ability to ameliorate Al toxicity more effectively than SBW was attributed to the SRFA having stronger metal binding capacity than SBW fulvic acid.

(1) Australian & New Zealand guidelines for fresh & marine water quality. Australian & New Zealand Environment & Conservation Council & Agriculture & Resource Management Council of Australia & New Zealand

046

DIFFERENTIAL TOLERANCE TO METAL CONTAMINATION AMONG POPULATIONS OF A MARINE HERBIVORE

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Metal contamination can have profound ecological impacts on marine ecosystems. In order to survive exposure to metal contamination in their environment, species must develop tolerance in the form of either acclimation or evolutionary adaptation. Metal contamination is not uniform in the environment and as a result populations from sites with high levels of contamination could develop a higher tolerance for metals. The potential for local adaptation to contamination has been seen in some marine species, however population-level differences in tolerance to metals in their diet has not been as well studied. This study looks at among and within population level differences in the ability of a marine herbivore (the amphipod Peramphithoe parmerong) to tolerate copper contamination in their algal diet. We will present results from experiments that quantify differences in survival and growth among families and among populations from eight different sites in Sydney Harbour with varying levels of contamination. Understanding the degree of local adaptation to metal contamination in P. parmerong fills a strategic knowledge gap regarding the potential for marine species to evolve tolerance to metals and combat the negative effects of being exposed to a contaminated food source.

047

TRACE METAL ACCUMULATION BY THE FRESHWATER DECAPOD *MACROBRACHIUM AUSTRALIENSE* EXPOSED TO METAL-ENRICHED SEDIMENTS

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Bioaccumulation of trace metals in the freshwater decapod *Macrobrachium spp.* has been measured in the Strickland River, PNG, however no obvious pathway has been determined. Lab accumulation studies were conducted using *M. australiense* as a surrogate species to investigate this phenomenon. Initial studies using metal-enriched particulates compared accumulation by these prawns from direct exposures, exposures to suspended particulates and exposure to metals released into the dissolved phase. Accumulated arsenic and lead were higher when the organism was exposed to particulates compared with the dissolved exposure, whereas cadmium, selenium and zinc showed no significant differences. Further studies examined the internal metal partitioning of trace metals within four compartments (hepatopancreas, abdomen and anterior and posterior exoskeletons) when directly exposed to metal-enriched particulates. Results indicated that cadmium accumulated significantly within the hepatopancreas, while it was undetectable in other compartments. Copper appeared to be excreted to the exoskeleton in control prawns but was internalised pre-ecdysis. Zinc, however, was externalised pre-ecdysis suggesting that the exoskeleton is an important trace metal storage and excretion tissue for this species. Metal release into the overlying water was also monitored during the prawn exposures to metal-enriched sediments. Copper and manganese were continuously released to the overlying water without reaching equilibrium over 14 d. Subsequent experiments assessed the influence of the following three processes on metal release: (i) bacterial oxidation of sulfide minerals; (ii) release associated with complexation by dissolved organic carbon (DOC); and (iii) internalisation of sediments within the prawns. Sulfide oxidation was not a significant metal-release mechanism, but strong correlations were observed between DOC and copper and manganese release. Higher DOC in the presence of prawns and food resulted in faster metal release. These observations, together with prawn-gut processes, are discussed in relation to the metal accumulation by the prawns.

048

CADMIUM AND ZINC UPTAKE AND EFFLUX RATES IN THE SIGNAL CRAYFISH *PACIFASTACUS LENIUSCULUS*

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Biodynamic modelling is a tool utilised to predict metal bioaccumulation in aquatic organisms, a component being the establishment of metal uptake and efflux rate constants for the organism. Parameters of bioaccumulation kinetics for the trace metals cadmium and zinc were investigated in the signal crayfish, *Pacifastacus leniusculus*. Cadmium and Zn uptake rate constants from solution (K_u), and subsequent efflux rate constants (K_e), were compared after uptake from water under different physiochemical conditions (Ca concentration). Significant linear increases in both metal uptake rates with dissolved concentration were recorded for all conditions. Water hardness (Ca) appears to have no impact on the uptake rates of Zn or Cd. Efflux patterns indicated differences between Zn and Cd. Cadmium has two phases of efflux – loss from a 'fast pool' and loss from a 'slow pool', unlike Zn which appears to have only the slow pool. The efflux rate constant from the slow pool is relevant for the biodynamic modelling of Cd and Zn bioaccumulation in the signal crayfish.

049

ENVIRONMENTAL RISKS OF FUNGICIDES USED IN HORTICULTURAL PRODUCTION SYSTEMS: CURRENT KNOWLEDGE AND RESEARCH GAPS

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Fungicides are widely used in horticultural production systems, however their use can cause adverse effects to terrestrial and aquatic ecosystems if residues persist in soil, or if they migrate off-site to surface and ground waters. Compared to insecticides and herbicides the environmental risks posed by fungicides have received little attention. An overview of current knowlede on the potential environmental risks posed by fungicides will be provided, with an emphasis on fungicide use in viticulture used as a case-study. Much is known about the fate, behaviour and toxicity of copper-based fungicide residues in both terrestrial and aquatic environments. However, comparatively little information has been reported for the synthetic organic fungicide compounds registered for use for which to enable an assessment the ecological risks. Further research into the potential environmental risks posed by fungicide use is needed so that evidence-based policy decisions can be made on the future management of fungicide use. In the first instance, field studies are needed to determine the fate and concentrations of fungicides in terrestrial and aquatic environments. Secondly, research needs to generate additional toxicity data for more species/endpoints, in particular aquatic fungi, microbial processes, and invertebrates of agricultural relevance to improve the robustness of ecological risk assessments. Further information on the types and amounts of fungicides being used is needed on a catchment to focus this research on priority fungicides of concern. Due to environmental concerns about copper-based fungicides the use of synthetic organic fungicide compounds (e.g. dithiocarbamates, triazoles, strobilurins) is increasing. In light of this, there needs to be increased understanding of the relative risks of different fungicide classes/compounds to ensure alternative compounds are in fact safer for the environment.

050

A COMPARISON OF MIXTURE TOXICITY ASSESSMENT: EXAMINING THE CHRONIC TOXICITY OF ATRAZINE, PERMETHRIN AND CHLOROTHALONIL IN MIXTURES TO *CERIODAPHNIA* CF. *DUBIA*

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Pesticides predominantly occur in aquatic ecosystems as mixtures of varying complexity, yet relatively few studies have examined the toxicity of pesticide mixtures. This study examined the chronic toxicities (7-d reproductive impairment) of the pesticides atrazine, chlorothalonil and permethrin (which have different modes of action) individually and in binary and ternary mixtures to the freshwater cladoceran *Ceriodaphnia* cf. *dubia* . The individual toxicities (IC25) of atrazine, chlorothalonil and permethrin to *C.* cf. *dubia* are 862.4 (780.9-943.9) μgL^{-1}, 66.4 (49.4-83.4) μgL^{-1}, and 0.19 (0.14-0.23) μgL^{-1}, respectively. The toxicity of the mixtures was then compared to that predicted by the independent action (IA) model for mixtures as this is the most appropriate for chemicals with different modes of action. Following this they were compared to the toxicity predicted by the concentration addition (CA) model for mixtures. According to the IA model, the toxicity of the chlorothalonil plus atrazine mixture conformed to antagonism, while that of chlorothalonil and permethrin conformed to synergism. The toxicity of the atrazine and permethrin mixture as well as the ternary mixture conformed to IA implying there was either no interaction between the components of these mixtures or the interactions cancelled each other out to result in IA. When we assessed the mixture interaction using the CA model, the binary mixture of atrazine plus chlorothalonil and the ternary mixture both conformed to antagonism, while the binary mixtures of atrazine plus permethrin and chlorothalonil plus permethirn both conformed to concentration addition. Using the CA model provided estimates of mixture toxicity that were accurate or overestimated the measured toxicity and therefore this model is the most suitable to use in ecological risk assessments of these pesticides. Evaluating pesticide mixture toxicities will allow regulators and the agricultural industry to better manage the use of pesticides and to minimise impacts on the aquatic environment.

051

INCORPORATING COMMUNITY LEVEL MACROINVERTEBRATE ENDPOINTS INTO GUIDELINE DERIVATION PROCEDURES: APPLICATION TO SEVERAL ENVIRONMENTAL STRESSORS

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Risk-based water quality guidelines have been developed and implemented in Australia and New Zealand for toxicants. The approach uses statistical extrapolation models fitted to laboratory chronic data in order to provide predictions (termed "trigger values") for various levels of protection. The suitability of different macroinvertebrate community metrics for detecting the impacts of different contaminant stressors in freshwater streams was assessed. Field surveys of contamination gradients and stream mesocosm studies were used to determine response thresholds for three major environmental stressors: heavy metals; ammonia and inorganic suspended solids. All studies provided quantitative data with a concentration-response design enabling regression relationships to be established. Abundance and species richness of mayflies, number of EPT (Ephemeroptera = mayflies, Plecoptera = stoneflies and Trichoptera = caddisflies) taxa, and taxonomic richness were the best indicators of heavy metals; and abundance of mayflies, number of EPT individuals and total invertebrate abundance for ammonia and inorganic suspended solids in New Zealand streams. Differential sensitivity of taxonomic groups, with relatively high tolerance of stoneflies and caddisflies to metals and ammonia with all EPT taxa sensitive to suspended solids, may provide useful indicators for regional and national scale monitoring applications. The relative slopes of the integrated community metric responses differed markedly in relation to the different stressors and provide quantitative measures for guideline development and community risk assessment – with high slope indicating community vulnerability and associated high risk of adverse effects. This analysis suggests that different community endpoints may be usefully incorporated in guideline derivation procedures depending on the stressor. The use of field gradient response and community mesocosm studies can provide quantitative risk assessment inputs for deriving water quality guidelines and for improved monitoring applications addressing protecting community structural and functional integrity.

052

RISK TO BREEDING SUCCESS OF FISH EATING BIRDS IN HONG KONG DUE TO PERSISTENT ORGANIC CONTAMINANTS IN EGGS

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Eggs of two Ardeid species, the Little Egret (*Egretta garzetta*) and the Black-crowned Night Heron (*Nycticorax nycticorax*), were collected from two egretries located in the New Territories of Hong Kong with one located near the internationally acclaimed wetland reserve, the Mai Po Marshes. The eggs were analyzed for persistent organic contaminants including the DDTs, PCBs, hexachlorocyclohexane (the HCHs) and the chlordanes (CHLs). All of these organochlorines were detected in the eggs of both species with significantly higher levels in the Little Egret (DDTs, 560-2200; PCBs, 270-1700; CHLs, 81-470 ng g^{-1} wet weight) than the Night Heron (DDTs, 210-1200; PCBs, 85-600; CHLs 59-75ng g^{-1} wet weight). The DDTs consisted mainly of DDE with levels ranging from 85 to 95% of the total. All of the compounds had linear concentration cumulative probability distributions on a log-normal basis which were used to evaluate exposure associated with these compounds as part of a probabilistic risk analysis. A linear dose/response relationship for the percentage reduction in the survival of young associated with DDE in eggs was developed. This probabilistic relationship was used to establish the threshold level (1000 ng g^{-1} wet weight) at which there was a significant level of reduction in the survival of young. Using a threshold level of 1000 ng g^{-1}, the Risk Quotient (RQ) had a 12.4% probability of RQ exceeding unity with the Night Heron, and 40.9% with the Little Egret. These results indicate that the DDTs in eggs would be expected to be associated with adverse effects on the survival of young of both species, particularly the Little Egret.

053

HISTOLOGICAL HEALTH INDICES: LINKING COMPLEX POLLUTANT EXPOSURE WITH TISSUE ALTERATION IN SAND FLATHEAD *PLATYCEPHALUS BASSENSIS*.

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Port Phillip Bay, Victoria, is a pollutant-impacted environment that is extensively fished both professionally and recreationally. Consumption of contaminated fish represents a potential threat to human health, and fish exposed to environmental contaminants may themselves be affected in a similar fashion. This study describes a fish health index based on histological alterations identified in multiple organs of the sand flathead *Platycephalus bassensis*. Alterations were evident in tissues from all individuals assessed, with common pathologies observed in the gills, skin, kidney, liver and spleen. Alterations commonly present included necrosis, melanomacrophage centres, inflammation and multiple alterations of the gill epithelium (e.g. hyperplasia and hypertrophy). Fish health, calculated using severity of histological alterations, differed significantly across Port Phillip Bay, with heavily industrialized regions of Altona and St. Helens showing greatest alteration prevalence across multiple organs. This study indicates that the health of *P.bassensis* from Altona, St. Helens, and Mornington to a lesser extent, are currently compromised, potentially due to complex pollutant exposures which require further investigation .

054

THE USE OF A SOCIO-ECONOMICALLY IMPORTANT SPECIES, THE INDO-PACIFIC ROCK OYSTER (*SACCOSTREA* SP.), AS A BIOMONITOR FOR WATER QUALITY IN NORTHERN TROPICAL AUSTRALIA.

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A pilot study was conducted in 2006 using the Indo-Pacific Rock Oyster (Saccostrea sp.), to assess the potential impacts on biota living within Gove Harbour, Northern Territory, Australia. Preliminary results demonstrated low level bioaccumulation of both PAHs and metals in resident oysters collected within the harbour. Histology data also suggested cellular changes in gill and digestive tissues of oysters, indicating that the water-column environment in which they live is potentially having an impact and warranted further investigation. In 2007 we assessed in situ exposure in resident oysters, Saccostrea mordax, within Gove Harbour and in translocated oysters, Saccostrea cucullata, placed in cages for 30 days within the harbour compared to a reference site. Water column chemistry and tissue bioaccumulation for metals and PAHs, biomarker responses, metallothionein expression and protein expression using proteomics were evaluated. Metal and PAH concentrations did not exceed the ANZECC (2000) water quality guideline levels nor any Australian seafood safety standards (FSANZ 2009), where available, at all sites. Biomarker responses (lysosomal stability and sorbitol dehydrogenase) and histopathological results (digestive gland atrophy and chronic parasitism) indicated that oysters in the harbour are physiologically stressed relative to reference sites. The metallothionein gene was isolated and sequenced from Saccostrea sp. for the first time, but RT-PCR results did not generate site-specific differences. Proteomic analysis indicated that two main proteins were expressed in Gove Harbour oysters and the expressions of these proteins suggest that mitochondrial energy systems are affected in Gove Harbour oysters. These studies confirm that Saccostrea sp. living within the harbour are physiologically stressed and demonstrate that Saccostrea sp. have great potential as a biomonitor species for water quality in northern tropical Australia.

(1) ANZECC (2000)
(2) FSANZ (2009)

055

DRAWING INFERENCE IN IN-STREAM TOXICITY MONITORING TESTS USED TO ASSESS MINING IMPACT IN A TROPICAL STREAM

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The Supervising Scientist Division conducts an intensive and integrated physicochemical and biological monitoring program to monitor and assess the effects of runoff water from the Ranger uranium minesite (NT) on the adjacent receiving waterways. One of the methods employed is in-situ biological monitoring where reproductive output (egg production) of the freshwater snail, *Amerianna cumingi*, is measured as a chronic (4d) exposure endpoint. This "early warning" biological monitoring is complemented by results from continuous in-situ monitoring of physicochemical parameters.

A BACIP design is employed for the snail tests in which paired (P) control (upstream, C) – impact (downstream, I) response 'differences' are compared before (B) and after (A) potential mine-related disturbances, using ANOVA.

A deficiency in the simple BACIP design applied to biological response data in the single 'impact' stream of interest (Magela) is the constraint it imposes on inferences made about the nature of impacts. Where significant change is detected, there may be no way to distinguish between mine-related and natural causes that may also have been observed in adjacent control streams. This weakened inference places an onus on the need to carefully examine other potential natural and mine-related environmental factors that could be responsible for the observation(s).

For the first time since 1992, significantly different (higher) egg production in snails was observed during the 2009 – 10 wet season at the 'exposed' downstream site in Magela Creek compared with data from the upstream site. A detailed assessment was made using a weight of evidence framework to determine whether methodological or systematic operator problems, unusual suppression in egg number upstream, and/or inputs of water from the Ranger site was responsible for the observation. It was concluded that the key solutes of potential toxicological relevance in mine water (in particular – magnesium and uranium) were not responsible for the enhanced downstream egg production.

056

EVALUATING THE USE OF BIOMARKERS AS INDICATORS OF ECOLOGICAL STRESS

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The use of biomarkers to assess exposure to or effects of environmental pollutants on aquatic ecosystems is increasingly becoming an integral component of environmental monitoring programs in the US and Europe. Biomarkers claim to be efficient at assessing the health status of organisms and to provide cost-effective early-warning signals of environmental risks. Currently, biomarkers are specific to particular contaminants and species, and no standard set of markers have been identified as useful indicators of the ecological health of estuarine systems as a whole. Here, we use the Sydney rock oyster (*Saccostrea glomerata*) to evaluate the effectiveness of biomarker responses as indicators of organismal stress. We assessed various biomarker responses using both field surveys and laboratory experiments. Oyster embryo development assays were also used to see whether there was a relationship between biomarker responses at the sub-organism level and individual and potentially population-level effects. Lysosomal destabilisation in the Sydney rock oyster proved to be an efficient indicator of an organism under anthropogenic stress. Destabilisation rates were significantly higher in stressed systems treatments when compared with references and these results were well correlated with embryo development success.

057

DGT- COPPER FLUX PREDICTS BIOACCUMULATION AND TOXICITY TO BIVALVESIN SEDIMENTS WITH VARYING PROPERTIES

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Many regulatory frameworks for sediment quality assessment include consideration of contaminant bioavailability, however, the snap-shots of metal bioavailability provided by analyses of pore waters or acid-volatile sulfide - simultaneously extractable metal (AVS-SEM) relationships do not always contribute sufficient information. The use of inappropriate or inadequate information for assessing metal bioavailability in sediments may result in incorrect assessment decisions. The technique of diffusive gradients in thin films (DGT) enables the in situ measurement of metal concentrations in waters and fluxes from sediment pore waters. We used the DGT technique to interpret the bioavailability of copper to the benthic bivalve *Tellina deltoidalis* in sediments of varying properties contaminated with copper-based antifouling paint particles. For concentration series of copper-paint-contaminated sandy, silty-sand and silty sediment types, DGT-probes were used to measure copper fluxes to the overlying water, at the sediment-water interface and in deeper sediments. The DGT-Cu concentrations (or fluxes) were shown to provide excellent concentration-response relationships in relation to lethal effects occurring to the copper-sensitive benthic bivalve, *T. deltoidalis*. The study demonstrates the strength of the DGT technique, which we expect will become frequently used for assessing metal bioavailability in sediments.

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SPECIES RESPONSES TO CONTAMINATION: INSIGHTS FROM SYDNEY HARBOUR .

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The monitoring of contaminant levels in biota is a common approach for assessing the health of our environment. The selection of biomonitoring species is, however, difficult as many variables can influence the concentrations of organic contaminants in their tissues leading poor discrimination of spatial and temporal patterns. The contamination of Sydney Harbour with dioxin like compounds created a significant contamination gradient along its length, in which 2,3,7,8 TCDD was the major component of the total TEQ. A large scale study of the concentrations of these compounds in seventeen species of fish and crustacea provided a unique data set from which we examined relationships between species and response to the spatially explicit contamination gradient. Patterns of accumulation varied along the contamination gradient but species specific responses beyond trophic influences were evident. Differences among species of different trophic level were probably typical of what may be expected but non-trophic species responses, in particular movement, strongly influenced patterns of contamination. Therefore our ability to predict outcomes for different species was affected. The results from this study has informed us about the likely behaviour of the various fish species and hence their ability to reflect the contamination gradient or integrate contaminant exposure throughout the harbour. We also have a better understanding for which species we may useful for understanding the effects of micropollutants in Sydney Harbour and similar systems.

059

WHENCE METAL ECOTOXICOLOGY? EXPLOITING INTEGRATIVE CONCEPTS

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Studies of metal contamination have evolved from different perspectives. Alliances occur among applied ecotoxicology, geochemistry, experimental biology and observations from nature. But differences in how the science is viewed through the lenses of these different disciplines are also common and explain some of the contradictions and controversies in managing metal contamination. For example, environmental quality standards for traditional chemical contaminants are largely derived from toxicity testing. But a holistic view of the state of knowledge shows instances of (sometimes severe) over-protection and under-protection among the metal regulations, although validation studies are rare. Just as important, the traditional approaches are proving insufficient for understanding implications of emerging issues like the proliferation in consumer products of metallo-nanoparticles. In this talk we suggest that as field biology, dietary exposure, model development and experimental biology push mechanistic knowledge of metal exposure and effects forward, integration among disciplines becomes more feasible. It is now increasingly accepted that exposures to metals are from both diet and dissolved forms: neither can be ignored. Knowledge of basic bioaccumulation properties and the basic mechanisms whereby organisms detoxify metals begin to explain differences in metal exposure and sensitivity among species. Long term field studies illustrate how exposure can be linked to ecological change. From such knowledge it is possible to begin to predict how metal effects will be manifested ecologically, and narrow uncertainties about the thresholds of ecological effects of metals in natural waters. This knowledge is leading an emerging generation of new ideas about contaminant management that is both practical and widely applicable.

060

ENVIRONMENTAL CHEMISTRY AND TOXICOLOGY OF ARSENIC

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Arsenic is a metalloid. In strongly reducing environments, elemental As and arsine can exist. Under moderately reducing condition, arsenite may be the dominant form whilst arsenate is generally present in oxygenated environments. Arsenic in surface and ground water is normally below 10 μg/L. Elevated concentrations of up to 100-5000 μg/L can be found in areas of sulfide mineralisation, and areas with mining and hydrothermal activities. Arsenic is the main constituent of more than 200 mineral species, of which arsenopyrite (FeAsS) is the most common form. Because of the ubiquitous nature and the toxicity of arsenic, its potential for environmental contamination from both geological and anthropogenic sources is a significant environmental concern.

Inorganic arsenic compounds are carcinogenic to humans. Chronic exposure to arsenic causes cancers involving the skin, lung, bladder, liver and kidney. Non-cancer end-points amongst others are typified by change of skin pigmentation and keratosis. Globally, it has been estimated there are over 100 millions of people at risk due to the consumption of arsenic-contaminated drinking water.

Following ingestion, inorganic arsenic is metabolised into methylated trivalent and pentavalent arsenicals in humans and most animal species. Speciation of arsenic in the contaminated matrix and its receptor organism is an important tool for toxicological and epidemiological investigations. We have utilised arsenic speciation coupled with biomarkers of effects for several studies involving humans in endemic-areas and laboratory animals. Carcinogenic effects of sodium arsenate- and monomethylarsonous acid (MMA^{III})-spiked drinking water were first demonstrated by our laboratory using a mouse model. Our data suggests that MMA^{III} is the proximal carcinogen.

JECFA evaluated arsenic in 2010 and decided to withdraw its previously set PTWI. A new benchmark dose of 2-7 μg/kg b.w. daily with a margin of exposure of 1-30 has been derived. This may have significant implications on setting future health standards.

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BIOMONITORING 2.0: GENERATING AND HARNESSING DATA ON AN EPIC SCALE FOR ECOSYSTEM ASSESSMENT

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Two late-20th century technologies - earth observation systems and the internet - have massively increased available data on the physical environment, fostering a glut of papers in glamorous journals, attempting to bring these new data sources to focus on the state of natural ecosystems. However, most stumble at the last data hurdle, on the realization that there is a fatal scale-mismatch between physical and chemical observations - which can be used to generate hypotheses about ecosystem status - and observations on biota, which must form the basis of any meaningful assessment.

Ecosystem-scale biomonitoring and both prospective and retrospective ecological risk assessment are currently limited by old-tech thinking, failing to progress from a comfort zone of one-at-a-time site-level assessments of general impairment towards the incorporation of diagnoses of causality. Statistical methods for the extraction of stressor-specific patterns from noisy environmental data exist, yet their use is restricted not just by limited quantity, but also by the patchy spatial coverage and inherently gnarly nature of biological observations.

Recent developments in genomics such as next-generation sequencing are transforming other areas of the life sciences, but their application in ecological risk assessment is limited by cost and infrastructure accessibility, and also by the 'Shock of the New' effect posed by their transformative nature. This is all about to change, however, and in this presentation, I anticipate the advent of cheap

and freely-available high-throughput sequencing, including the development of DNA-based taxonomy, illustrating their potential to transform the quantity, scale and accuracy of biological observation, through reference to specific examples from terrestrial and freshwater ecosystems.

062

MICROBIALLY MEDIATED CHEMICAL TRANSFORMATION OF METAL SPECIES IN LANDFILL LEACHATE

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Transformation of chromium, arsenic and mercury was investigated in municipal landfill leachate (MLL). This is a complex, real life matrix that contained a multitude of inorganic and organic chemicals, and a consortium of bacteria in an environment of changing pH and redox potential. Interactions among these variables provided an in-depth understanding of the role played by bacteria in transforming metal species in environment.

While hexavalent chromium (Cr^{VI}) was found to chemically reduce to less toxic trivalent chromium through a shuttle mechanism that entailed the microbial reduction of Fe^{3+} to Fe^{2+}, arsenate (As^{V}) was reduced to more toxic arsenite, demonstrating that the transformation of inorganic metal species in MLL is principally a microbially mediated redox reaction.

In contrast to the reduction of inorganic Cr^{VI} and As^{V}, the transformation of organic monomethylarsonic and dimethylarsinic species are more complex. Here, microbial conversion of sulfate to sulfide has to first occur in a reducing environment to initiate a continuous thiolation process for transforming methylated arsenic compounds into the extremely toxic thiol-orgaoarsenic species, such as dimethyldithiolarsinic and dimethyl mono thioarsinous acids. Bacterial activity also contributed to the decrease of inorganic and organic mercury concentration in the MLL solution.

In an attempt of trying to isolate which bacteria species from the consortium was responsible for the transformation reactions, metal resistant experiments were carried out using chromium, arsenic and mercury spiked MLL solutions. Bacillus species was identified, the preliminary experiments inferred that different strains of Bacillus bacteria may be involved for different metal.

This study demonstrates that the transformation of metals in MLL is critically dependent on the local environment condition at a particular time instance. Interactions between chemical and microbial processes in MLL will continuously transform metal species from its initially disposed forms. The results here have important implication for managing the disposal of metal waste.

063

RESILIENCE OF SOIL MICROBIAL FUNCTION TO A COPPER STRESS AND HEAT DISTURBANCE

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Elevated concentrations of metals in agricultural soils can adversely affect soil microbial activity. Often, concentrations of metals reported in agricultural soils are lower than those reported to have acute effects on soil microbial activity (i.e EC_{50}). However, exposure to a persistent chronic stress may affect the health of soil microbes, such as their resilience to additional transient disturbances (e.g heat). The aims of this study were to determine the soil copper concentrations adversely affecting the resilience of soil enzyme activity in soils collected from uncontaminated sites in three different wine-growing regions (to represent different soil types and climates). Bulk surface soil samples were spiked to achieve final added copper concentrations of 0, 50, 100, 200, 500, and 1000 mg/kg. Following copper aging processes, 18 sub-samples for each final soil treatment were created and half were exposed to a heat disturbance (60^{o}C, 24 hours; perturbed) whilst the other half remained unperturbed (kept at 20 – 22^{o}C). Phosphomonoesterase and urease activity were measured in triplicate samples 1, 2 and 7 days following the heat disturbance to track their recovery compared with the unperturbed sample. In the soil from regions B and C, phosphomonoesterase activity was directly adversely affected at ≥ 50 mg/kg total Cu. Urease activity was directly affected at ≥ 200 mg/kg total Cu in soil from region B. Pre-exposure to the different Cu concentrations did not adversely effect the resistance (day 1) nor the resilience (day 7) of the enzyme activities to the heat disturbance. The overall functional stability of phosphomonoesterase activity was adversely affected at ≥ 200 mg/kg total Cu in soil from region B and 1000 mg/kg total Cu in soil from region C; urease activity was largely unaffected. Overall the soil from region B (warm climate region) was more stable following the heat disturbance.

064

CELLULAR BIOMARKERS IN MICROALGAL TOXICITY BIOASSAYS - UNRAVELLING PHYSIOLOGICAL RESPONSES TO METAL EXPOSURE

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A flow-cytometric method was developed and evaluated as a rapid ecotoxicological tool to assess microalgal metabolic responses to metal exposure. A suite of staining protocols was used to assess the physiological responses of *Tetraselmis* sp. to copper exposures that induced 72-h growth inhibition of 0 (control), 50, 60 and 70%. After 24-, 48- and 72-h exposure, chlorophyll autofluorescence and DNA content were measured, and molecular probes were used to assess reactive oxygen species (ROS), mitochondrial membrane potential (MMP), the abundance of acidic compartments with cells; and reduced glutathione (GSH), using flow cytometry and confocal microscopy. Results showed copper induced changes in cell size and granularity, which was consistent with our previous findings. There was a dose-dependent response in ROS and MMP, with higher copper exposures producing significant differences in intracellular GSH and acidity. These findings will be presented and discussed in terms of algal detoxification strategies and defence mechanisms.

065

PROGRESS TOWARDS A DISSOLVED MN TRIGGER VALUE FOR SUBTROPICAL WATERS

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There is currently no Australian Water Quality Guideline (AWQG) value for dissolved manganese in the marine environment. In areas, such as Port Curtis, Queensland, elevations of manganese have been recorded in the estuarine environment; due to anthropogenic inputs, high natural manganese ore deposits, and with potential added inputs from a proposed nickel refinery, trigger values relevant to these waters are required. This project seeks to address this shortfall via manganese toxicity testing using a number of endemic organisms representative of several different trophic levels within Port Curtis. Both acute and chronic testing was conducted with wild caught and aquaculture specimens using standard or modified protocols. Results thus far demonstrate effects in the ppm range. For example, 50% growth inhibition of the microalgae *Nitzschia closterium* was found between 60-70 mg/L manganese, while acute toxicity with the tiger prawn *Penaeus monodon* revealed an EC_{50} of 54 mg/L. Further tests with other species endemic to the Port Curtis region are currently underway. The derivation of a trigger value and the implications of earlier research into the dynamics and fate of manganese in subtropical environments will be discussed, in relation to bioavailability of manganese in Port Curtis.

066

SPECIATION AND BIOAVAILABILITY OF ARSENIC ALONG THE SOIL-PLANT-HUMAN EXPOSURE PATHWAY

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Few elements have received in the last decade more attention than As. This scientific effort is largely the result of the well documented As poisoning occurrences in various parts of the world and in particular the situation occurring in West Bengal and Bangladesh. In this case the geology, hydrogeology and Quaternary sea level changes are strongly related to As contamination of groundwater. In recent years however, the attention to As has also developed in a great scientific effort in relation to the presence of this contaminant in food and in rice in particular. In this case the speciation of As plays a critical role in terms of As mobility and bioavailability in soil and the rhizosphere, plant uptake and finally in terms of As availability to humans. Various changes in As speciation occur along the soil-plant-human exposure pathway that ultimately are relevant in terms of human health. Briefly in the case of rice, geogenic or introduced As species partition in the soils as a function of soil mineralogy, pH and redox potential. Environmental conditions also influence As speciation. Under anaerobic conditions in paddy soils arsenite dominates. However, in the rhizosphere of rice an aerobic region is present where a Fe plaque is formed. Recent findings have demonstrated that the uncharged arsenite is taken up by rice through the same transporters responsible for silicic acid uptake. In the plant arsenite can then be complexed by phytochelatines or methylated. These As species have different mobilities within the plant in addition to different rates of translocation, uploading and distribution in the seed. Also, animal studies have demonstrated that the bioavailability of As is species specific. This contribution will elucidate, through the results of biological and spectroscopic studies, the role of speciation and availability in this complex exposure pathway.

067

SPECIES SENSITIVITY DISTRIBUTIONS: HOW THEY CAN BE IMPROVED?

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Species sensitivity distributions (SSDs) are cumulative distributions of species' physiological sensitivity to toxicants. An attractive attribute of SSDs is that they allow the severity of a particular concentration of a chemical to be estimated in terms of the potentially affected fraction of species. The severity of a pollution event is a critical component of risk: the severity of an undesirable event and the probability that it will occur. However estimates of the potentially affected fraction of species from SSDs are contingent on several assumptions that are unlikely to be met in conventional uses of SSDs. Recently various novel experimental, field and/or statistical methods have been suggested that will result in SSDs that better meet their assumption. At the same time there is growing recognition that physiological sensitivity of species to toxicants (as measured in laboratory tests) is only one aspect which will influence the response of populations to toxicants. Modelling a species' population will provide better estimates of the likely effect of chemicals on its populations but is unlikely to be feasible for a large and representative sample of species from environments/regions of interest. The combining of resilience traits (e.g. generation time and dispersal capacity) and an avoidance trait (e.g. spending a significant part of the life-cycle removed from the contamination) and physiological sensitivity has proven very useful in developing biological indexes that can indentify community level impacts from specific classes of chemicals. Here we examine how these traits might be combined with physiological sensitivity to make SSDs that describe both types of sensitivity and review suggested developments to SSDs. We conclude that there are modifications that will improve the use of SSDs but that their widespread adoption is not a purely technical issue.

068

SALINITY RISK ASSESSMENT: COMPARING GUIDELINE SPECIES SENSITIVITY DISTRIBUTIONS WITH SINGLE-SPECIES STUDIES.

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Freshwater salinisation is a global issue with deleterious environmental consequences that are difficult to remediate. Water quality guidelines and risk assessments recommend the use of Species Sensitivity Distributions (SSDs), commonly with the aim of protecting 95% of species. SSDs generally use laboratory derived toxicity data to compile a plot of species response to a given toxicant. From the use of a rapid approach to lab based toxicity testing there now exists salt toxicity data for >150 eastern Australian freshwater macroinvertebrate taxa. Using macroinvertebrate sensitivity data derived from rapid toxicity methods and extrapolations to related species, we conducted a salinity risk assessment on the Hunter River catchment, NSW. A SSD consisted of 432 toxicity values represented by the species of over 240 different genera expected in the catchment. A safety factor of 20% was calculated from sub-lethal and chronic toxicity data and applied to the SSD. The concentrations at which *p*% of the macroinvertebrate community are expected to be at hazard (HC_p) was estimated to be 0.85, 1.7 and 3.1 g/L for p=1, 5 and 10 respectively. We then selected a salt sensitive (*Austrophlebioides pusillus*) and a salt tolerant (*Paratya australiensis*) macroinvertebrate to experimentally estimate protective salinity values. Laboratory tests investigated osmoregulatory responses to salinity. For *P. australiensis* an increase in external salinity corresponded with an increase in haemolymph salinity. *A. pusillus* were strong osmoregulators. Direct transfer to salinities of 1, 2 and 4 g/L had no effect on haemolymph salinity. However, these mayflies could not withstand environmental salinities nearing their internal salinity. Our final results will compare protective levels based on results of sub-lethal salt toxicity experiments to protective levels derived from SSDs. This study proposes a risk assessment technique using current data, and a salinity threshold value which aims to protect freshwater biodiversity.

069

THE POSSIBLE THREAT OF LEAD POLLUTION FROM ATMOSPHERIC DEPOSITION IN TOWNSVILLE

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Some concerned members of the local community of Townsville living downwind of the industrial area surrounding the Port of Townsville have conducted their own, privately-funded field study at ten sites of the deposit of atmospheric black dust and its heavy metals. These people feel threatened by this dust both from a quality of life perspective and from a health/toxicology perspective. This study revealed that the black dust apparently has very little organics and the smooth, sometimes nearly spherical, shape of the particles, suggests an industrial origin (e.g. grinding?). The plume spread several km over Townsville City and North Ward during tradewinds and the plume shape was consistent with a source in the industrial area and with the heaviest particles most loaded with heavy metals to deposit first. The black dust deposits had concentration of particulate Pb, Cu, and Zn, but not Ni, well above that of legally hazardous soils, and the particulate lead concentration exceeded that in the black dust of Mount Isa. At one house in the city, particulate Pb concentration greatly exceeded that limit for all samples for five years. Queensland DERM has conducted a similar

study at two sites in the plume. Queensland Health has provided medical advice on human health risks based on the DERM study, suggesting a possible yearly Pb accumulation in infant's blood of 3 µg Pb/100 ML based on Lead concentration, and 1 µg Pb/100 ML based on Lead fallout rate. The safe Health level is 10 µg Pb/100 mL of blood based on the National Health and Medical Research Council. This suggests a hypothetical Pb biological accumulation time scale of 3.3 and 10 years for infants for dirty and clean households, respectively. This study reflects only the views of the author.

070

RISK ASSESSMENT AND ECOTOXICOLOGY -SOCIAL AND SCIENTIFIC CONTEXTS RELATED TO THE OCEAN DISPOSAL OF MINE WASTE.

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The use of ecotoxicology in envrionmental risk assessment is a constantly developing field and efforts have been made to establish standard toxicity tests for many specific environments. Some less studied environments include tropical and in particular tropical marine envrionments. Furthermore, there are significant challenges associated with developing toxicity tests and risk assessment assoicated with impacts on ecosystems in deep water (i.e. those beyond current SCUBA capabilities).

Mining is an important contributor to the economy of many developing tropical regions and many mines are in countries with island geographies which tend to look at the marine envrionment as a depository for mine waste. Assessment practices are often limited by budjets and timeframes and the development of relevant risk assessment methods can be challenging. In deeper marine envrionments sampling is difficult and there is often a lack of recognition of the high diversity and the interactions betwen deeper water and shallow waters.

This paper reviews the development of tropical marine ecotoxicology and, with the use of case studies, explores risk assessment practices in social and scientific contexts associated with mine waste disposal in marine environments.

071

ENVIRONMENTAL RISK ASSESSMENT OF CHEMICALS FOR CHEMICAL REGULATORS

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The Australian Government Department of Sustainability, Environment, Water, Population and Communities' (DSEWPaC) Chemical Assessment Section (CAS) is contracted by two of Australia's chemical regulators, the Australian Pesticides and Veterinary Medicines Authority (APVMA) and the National Industrial Chemicals Notification and Assessment Scheme (NICNAS), to undertake the environmental risk assessment of new and existing chemicals for consideration in the overall assessment carried out by NICNAS and the APVMA.

The presentation outlines the published National Environmental Risk Assessment frameworks for industrial chemicals and agricultural and veterinary chemicals, and provides an insight into the steps taken by CAS in undertaking environmental risk assessments. Topics to be covered include the processes on:

1. Data evaluation including the use of analogue, Quantitative Structure Activity Relationship and international data and subsequent data reliability assessment
2. Environmental exposure assessment, including use of spray drift, run-off and sewage treatment plant modelling
3. Environmental risk characterisation and interpretation of risk quotients
4. Environmental risk management options

If time permits the presentation will also cover the assessment of Persistent, Bioaccumulative and Toxic (PBT) substances, and the related international obligations under the Stockholm Convention on Persistent Organic Pollutants (POPs).

072

TOXICITY OF MAGNESIUM PULSE EXPOSURES TO TROPICAL AUSTRALIAN FRESHWATER BIOTA

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Continuous monitoring of electrical conductivity (a surrogate for magnesium (Mg)) in Magela Creek downstream of the Ranger Uranium Mine in northern Australia has provided an understanding of the behaviour of this solute in the receiving environment. During pulse events, Mg concentrations have occasionally exceeded the provisional site specific trigger value (TV) for Mg in the creek. However, these pulses occur over only minutes to hours, while the TV is derived from continuous ecotoxicological exposures of three to six days.

The toxicity of 4-, 8- and 24-h duration Mg pulse exposures was assessed for six tropical freshwater species (alga, macrophyte, cladoceran, hydra, gastropod and fish). Additional tests were conducted using the cladoceran to investigate the importance of the life-stage at which the pulse exposure occurred.

For most species, toxicity decreased with a reduction in exposure period (eg. IC50s for hydra of 919, 1045 & 1651 mg/L Mg for exposure durations of 24-, 8- & 4-h respectively; Continuous exposure IC50 = 679 mg/L). The fish were insensitive to all pulse durations tested.

The degree to which toxicity was reduced by a shorter duration exposure was species-specific. For example, based on IC50s, an 8-h Mg pulse was 29% less toxic than a 24-h exposure for the macrophyte whilst for the hydra the reduction was only 12%.

The life-stage at which the cladoceran was exposed was found to strongly influence the response. A 4-h exposure administered when the cladocerans reached reproductive maturity (27h old) was ~four times more toxic than when the cladocerans were exposed at ~3-h of age. A similarly sensitive response was found for a 24-h pulse exposure started at ~3-h of age.

The data were used to derive Mg TVs for each pulse duration using species sensitivity distributions. The development and application of a TV/exposure duration relationship will also be discussed.

073

CLADOCERAN BEHAVIOUR AS A SENSITIVE INDICTOR OF WATER CONTAMINANTS: THEIR POTENTIAL USE IN A BIOLOGICAL EARLY WARNING SYSTEM

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Early warning and prevention of toxic and potentially harmful substances in source and drinking water supplies is important. The detection of episodic pulses of chemical and biological hazards is critical to minimise environmental harm. As most of these pulse events are short term, conventional approaches to detection often miss or have significant delayed response times. Continuous real time monitoring systems utilising crustacean Cladocerans, such as *Daphnia magna*, have been developed as rapid tools for inline treatment plant monitoring. This approach provides a detection system based on deviations from normal behaviour patterns used to trigger a series of early warning/alarm responses for which action can be taken. To date this approach has not been trialled with native Cladoceran species or in evaluation of the quality of local water supply. As an initial feasibility study, behavioural responses of *Daphnia carinata* exposed to key water contaminants were monitored using digital image detection equipment. The images from exposure aquaria were compared to control patterns of movement using vicinity based fuzzy similarity analysis. Results indicated that altered behaviour could be detected in less than 30 minutes for some parameters (e.g. Copper, pH) while others took longer or showed no behavioural change. In comparison to standard toxicity testing methods, it has been shown that video image analysis has sufficient resolution and sensitivity for observing and detecting changes in Cladoceran behaviour and therefore provides a more sensitive test approach. The advantages and limitations of this technique will be discussed with recommendations made for the feasibility of the use of native Cladocerans in early warning systems.

074

DO PESTICIDES IN VICTORIAN FRESHWATERS AFFECT MICROALGAE: DEVELOPMENT AND VALIDATION OF A MICROALGAL BIOASSAY.

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Toxicity tests with microalgae are playing an increasing role in the assessment of the environmental impact of pollutants. Algae are the foundation of most aquatic food chains and constitute a major component of non-target organisms at risk from pollutant impacts. Algae are known to be comparatively sensitive to many chemicals, and their inclusion in test batteries has shown to improve the capacity to predict the most sensitive ecosystem responses. Due to these points, a microalgal growth and photosynthesis inhibition bioassay, using the green alga *Scenedesmus sp*., was developed and incorporated into the battery of freshwater assessment tools used by the Victorian Centre for Aquatic Pollution Identification and Management (CAPIM). The bioassay has been used to assess the acute toxicity of a number of agricultural pesticides, including the herbicides atrazine and simazine and fungicides myclobutanil, pyrimethanil and trifloxystrobin. CAPIM surveys undertaken during 2009-10 have consistently reported these three fungicides and two herbicides in Victorian freshwater systems. While the toxicity of the herbicides to microalgae has been investigated, little to no work has been undertaken on the effects of these fungicides. Inhibition of both endpoints was greatest when *Scenedesmus sp*. was exposed to atrazine ≥simazine>trifloxystrobin>pyrimethanil >myclobutanil. While the herbicides were similar in toxicity to both endpoints, only the fungicide trifloxystrobin showed toxicity to both photosynthetic efficiency and growth. Both myclobutanil and pyrimethanil were less toxic to photosynthetic efficiency compared to growth showing the importance of using multiple endpoints for toxicity assessment. The bioassay has also been validated in the field by incorporation into the freshwater assessment program of CAPIM. A number of samples from various catchments across Victoria shown to have high levels of agricultural pesticides were examined for toxicity using the *Scenedesmus sp*. bioassay. Results of pesticide tests and field assessments will be discussed.

075

DEVELOPMENT OF OXIDATIVE RESPONSE ASSAYS TO MEASURE STRESS IN DUCKWEED (*LEMNA DISPERMA*)

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The levels of reactive oxygen species (ROS), such as hydrogen peroxide, are increased in plants in response to external stressors. Plants have developed a range of mechanisms to control and detoxify ROS; both enzymatic (e.g. catalase and several peroxidises), and low-molecular weight compounds (e.g. thiols such as glutathione). Evidence of an elevated antioxidant response can thus act as a biomarker of plant stress. Different patterns of enzymes are induced in response to different stressors, therefore it is desirable to measure a suite of responses.

This study aimed to develop a suite of assays using the small aquatic plant, *Lemna disperma*; with $CuSO_4$ as a reference toxicant. Plants were exposed for up to four days in culture solution. The tissues were then homogenised and centrifuged to provide a particulate-free preparation which was used as the crude enzyme extract. Sample volume was adjusted based upon total protein levels.

Our first success has come with tissue peroxidase activity. To date, published assays for tissue peroxidase have principally relied upon conventional spectrophotometric assays. To increase efficiency (i.e. increased rate of throughput, reduced sample size and quantity of reagents required for the assays), we have developed and optimised the assay for a microplate platform.

While we initially used 2,2'-Azinobis[3-ethylbenzothiazoline-6-sulfonic acid] (ABTS) as a substrate, this was unsuitable as the response was non-linear, with an initial lag phase, possibly due to some interfering compound not thought to be of the phenolic type. Subsequently we have used *o*-phenylenediamine (OPD) where the reaction is rapid and linear from time zero. Changes in OPD-dependent tissue peroxidase activity in response to a range of copper concentrations have been compared to macro changes (e.g. frond number and area) in the same specimens.

We have now commenced optimising assays for catalase, ascorbate peroxidise and total thiols.

076

VARIATIONS IN TOLERANCE TO ATRAZINE FOR THE CANE TOAD, *RHINELLA MARINA* AT DIFFERENT LARVAL DEVELOPMENTAL STAGES

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Atrazine is one of the most widely used herbicides in Australia and commonly detected in surface and ground waters. According to overseas studies atrazine has well documented adverse effects on amphibians, particularly at the aquatic larval stages. Studies on atrazine toxicity to amphibians are very limited in the Australian environment. Moreover, there are significant knowledge gaps on pesticide sensitivities to different amphibian larval developmental stages.This study investigated the survival and swimming behaviour of different larval developmental stages of the introduced cane toad, Rhinella marina to atrazine. Test design involved a series of 96-h static exposures of six different cane toad larval stages including Gosner stages (GS) 22-23, 25-26, 28-29, 32-33, 36-37 and 40-41 to six concentrations of atrazine ranging from 0 - 24mg/L. Results so far showed that the early larval developmental stages were more tolerant to atrazine toxicity compared to later larval developmental stages both in swimming behaviour and in survival. EC_{50} was 20.76mg/L and 24.39mg/L for GS 22-23 and 25-26, respectively, whereas, EC_{50} was 15.04mg/L and 8.50mg/L for GS 28-29 and 36-37, respectively. This difference in sensitivity to atrazine exposure may be due to greater biochemical and hormonal activity, thus, making the timing of exposure critical to the response observed. Further testing is underway and implications of exposure pathways will be further discussed.

077

ECOTOXICOLOGY & CLIMATE CHANGE: USING A SEA URCHIN FERTILISATION BIOASSAY TO ASSESS COMBINED EFFECTS OF CLIMATE CHANGE AND POLLUTION.

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Marine ecosystems are facing dramatic changes as a result of climate change. Changes in the physicochemical parameters of seawater systems, as a result of climate change, can potentially alter a number of factors that determine toxicity of any given pollutant. For marine systems, it is accepted that the world will contain warmer, more acidic oceans under future climate change conditions. These changes alone (increased temperature and/or decreased pH) have been shown to influence survival, development and reproduction for a number of marine species. But such effects have always been in clean, uncontaminated waters. The reality is that many marine species, particularly near-shore species, will face the effects of changes in seawater physicochemistry in combination with toxicant stress. Additionally, the changes in seawater chemistry may alter the toxicokinetics of marine pollutants in such a way that may result in synergistic effects of climate change and pollution. Here, we present an overview of how global climate

change may influence the field of environmental toxicology and chemistry and discuss results from an investigation where the well-established sea urchin bioassay was performed under a number of different future climate change scenarios.

078

THE EFFECT OF SEAWATER TEMPERATURE ON SEA URCHIN SPERM VIABILITY

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Many marine invertebrates reproduce by broadcast spawning, where their gametes are released into the water column with fertilisation taking place externally. It has been hypothesised that the slight increases in seawater temperature and pH predicted by climate change research, may have adverse effects on the viability of the gametes of broadcast-spawning species. To evaluate this, the viability of sea urchin (*Heliocidaris tuberculata*) sperm was assessed under several predicted temperature scenarios from 18 to 26°C) . Using measures of fertilisation success, it was found that s perm viability decreased at a significantly faster rate at higher seawater temperatures than at current average seawater temperature. It is theorised that this is due to increased sperm mitochondrial activity at higher temperatures. To confirm this, mitochondrial activity and membrane permeability of the sperm were assessed by flow cytometry using the fluorochromes propidium iodide (PI) and rhodamine 123 (Rh123). The implications of this research for broadcast spawning organisms will be discussed with reference to the predicted changes in seawater temperature.

079

THE EFFECT OF CONTAMINANTS ON MAXIMUM THERMAL TOLERANCE LIMITS OF AQUATIC INVERTEBRATES

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Climate change induced by anthropogenic warming of the earth's atmosphere is proceeding more rapidly than previously predicted. In Australia, sea level rise, increasing drought, more frequent extreme events and impacts from increasing ocean temperatures and acidification on marine biota are predicted. These climate change scenarios have the potential to alter the environmental distribution of contaminants, together with contaminant exposure and toxicity, rendering an organism more, or in some cases less, susceptible to contaminants. Conversely, contaminants can act as an additional stressor, increasing the organism's susceptibility to environmental factors such as decreasing thermal tolerance of biota. While previous studies have focused on investigating the varying sensitivity of organisms to contaminants at a range of temperatures, this study investigates the effect of contaminants on the thermal tolerance (tipping point) of aquatic biota. Tropical organisms already living near their thermal tolerance limits are believed to be more susceptible to small increases in temperature and exposure to additional stressors such as contaminants could have significant consequences to biota diversity. Two aquatic invertebrates were selected for this study, the tropical marine copepod *Acartia sinjiensis* and the temperate freshwater cladoceran *Ceriodaphnia dubia.* Invertebrates exposed to low concentrations of contaminants (< EC50 value) for 24 h at standard test temperatures were subjected to incremental increases in exposure temperature (e.g. 1 °C/30 min) and the number of mobile invertebrates recorded at 30 min intervals until all invertebrates were dead or immobilised. For *C. dubia*, increases in copper concentrations from 4 to 6 µg Cu/L resulted in a significant reduction in the organism's ability to survive at high temperatures with the thermal tipping point decreasing by about 1 °C. The effect of copper on the thermal tolerance of tropical copepods will also be presented.

080

STRESSOR INTERACTIONS: SYMBIONT-SPECIFIC RESPONSES OF MARINE INVERTEBRATES TO PSII HERBICIDES AND HIGH TEMPERATURE

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Stressor interactions are one of the key challenges in environmental risk assessment. Our research focuses on the negative effects agricultural herbicide residues may have on symbiotic reef species and how this may impact resilience to other stressors, e.g. global climate change. Previous research into the effects of herbicides on coral reef organisms has primarily yielded single dose-response relationships and focused on limited target organisms (reef building corals). We aim to contribute to the development of threshold values by investigating a wider range of target organisms, associated symbiont types and stressor interactions. A series of laboratory studies examined the potential of stress caused by low concentrations of photosystem II herbicides to impact upon the thermal thresholds of corals and several foraminiferan species, hosting multiple microalgal phyla. Overall, additive adverse effects were observed, supporting the hypothesis that environmentally relevant concentrations of chemical stressors may intensify adverse effects of thermal stress at projected climate change scenarios.

081

COPPER REDUCES THE RESILIENCE OF CORAL LARVAE TO THERMAL STRESS

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Elevated sea surface temperatures (SST) pose significant risks to the health and survival of both adult and larval corals. Successful larval recruitment is crucial for maintaining coral populations and is particularly important to the recovery of degraded reefs following events such as bleaching, storm and pollution. Whilst improving water quality through land management practices is a primary strategy to maximise the resilience of corals to a changing climate, there is little direct research to support the efficacy of this approach. Here we quantified how increased SST and copper (Cu) contamination influence the metamorphosis of larvae of two common broadcast-spawning coral species, *Acropora millepora* and *A. tenuis*. This study resulted in a fully parameterised model of larval metamorphosis success that incorporated both the influences of Cu and SST. A s ynergistic interaction was identified between Cu concentration and SST: increasing temperatures resulted in larval metamorphosis being inhibited at lower Cu concentrations and Cu contamination reduced the thermal tolerance of coral larvae. Although *A. millepora* larvae were more sensitive to both stressors, very similar patterns were observed for both species indicating that Cu and SST are likely to have similar inhibitory effects on larval metamorphosis for corals in general. Limiting contamination therefore has the potential to increase the resilience of coral populations to hyperthermal stress. For example, halving the concentration of Cu can protect larval metamorphosis from the negative effects of a 2 – 3^{o}C increase in SST. These results provide empirical support for reef management practices that attempt to improve coral resilience to climate change by improving water quality.

082

USE OF THE MAM-PEC MODEL TO PREDICT ANTIFOULANT CONCENTRATIONS IN NEW ZEALAND PORTS AND MARINAS

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Antifouling paints are essential to marine vessels, to minimise biological growths, reduce drag and the risk of transporting exotic pest species. However, many active compounds in antifouling paints can have adverse effects on non-target organisms. The effect of low concentrations of TBT on marine gastropods is a good example of this. Risk assessment of currently used and future antifouling compounds requires estimates of their environmental concentrations. A model was developed by Deltares|Delft Hydraulics and Institute for Environmental Studies to predict environmental concentrations of antifouling compounds leaching from painted vessels in marinas, ports, shipping lanes and the open sea, based on the environments, number and size of vessels and the chemical characteristics of the antifouling compounds.

This model has recently been applied to New Zealand ports and marinas, to predict concentrations of two commonly used antifouling compounds: diuron and copper. Data was collected on the dimensions, background water quality and flushing characteristics of each port or marina, and the number of vessels using each marina or port. Diuron and copper concentrations were predicted for 11 ports and 12 marinas to identify those with the highest concentrations. The model predicts copper concentrations can vary by about 40 times between different ports and marinas, and exceed water quality guidelines in most marinas (by up to 7x). The predicted concentrations were compared to measured concentrations where data was available to validate the model. For copper, this showed the importance of other sources of antifouling paints, such as runoff from boatyards. Measured diuron concentrations were much lower than predicted, however, more data is needed on the prevalence of antifouling paints using diuron. The mass loads of antifouling compounds leaching from paint on vessels is predicted to be much more than loads discharged from dry dock and boat yard operations (paint application, removal and maintenance).

Key words: model, antifouling, risk assessment, stressors

083

RISK ASSESSMENT OF SOILS AND SEDIMENTS FOR CLOSURE PLANNING AT RANGER URANIUM MINE

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Energy Resources Australia's Ranger uranium mine is located ~ 250km east of Darwin in the wet and dry tropics of northern Australia. As part of the mine's water management strategy, and in accordance with strict regulatory requirements, certain water streams are released from site via natural wetlands, constructed-treatment wetlands or have, over the last twenty years, been irrigated onto natural woodland on the mine lease. Consequently, the aquatic sediments and woodland soils in these authorised Land Application Areas exhibit a range of uranium, radionuclides and heavy metal concentrations.

Monitoring of surface and ground water, sediments and soils has occurred throughout the life of the mine, about 30 years, with numerous research projects to characterise and assess the nature of uranium and heavy metals in aquatic systems and soils at and adjacent to Ranger mine.

ERA, in collaboration with stakeholders, is in the process of developing closure criteria and rehabilitation plans for the site. To support development of these plans and criteria reviews of previous research findings and data and new studies have been undertaken.

The results of historical and recent work, including; metal concentrations in soils and aquatic sediments before and since wetland treatment, land application and mine water release; observations of uranium partitioning in aquatic sediments; spatial and temporal profiles of total and leachable fractions in treatment and natural wetland sediments; chemical and radiological assessments of soils in land application areas; and plans for future work, will be discussed in this presentation.

084

A RISK BASED APPROACH TO RADIO-ECOTOXICITY

F. Harris

Radiological protection has historically been based on the protection of human kind. The accepted philosophy was that if every individual of the human population was protected against both deterministic and stochastic effects than the general environment would also be protected. However, concerns over both sensitive organisms and receiving environments where there was no human receptors lead to a reconsideration of this accepted paradigm.

In the 2007 Recommendations of the International Commission for Radiological Protection (ICRP 103), the Commission stated that it "*also believes that it is necessary to consider a wider range of environmental situations, irrespective of any human connection with them*". In 2008 the Commission published guidance on the use of reference plants and animals to assess the radiological risk to the environment (ICRP 108). A number of international models and assessment tools have been developed to assist in this assessment of radiological risk to the environment. These recommendations and tools are now being incorporated into the determination of radiological exposure and public environmental impact assessments. With respect to uranium mining, the findings to date have confirmed that the radiological risk to the environment is extremely small and far lower than the risk associated with more conventional toxins (such as metal salts) and other ecological risks such as weed infestations.

085

SEDIMENT RISK ASSESSMENT: USING THE EXPOSURE-DOSE-RESPONSE PARADIGM

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The use of exposure-dose-response data in undertaking the risk assessment of metal contaminated sediments is presented. Three approaches, laboratory microcosms using (1) spiked sediment or (2) contaminated sediments collected from an estuary and (3) transplantation of sediment dwelling organisms into a metal contaminated estuary are illustrated and their role in risk assessment described. Factors influencing the choice of organism and measurement parameters are discussed. For metal exposure assessment, alternatives are: measurement of total metal sediment concentration; or a bioavailable metal fraction. For metal dose alternatives are: measurement of total tissue bioaccumulation; or the biologically available metal fraction. For organism response, a range of biomarkers or whole energy measurements can be made. The choice of response measurements should represent a suite of biomarkers to demonstrate cascade of effects, so allowing a weight of evidence approach in interpretation of adverse effects.

086

MARINE POLYCHAETE RESPONSES TO ELEVATED LEVELS OF METALS CAN BE DETECTED IN THE TRANSCRIPTOME AND PROTEOME

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Polychaete worms are an important part of marine ecosystems and are considered good surrogates for macrobenthic community diversity (Olsgard and Somerfield 2000). Polychaetes are often used as indicators of marine pollution because of their prevalence and functional significance (Chariton et al. 2006; Fielman et al. 2000), however we know little about how polychaetes survive in these environments. More specifically, we do not know what genes or proteins are activated in response to exposure. To start to address this, we collected *Ophelina* sp.1 (Opheliidae) from sediment with high levels of copper resulting from treatment for a black striped mussel outbreak in 1999 (Ferguson 2000). The same species was also collected from unimpacted sediment. We sought to measure metal accumulation in the worms and investigate changes in gene and protein expression. We sequenced the transcriptome of polychaetes from impacted sediment and identified changes in gene expression relative to the transcriptome of worms from unimpacted sediment. Genes coding for general stress responses, oxidative stress responses, metal transport, calcium-binding and cytoskeletal reorganisation were significantly different at the impacted site. We also measured changes at the proteomic level and many of the transcriptional changes were also observed in the proteome. This dual approach has provided a lead in our understanding of heavy metal resistance in polychaetes, and we now have a greater field of candidate indicator genes for future biological assessment tools.

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087

CAN METABOLOMICS IDENTIFY CHEMICAL-SPECIFIC CHANGES IN *CHIRONOMUS TEPPERI* LARVAE EXPOSED TO METAL AND NON-METAL CONTAMINANTS?

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Metabolomics can be defined as the analysis of the complement of small molecules associated with metabolism. Metabolic profiles can be used to investigate the underlying biochemical response of an organism following exposure to chemical or non-chemical stressors. The aim of the first experiment was to establish whether metabolomics techniques (Nuclear Magnetic Resonance spectroscopy (NMR)) could measure the metabolic profile of third instar *Chironomus tepperi* larvae. Results showed that a suite of metabolites in *C. tepperi* larvae could be measured, such as pyruvate, valine and histidine, from a number of biochemical pathways. A second study was conducted to investigate whether metal-specific changes in the metabolic profile of *C. tepperi* larvae could be identified following exposure to metal and non-metal contaminants. Third instar *C. tepperi* larvae were exposed to two sub-lethal aqueous concentrations of zinc chloride, copper sulphate and ammonium chloride for 24 hours. Larvae were sampled after 2 and 24 hours exposure. These exposures were repeated three times to ensure there was enough tissue for the analyses (based on results from the pilot study). There were three replicates per treatment, per period. Controls (artificial water) were sampled at 2 and 24 hours exposure and at the start of the experiment. Changes in the metabolite profile following exposure to metals and non-metals are linked to the different mechanisms of toxicity of these chemicals. The value of this technique for identifying pollution impacts on aquatic ecosystems and understanding the mechanistic basis of pollution responses will be discussed.

088

SYNCHROTRON X-RAY MAPPING OF BIO-ACCUMULATED METALS IN A TROPICAL SPONGE

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The marine sponge *Spheciospongia vagabunda* from Darwin Harbour contains high metal concentrations (dry weight): Co (≈140 ppm), Cd (≈100 ppm), Fe (≈4,000 ppm), Ni (≈1,400 ppm) and Zn (≈800 ppm) in spite of near-pristine metal levels in sediment and seawater. Metal levels in *S. vagabunda* greatly exceed those of several other sponge species in Darwin Harbour (Padovan et al., in review).

Bio-concentration factors for Co, Cd, Fe, Ni and Zn in *S. vagabunda* tissue were $\approx 10^6$-10^7 relative to 0.45 µm filtered seawater and for Co, Cd, Ni and Zn were $\approx 10^1$-10^3 relative to sediment, suggesting a highly effective metal uptake mechanism in *S. vagabunda*. Inter-site differences in sponge metal concentrations are likely related to differences in sediment texture and metal availability.

Mapping of Co, Cr, Fe, Mn, Ni and Zn concentrations in sponge tissue was carried out at the Australian Synchrotron using the X-ray fluorescence microprobe (XFM) beam line at a resolution of 2 µm. A Maia 384 silicon detector array (Ryan et al. 2010) allowed for high count rates and rapid mapping of large areas (approximately 1 M pixels per hour in this experiment). Detection limits were in the range 20-40 ppm for a 100 μm^2 area. Cadmium could not be analysed in this experiment.

Quantitative mapping showed that Co, Fe, Ni and Zn were often localised in highly concentrated 'hotspots' of (semi-) circular clusters up to 200 µm in size or, in linear seams several 100 µm in length adjacent to tissue water canals. A close correspondence of Co, Fe, Ni and Zn 'hotspots', suggests that a common mechanism is responsible for accumulation of these metals in *S. vagabunda* . The distribution pattern of 'hotspots' is similar to that of zooxanthellae reported in other sponges and we speculate that these dinoflagellates may be responsible for the metal accumulation in *S. vagabunda* . In contrast, Cr and Mn contents were highly dispersed throughout the tissue, mainly in small areas a few microns in size. These areas may represent small embedded inclusions of sediment grains.

Further research is focused on coupling metal microanalysis to ultra structural features and molecular microbial community identification, to further investigate the mechanism of metal accumulation in *S. vagabunda.*

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089

INDUCTION PROFILE OF POTENTIAL METAL RESPONSE GENES IN *CHIRONOMUS TEPPERI*

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Metal contamination in aquatic ecosystems, often due to anthropogenic activities, can be toxic to aquatic organisms. Because the bioavailability and toxicity of metals is influenced by environmental parameters, biomarkers reflecting the stress that organisms experience can be useful for monitoring the effect of metals in aquatic ecosystems. Recent advances in genomics and ever expanding databases have provided opportunity to isolate potential biomarker genes in species relevant to ecotoxicology. In this study, we isolated seven potential metal response genes previously unidentified in the chironomid, *Chironomus tepperi*. Expression of these genes was then measured during 24 h exposure to low and high sublethal concentrations of copper, cadmium and zinc. The isolated genes are known to be involved in oxidative stress, protein repair/breakdown and detoxification pathways. The regulation of genes varied in response to time, metal and concentration. One gene showed potential as a sensitive biomarker to all metals. Another was dose dependant between low and high metal concentrations. Four other genes responded differently to each metal, changing in both direction and magnitude of expression. These four genes offer potential opportunities to quantify the level of stress or identify specific stressors. The last isolated gene showed little response to metals and may not be useful in identifying metal stress. We have therefore identified a number of genetic biomarkers that might be useful for detecting metal stress in the environment. Changes in expression across multiple genes provide a convincing picture of organism stress and more genes will be investigated to further strengthen this research.

Keywords molecular biomarker, time course, kuzbanian, glutathione S-transferase, heat shock protein70, alpha-tubulin, super oxide dismutase, cytochrome P450, glutathione synthetase

090

DEVELOPMENT OF A NEW AND NOVEL SUB-LETHAL TOXICITY TECHNIQUE USING THE UPSIDE-DOWN JELLYFISH, *CASSIOPEA* SP.

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Jellyfish, due to their perceived tolerance to poor environmental conditions, have not previously been used as an indicator species in marine ecotoxicology. *Cassiopea* sp. is an atypical jellyfish in that it normally rests aboral side up on the bottom of shallow coastal lagoons, marine lakes etc. It also possesses symbiotic *Symbodinium* sp. zooxanthellae within its tissues. Here we describe a new and novel technique for a 7-day chronic test using *Cassiopea* sp. medusae. Using a mini-PAM, we measured electron transport activity daily in animals exposed to different metal concentrations in seawater. Post- testing, zooxanthellae concentrations were determined in the tissues and compared to electron activity. The results show that these techniques may be useful for measuring sub-lethal responses to metals in photosynthetic species and that *Cassiopea* sp. has potential as an indicator species in tropical & sub-tropical marine environments.

091

TEMPERATURE-DEPENDENT PHYSIOLOGICAL RESPONSES OF THE MARINE MEDAKA *ORYZIAS MELASTIGMA*: IMPLICATION ON POLLUTANT RESPONSES AT THERMAL EXTREMES

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According to the latest report of Intergovernmental Panel on Climate Change (IPCC), there will be increasing incidence of extreme temperature events worldwide due to the anthropogenically driven climate change. Most aquatic animals are ectothermic and their metabolism is highly temperature-dependent. At both high and low temperature extremes, aquatic ectotherms are expected to face a mismatch in energy demand, and eventually become more vulnerable to other stressors such as chemical pollutants. This study aims to gain better understanding on the effects of temperature on the marine medaka fish *Oryzias melastigma* through measurement of oxygen consumption rate (OCR) and heat shock proteins (HSPs) expression. Thermal acclimation was conducted in both acute and chronic stepwise manners; the experimental temperature was either increased or deceased by 1°C/10 min and 2°C/day, respectively. The results showed that OCR was relative low from 26 to 30 °C and gradually increased and peaked around 24°C and 36-39°C. Their OCR reduced when the temperature was further increased or decreased. At the thermal extremes, the fish might have switched to anaerobic respiration for compensating the mismatched energy demand. Also, a significant up-regulation was recorded at 10, 15, 32 and 38°C for HSP 70 and at 10 and 38°C for HSP 90. The over expression of these molecular chaperones represents a stress response to protecting the cellular structure and function at the thermal extremes. It is deduced that overall energy reserve will be depleted at such stressful conditions because the animal needs energy to synthesize functional proteins such as HSPs. Given that detoxification is also energy demanding, further exposure to chemical toxicants at the thermal extremes probably worsens the situation and hence

increases the chemical toxicity to the fish. In this presentation, we will share our latest findings about the combined effect of thermal extremes and selected pollutants on *O. melastigma*.

092

HERBICIDES INCREASE THE VULNERABILITY OF CORALS TO HIGH SEA SURFACE TEMPERATURE

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In order to examine the potential interactive pressures of local pollution and global climate change, we exposed corals and crustose coralline algae (CCA) to three agricultural photosystem II (PSII) herbicides at four temperatures (26°C - 32°C). The coral Acropora millepora was 3- to 10-fold more sensitive to the three herbicides than the CCA Neogoniolithon fosliei. While the photosynthesis of CCA was not affected by the herbicide concentrations used (< 1 μg L-1), temperatures of 31°C and 32°C alone significantly inhibited photosynthetic efficiency (ΔF:Fm′) and caused chronic photoinhibition (reduced Fv:Fm) and substantial bleaching. Environmentally relevant concentrations of each herbicide increased the negative effects of thermal stress on coral at 31°C and 32°C. Mixed model analysis of variance showed that the effects of elevated sea surface temperatures (SST) and herbicide on photosynthetic efficiency of coral symbionts were additive. Furthermore, the effect of either diuron or atrazine in combination with higher SST (31°C and 32°C) on chronic photoinhibition was distinctly greater than additive (synergistic). Reducing the herbicide concentration by 1 μg L-1 diuron above 30°C would protect photosynthetic efficiency by the equivalent of 1.8°C and reduce chronic photoinhibition by the equivalent of a 1°C reduction. Reduced water quality increases the vulnerability of corals to elevated SSTs and effective management of local water quality can reduce negative effects of global stressors such as elevated SST.

093

DEVELOPMENT OF LABORATORY CULTURING AND ECOTOXICOLOGICAL TESTING METHODOLOGIES FOR THE SEA ANEMONE *AIPTASIA PULCHELLA*

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The preferences expressed in the ANZECC and ARMCANZ (2000) water quality guidelines, for toxicity data from five regionally relevant species from four taxonomic groups, cannot currently be met for tropical marine ecosystems because of a severe paucity of applicable standard test species. Furthermore, the application of toxicity data from temperate species into tropical areas has been widely questioned and criticized. Consequently, the urgent need to fill these critical gaps in our understanding of ecologically acceptable concentrations of contaminants for the proper protection of tropical marine environments has been widely acknowledged.

Aiptasia pulchella is a sea anemone found in tropical and sub-tropical oceans; it has been observed in Australia, Japan, the Hawaiian Islands, the Marshall Islands and Taiwan. This species thrives in laboratory conditions and has been used extensively in research into cnidarian bleaching mechanisms, photophysiology, and algal-host symbiosis. *A. pulchella* reproduces both sexually (spawning), and asexually by pedal laceration which produces large numbers of cloned individuals. This cnidarian may potentially be used in ecotoxicology as a proxy for coral reef communities in tropical marine waters.

A viable population of *A. pulchella* are currently being maintained at Southern Cross University, NSW, with optimised laboratory conditions inducing abundant reliable reproduction and recruitment of individuals for ecotoxicological testing. Preliminary acute toxicity tests established a Cu 96 hour LC_{50} of 133μg/L (Clark, Reichelt-Brushett and Scott, in prep), which shows relative sensitivity to Cu. This presentation reports on further acute LC_{50} test results for Cd, Pb, Zn and Ni. Current research exploring the development of sub-lethal test endpoints with ecological relevance including changes in behaviour, growth, reproduction and recruitment, and efficiency of photosystem II of associated zooxanthellae measured by PAM fluorometry, will also be discussed.

094

REAL WORLD CONDITIONS VS. LABORATORY STUDIES: HOW THE TROPICAL NORTH DIFFERS FROM THE LABORATORY.

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The tropical north of Eastern Australia undergoes extreme changes in climatic conditions each year as the seasons change from ‘the dry' in the winter months, to ‘the wet' in the summer months. Catchments in this region boast rivers where flow can change from <1 to more than 3000 cubic metres per second and flow velocities that reach speeds of more than 60 km/hour. The catchments of Queensland's tropical north also support some of Australia's major agricultural industries, including grazing, sugar cane, horticulture and cotton. Furthermore, these catchments drain into some of Australia's most valuable ecosystems, including the Great Barrier Reef (GBR), RAMSAR wetlands and seagrass communities. As part of the Queensland Government's Reef Plan 2009, a large scale monitoring program is underway, to monitor pesticides in catchments that drain into the GBR lagoon. Here we present the data that encompasses one year of sampling across 11 sites and over 9 catchments. Water-quality data indicated that pulse-exposures to biota would be common during the wet season, biota are likely to be exposed to mixtures of pesticides, and the presence of other stressors such as high suspended solid concentrations and high flow rates are concomitant with the presence of pesticides. The results are

discussed in terms of a lack of laboratory derived ecotox data that is representative of field conditions in Eastern Australia's tropics and the pressing need for their development.

095

ACUTE EFFECTS OF SEDIMENT-BORNE TOXICANTS ON A NEW ZEALAND COPEPOD: *QUINQUELAOPHONTE STRINGERI*

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Estuaries are very productive ecosystems often impacted by pollution from human activities. In New Zealand, there is extensive urban growth around estuarine regions and consequently many contaminants, such as heavy metals, polycyclic aromatic hydrocarbons (PAHs), and pesticides can potentially accumulate in sediments. Copepod sediment bioassays have become very useful tools to assess toxicity of contamination in estuaries .

This study sets out to define and quantify the sensitivity and the effects of sediment-borne contamination on *Q. stringeri*. Acute mortality was the primary endpoint however; the inhibitory effect on swimming was also used as a sublethal toxicity endpoint to enhance the understanding and knowledge of toxic effect concentrations. Ninety- six hour acute exposures of three sediment-borne reference contaminants (zinc, phenanthrene, and atrazine) were used to assess both lethal and the sub-lethal endpoints. LC_{50}s, EC_{50}s, LOEC and NOECs were used to assess the onset of toxicity for each contaminant. Toxic effects were seen in concentrations as low as 1 µg/g sediment dry wt. for atrazine, 5 µg/g sediment dry wt. phenanthrene, 125 µg/g sediment dry wt. zinc and with sediment LC_{50} ranging from 129 µg/g sediment dry wt. for atrazine 319 µg/g sediment dry wt. for zinc and 476 µg/g sediment dry wt. for phenanthrene. The level of effects are of concern as they are within the levels of contamination found in NZ estuaries, especially for zinc which has been found at concentrations up to 366 µg/g. This research validates a method for acute testing of sediments both spiked and field contaminated which is a valuable tool in pollution monitoring and environmental risk assessment especially when combined with *Q. stringeri* chronic 14 day partial lifecycle testing which has also been developed.

096

FINGERPRINTING BACTERIAL COMMUNITIES IN ESTUARINE SEDIMENTS: IDENTIFYING POTENTIAL BIOINDICATORS OF ESTUARINE HEALTH

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In heavily polluted estuarine sediments, there is need to identify more sensitive bioindicators of ecosystem health. Shifts in bacterial community structure have been reported to respond to anthropogenic contaminant loading. This study investigated the response of estuarine sediment bacterial communities to anthropogenic contaminants using a combination of Automated Ribosomal Intergenic Spacer Analysis (ARISA) and 454 ribosomal tag-pryosequencing.

Sediments were collected from five sites in both inner and outer zones in three heavily modified and three relatively unmodified estuaries in NSW, representing a gradient of contamination. Using forward-selection multivariate ordination techniques and boosted regression tree analysis, we found that shifts in both bacterial community composition and diversity showed strong correlation with sediment granulometry and heavy metal contamination, in particular lead and copper. Our analyses revealed distinct shifts in certain members of the bacterial community. In the outer zone sediments of all estuaries (unpolluted sand), members of the Gammaproteobacteria, Cyanobactera, Actinobactera, Alphaproteobacteria and Spingobacteriains dominated. With increases in the sediment silt fraction (inner zone sediments), members of the Deltaproteobacteria, Alphaproteobacteria, Acidobacteria, unclassified groups and Anaerolineae (Chloroflexi) increased in abundance. Importantly, contaminant-rich inner zone sediments of heavily modified estuaries experienced the most dramatic community shifts, with large increases in Deltaproteobacteria, Verrucomicrobiae and unclassified groups observed, but decreases across all other groups.

While the data remains correlative, there is a strong suggestion that anthropogenic contaminants are driving shifts in bacterial community composition and reducing the diversity of these communities. Bacterial communities may be comparatively more sensitive to contamination than the well-studied macrofauna of benthic marine systems. This makes them ideal organisms for use as bioindicators in highly complex natural systems such as estuaries.

097

A HIGH RESOLUTION STUDY OF ARSENIC, SELENIUM AND PHOSPHATE FLUXES FROM SPIKED MARINE SEDIMENT BY SIMULTANEOUS DEPLOYMENT OF DGT AND DET PROBES.

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Diffusive Gradient in Thin Films (DGT) incorporates an ion-exchange resin separated from the solution by an ion-permeable gel membrane and a filter membrane (0.45 or 0.2 µm). Mass transport through the gel is a controlled diffusion (based on Fick's Law) and thus is well defined, making it possible to obtain quantitative data on concentration and speciation over relatively short time periods (hours to days). In this study, well established marine sediment mesocosms were spiked at depth with arsenic and selenium, equilibrated for 24-48h, and then analysed by deploying sediment probes; DGT containing ferrihydrite and TiO_2 binding layers and a DET probe.

Analyte porewater depth distributions were compared to sorption activity of arsenic, phosphate, selenium, manganese and selected trace metals on the DGT binding layers. Sharp features were o bserved in porewater profiles for manganese and iron at depths of 8 and 4cm indicating the two main areas of remobilisation. Porewater arsenic availability to DGT was closely aligned with the 4cm peak .

Quantitative DGT measurements of phosphate, arsenic and vanadium, when compared with porewater profiles, suggest re-supply of phosphate from solid phase between depths between 1 to 3.5cm below the sediment-water interface, with simultaneous depletion of vanadium and arsenic. The depletion of porewater arsenic was most likely ac combination of adsorption to binding layers, and precipitation as sulfides or Fe/Mn (oxy)hydroxides. Selenium (IV) was quantitatively DGT labile, however, Se(VI) was not.

Combined deployments of DGT/DET are able to document the controlling phases for arsenic, phosphate and trace metal release and estimate the flux and re-supply activity of DGT labile analytes.

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BACTERIA AND ARCHAEA AS CANDIDATES FOR A RAPID BIOLOGICAL ASSAY FOR METAL-IMPACTED COASTAL SEDIMENTS

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Coastal sediments accumulate metals from anthropogenic sources. Consequently, industry and regulatory bodies monitor the health of metal-impacted sediments along Australian coastlines. It is well established that the total concentration of a metal does not necessarily reflect its potential toxicity, so biological assessment tools are employed as part of the monitoring process. Few appropriate biological tools are available for tropical sediments, and none are available to detect subtle changes in toxic or bioavailable concentrations of sediment metals. Rapid Biological Assessment (RBA) tools sensitive enough to detect relatively small increases in sediment metal concentrations would provide early warning of future ecosystem damage. We are investigating in situ populations of bacteria and archaea as potential RBAs in sediment from impacted and control sites at three tropical Australian coastal locations. Samples were collected over two years, in both wet and dry seasons, and metal concentrations in total sediment and porewater, as well as in potentially bioavailable and bioaccessible fractions were measured. Bacteria were cultured from sediment and identified by sequence analysis. Bacteria and archaea community profiles were obtained by amplification of the V6 region of the 16S rRNA gene using DNA extracted from the sediment, and 454 sequencing. We observed that changes in microbial populations between sites reflected changes in metal concentrations. Confounding factors which also correlated with microbial population shifts included seasonal and yearly fluctuations, sediment grain size and redox potential. While we conclude that in situ bacteria and archaea are potentially sensitive indicators for changes in bioavailable concentrations of metals in tropical coastal marine sediments, the seasonal effects suggest that we also need to identify functional genes that may be independent of season, and thus provide a useful adjunct to identity based assays.

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THE SCIENCE POLICY INTERFACE: "NEVER CUT WHAT YOU CAN UNTIE; NEVER NAIL WHAT YOU CAN SCREW"

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"Science-based policy involves producing high-quality scientific evidence, building bridges between the producers and users of scientific evidence, and incorporating scientific evidence into health [and environmental] policy and practice" (Choi 2005). This presentation takes a look at the definitions and roles of science, policy, and science policy in the design and implementation of science-based policy for human and environmental health protection and restoration. Also discussed will be the "zig-zag approach" to achieving environmental goals and the drivers that make taking such an approach the only practicable option. Examples of environmental programs that have or are evolving based on advances in science informed policy will be presented (e.g., metals bioavailability, water quality based protection, contaminant benchmarks, biological assessment, watershed assessment and restoration, etc.).

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EFFECTS OF POLLUTANTS IN TROPICAL AQUATIC ECOSYSTEMS: ARE THEY DIFFERENT FROM TEMPERATE SYSTEMS.

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Tropical aquatic systems in Australia and globally are characterised by highly variable water flows from monsoonal weather patterns and associated intense rainfall events following cyclones. Many rivers in the 'dry tropics' have extended periods of no flow where the river is reduced to a sandbed or a series of disconnected pools. Discharge of rivers to coastal waters occurs in large events following monsoonal and cyclonic rainfall e.g. the 2010/2011 events in NE Australia. River discharge extends into coastal waters as extensive flood plumes and such waters can be considered to be offshore estuarine systems in addition to the traditional 'between the banks' estuary.

Cropping in tropical catchments (e.g. sugarcane, oil palm, grains, cotton and horticulture) involves heavy use of fertilisers and pesticides and soil erosion from cropping and grazing land uses can be intense. As a result in high flow conditions rivers, wetlands and coastal waters may be subject to high loads and concentrations of suspended sediment, nitrogen and phosphorus compounds and pesticides. In low flow conditions aquatic systems may be subject to low dissolved oxygen, variable pH, high temperatures, high turbidity and prolonged nutrient enrichment.

Many of these situations are quite different to those more normal in temperate aquatic systems where much of the research work into ecosystem interactions with aquatic pollutants has occurred. The presentation will examine the differences between tropical pollutant/aquatic ecosystem responses with those familiar from temperate systems. The response of uniquely tropical ecosystems such as coral reefs will also be examined and consideration of different indicators, water quality guidelines and monitoring techniques explored.

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EMERGING ISSUES AND KEY CHALLENGES IN SEDIMENT CHEMISTRY AND ECOTOXICOLOGY

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Inadequate guidelines, tools and frameworks for sediment quality assessment impede decision-making processes, increasing the costs to both industries and regulators. In this presentation, a number of issues and challenges in the application of chemistry and ecotoxicology to sediment quality assessment are addressed, including improvements in the tools available for assessing the bioavailability of contaminants, whether the species used in toxicity testing are sensitive enough, and the benefits gained from including measures of exposure or bioaccumulation. This is discussed in the context of the existing tiered, decision-tree assessment framework, including considering how adequate this is. The tools used for assessing contaminant bioavailability, namely porewater analysis, dilute acid extraction and measurement of acid-volatile sulfides, are revisited to determine their usefulness. The application of diffusive gradients in thin films (DGT) to link exposure to bioaccumulation and toxicity is discussed. Results from assessments of contaminated sediments are used to demonstrate strengths and limitations of whole-sediment toxicity testing using Australian species. Improvements to sediment quality guideline trigger values to account for variations in sediment properties are also discussed. A dynamic biokinetic model of contaminant exposure is converted to a model that accurately predicts chronic effects copper to the benthic amphipod *Melita plumulosa*. There are still many issues that are not being adequately assessed, indicating that there is still a lot of research to do, but what we know now is significantly more than we did ten years ago. The accuracy of our assessments is improving!

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EVALUATING ENDPOINTS TO DETERMINE METAL TOXICITY OF GROUNDWATER MICROBIAL COMMUNITIES

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The interpretation of toxicity assessment data for aquatic microbial communities is often complex because of the natural plasticity and adaptability of microbes. For groundwater this is further complicated by the heterogeneous structure of microbial communities in these ecosystems. Hence, it is not surprising that microbial community toxicity data have not been included in setting of water quality criteria. This study evaluates the utility of various structural and functional endpoints with no or low effect values, reflecting change in microbial communities following exposure to As, Zn and Cr (VI), using microcosms established on the natural microbial assemblages from a fractured sandstone aquifer.

The sensitivity of the endpoints varied considerably between the metals with the microbial community being considerably more resilient to Zn than As or Cr. In terms of community structure, the fungal component of the community was generally more resilient than the bacterial component. Fungal richness declined with increasing As and Cr concentrations but increased with increasing Zn concentration, while bacterial communities shifted significantly in community function with increasing concentrations for all metals. Both fungal taxa and bacterial functional succession was evident at increasing concentrations of all metals.

Overall, structural endpoints yielded higher EC10 values than those obtained from functional endpoints suggesting that measures of microbial function might provide a more realistic representation of the sensitivity of the microbial community to impacts. Target-specific functional endpoints were more sensitive and less variable at the community-level response than endpoints that targeted general microbial community activity. We conclude that the use of parallel endpoints in toxicity assessments for groundwater microbial communities contribute to provide approximate community threshold level for toxicants whilst elucidating the dynamics of the microbial community during impacts.

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EXTREME ECOTOXICOLOGY: CASE STUDY OF THE LONG TERM PERSISTENCE OF CARBOFURAN IN THE DEAD ZONE, LAYSAN ISLAND, HAWAIIAN ISLANDS NATIONAL WILDLIFE REFUGE, PAPAHĀNAUMOKUĀKEA MARINE NATIONAL MONUMENT.

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Laysan Island is part of the Hawaiian Islands National Wildlife Refuge and the Papahānaumokuākea Marine National Monument managed by the U.S. Fish and Wildlife Service. Laysan Island is a remote island approximately 1,100 km northwest of Honolulu, Hawaii and is critical habitat for the endangered Laysan finch, Laysan duck, and Hawaiian monk seal; threatened green sea turtle; and provides nesting habitat for 19 species of seabirds.

The "Dead Zone" got its name when unusual clusters of dead birds, crabs, and flies were first observed in the area in 1988. Bird carcasses are not uncommon in a seabird colony, but elsewhere on the island carcasses are quickly consummed by scavengers such as crabs. In the Dead Zone the carcasses were not being consummed and the scavengers were dying. The cause of this mortality was found to be due to the carbamate pesticide carbofuran.

Carbofuran normally degrades rapidly in the environment. Recorded soil half-lives range from 0.25 to 35 days. In the Dead Zone carbofuran has persisted for 23 years.

This case study will discuss how the extreme environment of atolls and islands can affect the degradation of contaminants.

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EFFECTS OF SPECIAL ANTARCTIC BLEND (SAB) DIESEL ON SURVIVAL AND REPRODUCTION OF THE EARTHWORM *MICROSCOLEX MACQUARIENSIS.*

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A number of fuel spills (diesels and lubricating oils) have occurred on sub-Antarctic Macquarie Island in association with fuel storage and power generation for the island's research station. The Australian Antarctic Division is working to remediate these sites over the next 5-10 years. In order to develop appropriate protective target concentrations for remediation, a suite of toxicity tests using single species and microbial and invertebrate community responses is being developed. Acute and chronic tests were developed with the endemic earthworm species *Microscolex macquariensis* using survival and reproductive endpoints. Two field collected soils, containing low (~5%) and high (~25%) carbon, collected from clean sites on Macquarie Island were used in tests. Soils were spiked with SAB (five target concentrations between 100 and 1000ppm plus control) and homogenised. In the survival test, freshly spiked soils were used, while in the reproduction test, aged soils (4 weeks post-spiking) were compared to freshly spiked soils. Three replicate exposure jars per treatment, each containing 350 g soil and five sexually mature earthworms were incubated in growth cabinets under field-simulated conditions (8°C, 16 h light / 8 h dark) for 14 days for the survival test and 10 weeks for the reproduction test. The reproduction test exposed adult worms for 6 weeks, at which point survival was recorded. A further 4 week exposure period allowed for cocoons to hatch, after which juveniles and remaining cocoons were extracted and counted. Soil carbon was found to significantly reduce the toxicity of SAB fuel. Protective target concentrations were established for this species which contributes to the development of environmental guidelines for fuels in the sub Antarctic.

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HISTOLOGICAL ALTERATIONS IN THE ANTARCTIC COD, *TREMATOMUS BERNACCHII* FROM DAVIS STATION, EAST ANTARCTICA.

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During the summer season 2009/10, a comprehensive environmental impact assessment of the sewage discharge was conducted at Davis Station in the Vestfold Hills region of East Antarctica. As part of this project, a survey of the histology of liver, gill, gonad and muscle tissues in the Antarctic rock cod *Trematomus bernacchii* from nearshore sites in the receiving environment close to Davis Station in was completed. Fish from 4 sites were examined; 1 site adjacent to the Davis Station sewage outfall (within 500 m of the point of discharge), 2 sites approximately 2 km from the outfall (Anchorage Island and Antennae farm), and 1 site approximately 10

km away from the outfall and adjacent to an Adelie penguin population (Kazak Island). All fish sampled from the sewage outfall site exhibited significant histological alterations in all major tissues. Fish from the other 3 sites showed some alterations in either gill and/or liver tissues. Pathological abnormalities present in all fish collected near the sewage outfall included: extensive multifocal cysts of unknown etiology with necrotic liquification; multifocal granuloma with associated inflammation; coagulative necrosis in the liver; and lamellar hyperplasia with associated proliferation and lamella fusion of the gills. Results of this work form part of a weight of evidence approach alongside ecological monitoring, chemical analysis, ecotoxicological testing and dispersal modelling of the discharge plume which is being used to inform and direct upgrades to the Australian Antarctic Divisions operations and current sewage discharge practises at Davis Station.

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ENVIRONMENTAL IMPACT ASSESSMENT OF THE SEWAGE OUTFALL AT DAVIS STATION, EAST ANTARCTICA.

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During the summer 2009/10, an environmental impact assessment of the sewage outfall was conducted at Davis Station, East Antarctica. An investigation of the nature and extent of impacts to the marine environment associated with current sewage treatment and effluent discharge practices included ecological surveys of macrobiological communities, physico-chemical analysis of sediments and receiving waters, microbiological analysis, and histopathological analysis of fish. Ecotoxicological testing using local invertebrates to determine effluent toxicity was interpreted alongside dispersal modelling data of the discharge plume to determine the potential extent of impacts and inform recommendations on the level of treatment and dilution of sewage required to minimise impacts. No evidence of impacts was detected on soft sediment infaunal or epifaunal communities, and only low levels of contamination and accumulation were found in sediments and waters in the immediate vicinity of the outfall and in the direction of primary current flow. In contrast, sterol biomarkers and faecal coliforms (*E. coli*) were detected in sediments collected adjacent to the outfall and in most water column samples. Marine invertebrates (*Abatus* and *Laternula*) also tested positive for *E. coli* and antibiotic resistance mechanisms were present in *Laternula* indicating the introduction and dispersal through the water column of foreign microbes and bacteria associated with human effluent. Fish (*Trematomus bernacchii)* close to the outfall showed significant histological alterations in all major tissues (liver, gill, gonad, muscle) resulting from exposure to sewage. Effluent was toxic to amphipods (*Paramoera walkeri*) and microgastropods (*Skenella paludionoides*), with reduced survival in concentrations as low as 3.125% over a 21d exposure period. Acute effects were also observed in both species following 24h exposure, with 100% mortality at the highest effluent concentrations tested (68%). The application of these results to support and guide decisions regarding the planned installation of new sewage treatment facilities at Davis will be discussed.

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THE RESPONSE OF MARINE EPIBENTHIC FAUNA TO SHORT EXPOSURES TO CONTAMINATED SEDIMENT: A STUDY OF AVOIDANCE AND TOXICITY

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The distribution of contaminants is seldom homogeneous in aquatic systems and microniches within benthic sediments can make them particularly heterogeneous. In this study, we investigated the behavioural response of amphipod *Melita plumulosa*, harpacticoid copepod *Nitocra spinipes* and snail *Salinator solida* to contaminated marine sediments. Based on the rate at which the organism avoided contamination, we then investigated how toxic effects may occur through pulsed exposures to contaminated sediments.

Contaminated marine sediments were used in exposure assays varying from 6 h to 10 days. Initial assays showed that all three test species avoided the contaminated sediment, moving to clean sediments as early as after 6, 6, and 24 h exposure for *N. spinipes*, *S. solida* and *M. plumulosa* respectively. This suggests that these organisms are able to detect sediment contamination and choose to inhabit uncontaminated sediment.

To explore the implications of this avoidance on the toxic effects elicited during migration across heterogeneous contaminated sediments, pulsed contaminated-sediment exposure bioassays were performed with *M. plumulosa* and *N. spinipes.* For sediments that caused significant acute lethality during 10-day exposures, short exposures caused insignificant acute lethality but resulted in sub-lethal effects to the reproduction of *M. plumulosa* (a 34% reduction in offspring production for 16-h exposure). Similarly, for a sediment that was acutely toxic for a 10-day exposure, a 48-h exposure resulted in the 10-day reproductive output of *N. spinipes* decreasing by 37%.

This study demonstrated that benthic organisms such as *M. plumulosa, N. spinipes* and *S. solida* have the ability to detect and avoid contaminated sediment. However, the significant sub-lethal effects observed following 16- and 48-h exposures to contaminated sediment for *M. plumulosa* and *N. spinipes*, respectively, must be considered in relation to their avoidance behavior. Sub-lethal effects are discussed in relation to the potential frequency and duration of contaminant exposures and organism mobility.

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DISTRIBUTION, CHEMICAL FRACTIONATION AND POTENTIAL ECOLOGICAL RISK ASSESSMENT OF ARSENIC AND HEAVY METALS IN SURFACE SEDIMENTS FROM A CONTAMINATED COASTAL ENVIRONMENT IN FIJI

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Existing data, though limited, suggest that heavy metal contamination is prevalent in Fiji's coatal environments as a result of improper waste management from industrial activities. The Lami estuary in particular, located near Fiji's capital city Suva, is within the presence of several types of metal-based factories and has been found to be highly exposed to anthropogenic metal pollution. As part of an environmental monitoring activity, this study investigated the spatial distribution and chemical fractionation of arsenic and heavy metals in surface sediments collected from ten sites of the coastal and estuarine areas of Lami in Fiji. The total concentrations of As, Cd, Cr, Cu, Ni, Pb and Zn in the sediment samples ranged from 1-345, 1-2, 54-519, 15-530, 12-122, 13-800 and 25-1720, respectively, as mg kg^{-1}dry weight. Pearson's correlation matrix using Al as a normaliser, calculation of enrichment factors and determination of degree of contamination showed that the origin of elements is predominantly from anthropogenic sources. Some sites were found to be moderately to heavily polluted with As, Cr, Cu, Pb and Zn when compared to local background levels of these elements. Application of reference sediment quality guidelines developed for similar systems indicate the levels of As and metals in the sediments exceed levels at which adverse biological effects can occur. Chemical partitioning of sediments using the standard BCR sequential extraction procedure show that significant fractions of As and heavy metals are associated with bioavailable phase (exchangeable, water and acid soluble) of the sediment, hence potentially harmful for biota in the affected area. Further research is warranted to study the ecological effects of this incident and to devise strategies for remediation and management of the contaminated sites.

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ESTABLISHMENT OF FRESHWATER COMMUNITIES IN MESOCOSMS WITH COPPER CONTAMINATED SEDIMENT FOR RESEARCH INTO CLIMATE CHANGE EFFECTS.

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Heavy metal contamination has become a worldwide problem (Peng *et al.* 2008) with contamination of aquatic sediments being a major threat to public health, biodiversity and the functioning of aquatic ecosystems. Our research is focussed on copper. The predominant anthropogenic sources of copper include copper mines (present in all Australian states bar Victoria and ACT) and sewage sludge.

The aims of our research are to:

· Analyse the susceptibility of copper contaminated freshwater communities to climate change.

· Compare traditional and metagenomic techniques of community level analysis.

Twenty 1500L mesocosms have been set up at Macquarie University, Sydney. The set up required a large amount of infrastructure to be installed and the selection of appropriate sediment. A pilot study was carried out to understand the copper binding capacity of the selected sediment. The Australia and New Zealand Guidelines for Fresh and Marine Water Quality – Interim Sediment Quality Guidelines have been used to define treatment levels. Sediments were contaminated with copper *in situ* for a period of two months between August to October 2010.

The mesocosms will be monitored from November 2010 to April 2011. Biological monitoring will focus on algae in the water column (to consider phytotoxic effects) and changes in benthic communities (to consider sediment bioavailability of copper). Specifically, biological monitoring will involve:

· Analysis of the phytoplankton community using metagenomic analysis (based on pyrosequencing) and the FlowCAM (fluid imaging technology).

· Analysis of benthic communities using metagenomic analysis and traditional sediment processing and whole animal counts.

The copper distribution in the mesocosms will be monitored using ICP-MS to analyse the levels of copper in the sediments, porewaters and surface waters. Standard physico-chemical indicators will also be measured.

Stage two of this project will involve assessment of the synergistic effects to the community of copper and climate change.

(1) Peng J-f., Song Y-h, Yuan P., Cui X-y. and Qiu G-l. (2009) The remediation of heavy metals contaminated sediment. Journal of Hazardous Materials, 161 (2-3) 633-640.

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RELATIVE SENSITIVITIES OF WHOLE-SEDIMENT TOXICITY TEST PROTOCOLS WITH THE AMPHIPOD *MELITA PLUMULOSA* AND COPEPOD *NITOCRA SPINIPES*.

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Chronic whole-sediment toxicity tests are being used with increased frequency in Australia since the recent development of two novel reproductive bioassays using the amphipod *Melita plumulosa* and copepod *Nitocra spinipes.* However, little is known about their relative abilities to detect toxicity to a range of contaminants. The purpose of this study was to compare the response of these two sublethal methods for assessing the potential toxicity of sediment contaminants. The reproductive output of both species was excellent when exposed to uncontaminated sediments representing a full spectrum of sediment types (sand to silt, high to low organic carbon). The resulting reproductive responses demonstrated greater variability in the copepod bioassays (CV = 25%) than in the amphipod bioassays (CV=15%). These CV values were used, in addition to a t-test ($p<0.05$), as a threshold for identifying toxicity in a sediment. The test species were exposed to 21 sediments of varying degrees of contamination as represented by a chemical hazard quotient (HQ). In general, sediment with larger HQs resulted in lower reproductive output in both species. *N. spinipes* detected 12 of the 21 sediments as toxic and *M. plumulosa* detected 9 of the 21 sediments as toxic, suggesting the copepod was the more sensitive of the two test species. However, a range of factors were observed to influence the results, including control sediment selection, 'pest' meiofaunal species, ability to recover female and juvenile amphipods, ammonia concentrations and variability in test data/replicate numbers that affect the toxicity data. The need to carefully consider such factors when interpreting results from these tests or selecting other species for use in a battery of tests is discussed.

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EFFECTS OF URANIUM SPIKED SEDIMENTS ON BACTERIAL, MICROINVERTEBRATE AND MACROINVERTEBRATE BENTHIC COMMUNITIES

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There are currently no robust national or international toxicity guidelines for uranium in sediments. Based on the limited published data, toxicity estimates vary by at least three orders of magnitude. This level of uncertainty represents a substantial gap in environmental management capacity given the major upswing in uranium exploration and mining activity. Sediment U toxicity guidelines are required for both the operating and closure stages of mine life. To address this gap a field-based approach combining various traditional biological assessment and emerging ecogenomic approaches is being used to quantify the toxicity of U to sediment-dwelling biota across multiple trophic levels. During the 2009-2010 wet season, a range finding pilot investigation was undertaken to test and optimise sediment spiking methods, U concentration range and experimental design required for a subsequent full scale assessment. U-spiked sediments (400 mg/kg and 4000 mg/kg) and appropriate control sediments were deployed in retrievable containers in a natural northern Australian waterbody for three months. Detailed chemical characterisation of the sediment was undertaken prior to deployment and on retrieval. At the end of the exposure period, the extent of re-colonisation of the sediment by macroinvertebrate, microinvertebrate, biofilm and bacterial communities was measured. Unfortunately, interpretation of results from the pilot study was potentially confounded by the inadvertent creation of highly compacted sediments that appeared to be unrepresentative of natural sediments, and especially inhibitory to macroinvertebrate colonisation. Notwithstanding this limitation biological effects of U in the sediments were able to be discerned from analysis of the bacteria data. Different methods of spiking to minimise physical disruption of the sediment structure will be trialled over the 2010-11 wet season. The application of ecogenomic assessment approaches to determine effects will be discussed.

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CONTAMINANT SOIL-SPECIFIC QUALITY GUIDELINES FOR ECOSYSTEM PROTECTION: THE PROPOSED AUSTRALIAN NATIONAL ENVIRONMENT PROTECTION (ASSESSMENT OF SITE CONTAMINATION) MEASURE

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It has long been known that metal background concentrations vary spatially and that various soil physicochemical properties affect toxicity of metals to terrestrial organisms, but a conceptual framework to incorporate this into guidelines has been lacking. Thus most soil quality guidelines (SQGs) are generic – they do not account for the effect of soil properties and a single numerical limit applies to all soils within a jurisdiction. The Dutch, German and US SQGs have partially addressed these issues. While the recent Flemish guidelines which derive soils-specific guidelines based on pH, organic matter and clay content. Recently, models that relate the toxicity of metals to a suite of test organisms have been developed. In addition, factors that account for artefacts of laboratory-based ecotoxicity tests (e.g. ageing and leaching) have been determined that can be used to convert laboratory data to field-relevant data. Key features of the framework are that it: assesses the most important exposure routes; provides land-use based levels of protection;

uses EC30 and LOEC data; accounts for the effect of soil properties; accounts for background concentrations of contaminants; and accounts for ageing and leaching that occurs in the field. The framework has been used to derive ecological investigation levels (EILs) that indicate when the soil concentration of a chemical is sufficient that it warrants further investigation. Soil-specific EILs in fresh and aged contaminated soils were developed for Cu (modified by pH and CEC), Ni (modified by CEC) and Zn (modified by pH and clay content). Generic EILs in fresh and aged contaminated soils were also developed for As, Cr(III) and Pb. The proposed EILs that have been released for public comment will be presented.

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PESTICIDE RISK ASSESSMENT, MONITORING AND MANAGEMENT IN AUSTRALIA: USING THE 'ICONIC' GREAT BARRIER REEF AS A CASE STUDY.

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There is considerable evidence that Australian waterbodies are regularly contaminated with pesticides. However the data to support this contention are fragmentary, generally not published after peer review, not properly analysed or interpreted and mostly not in the public domain. There is no comprehensive pesticide usage reporting system in Australia. This means our ability to predict pesticide residue concentrations and loads in waterbodies using models is also very limited. Usage reporting systems have been recommended in special circumstances, e.g. for the Great Barrier Reef 'Reef Plan' but have not been implemented.

This paper reviews knowledge of pesticides in Australian waters, the management regime and its effectiveness. The Great Barrier Reef is used as a case study where more work has been done and more management proposed than for other Australian ecosystems.

The state of pesticide monitoring in all states of Australia is abysmal. The programs that do exist are almost uniformly reactive, *ad hoc*, with no formal design and the results when publically released are not published in the peer reviewed literature. A particular issue is the lack of follow up action when pesticides are detected in drinking water. In these circumstances, the NHMRC (2005) and ANZECC and ARMCANZ (2000) recommend that action be taken to find the source of the residue and manage where appropriate. This rarely seems to happen when such detects occur.

A particularly noticeable problem with pesticide management in Australia is the extraordinary long times associated with the official reviews of pesticides by APVMA - often longer than 10 years. Given that properly designed and implemented pesticide studies generally run by organisations such as CSIRO, universities and the like find pesticide residues are ubiquitous in Australian water bodies we can only conclude that the current pesticide regulatory regime in Australia is not working.

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THE CHALLENGES IN SEARCH OF THE "HOLY GRAIL" FOR PROTECTING AQUATIC ECOSYSTEMS FROM CHEMICAL POLLUTANTS

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Since 2000, I have been working on environmental quality standards for regulating and managing toxic substances in Europe and then in Hong Kong. When I engage in this research area longer and deeper, I gradually realise that there are many unresolved problems in the scientific derivation of water and sediment quality guidelines (i.e., trigger values). In this talk, I will discuss and highlight some of the major challenges in search of the "Holy Grail", i.e. ecologically relevant trigger values, for protecting aquatic ecosystems from chemical pollution. First, I will examine the possible ecological impacts of toxic substances when they enter into an aquatic ecosystem. This will lead to discussion on a series of questions such as: "What should we protect?", "Should we protect all species?", "Should we primarily focus on protection of ecological function?" etc. Second, I will review and evaluate the conventional methods for determining predicted no effect concentrations (PNECs) and trigger values. In particular, I will elucidate various problems and uncertainties in using laboratory ecotoxicity data and species sensitivity distributions to derive PNECs. Third, I will argue that fundamental field-based study on ecology and biodiversity in conjunction with pollution monitoring is indispensable, as such information is vital to validate or refine the trigger values. Finally, I will suggest some possible solutions and advocate that more research effort should be made to fortify the ecological realism in derivation of the trigger value.

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INCORPORATION OF ECOTOXICOLOGY INTO DANGEROUS GOODS CLASSIFICATION OF METALS AND SPARINGLY SOLUBLE INORGANIC SUBSTANCES

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The latest edition (7th) of the Australian Dangerous Goods Code for transport by road or rail has adopted internationally harmonised classification rules for environmentally hazardous substances from the United Nations Global Harmonised System (GHS) for classifying substances.

For the first time, the new edition contains classification criteria to consider environmentally hazardous substances (Class 9). The introduction of the criteria formally requires manufacturers and importers to consider Class 9 classification for their goods.

Environmental hazard classification is traditionally based on aquatic toxicity testing of substances. Since the aquatic toxicity of metals and sparingly soluble inorganic substances such as metal compounds and minerals depend on the bioavailable fraction and this roughly translates to the transformed or dissolved free ion concentrations in water, the GHS provides special guidance and procedures for such compounds.

The GHS, which is referred to by ADG7, has adopted a standard test method from the OECD to measure transformation or dissolution of poorly soluble metal compounds called the transformation/dissolution test (T/D). The test provides an ideal medium and circumstance for the metals and sparingly soluble inorganic compounds to dissolve. Thus it is meant to allow for a "worst case" prediction of expected solubility of the metal in the environment. The results of these tests are then compared to ecotoxicity reference values (ERVs) to inform a dangerous goods classification under Class 9. ERVs represent standard acute or chronic endpoints for what is deemed one of the most sensitive organisms for which data exists. There are a variety of factors which need to be considered when selecting an ERV for comparison to the T/D test data.

As the test method and interpretation of the results are both still new and evolving, both aspects require careful consideration. The test itself, the selection of an appropriate ERV, and the classification process are discussed.

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MANAGEMENT OF PROSPECTIVE AND RETROSPECTIVE GENERATIONS OF INDUSTRIAL CHEMICALS

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The National Industrial Chemicals Notification and Assessment Scheme (NICNAS) is the Australian Government's risk assessment body for industrial chemicals. The scheme assesses new industrial chemicals prior to their entry into the market and chemicals already in commerce (existing chemicals) in response to concerns about adverse health or environmental effects. The presentation focuses on two challenging projects that NICNAS is currently progressing that on nanomaterials and the assessment of all the chemicals on the national inventory.

Prospective - Nanomaterials present different challenges to conventional chemicals in determining their human health and environmental impacts. These include the appropriateness of conventional risk assessment methodologies and toxicological study protocols and a paucity of information on health and environmental effects. NICNAS is developing its risk assessment capability, determining data requirements for risk assessment of nanomaterials, benchmarking risk assessment methodologies against international standards and developing and monitoring the toxicology relating to certain nanomaterials of relevance to NICNAS. Nanomaterials of particular interest to NICNAS are titanium dioxide, zinc oxide, cerium oxide, silver oxide, carbon nanotubes and fullarenes.

Retrospective – The national industrial chemicals inventory has approximately 38,000 chemicals most of which have been grandfathered onto the inventory. NICNAS has developed a risk based framework for a multi tiered assessment of the chemicals on the national inventory (AICS). A major challenge is the availability of hazard and exposure data on these chemicals. An analysis of the availability of publicly held human health and environmental hazard data indicated that a vast majority of the chemicals on AICS (>80%) are data poor highlighting the need for utilising non experimental data generated from Quantitative Structure Activity Relationship (QSAR) models to fill experimental data gaps. The framework also includes a strategy to use surrogate data for use and volume information on industrial chemicals in the absence of any such data on the inventory.

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AN OVERVIEW OF KEY FEATURES OF THE REVISION OF THE *AUSTRALIAN AND NEW ZEALAND GUIDELINES FOR FRESH AND MARINE WATER QUALITY* AFFECTING AQUATIC ECOSYSTEMS

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In 2009, ministerial approval was given to revise the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (the "Guidelines"). This document is a key resource for managing water quality and protecting aquatic ecosystems in Australia and New Zealand.

Since the 2000 Guidelines revision, substantial new data and techniques for monitoring and assessment have arisen. Apart from incorporating new data and assessment methods for physico-chemical and biological indicators, a number of key cross-cutting issues will be at the forefront of the new revision. A number of these will improve site-specific guidelines' derivation and guidance (eg improved regionalisation, ecosystem classification and definition of reference condition) while others take advantage of new delivery mechanisms, including:

Web-based delivery. A move designed to make the Guidelines more user-friendly, easier to update and easier to deliver under a decision support and integrated assessment framework.

Revised decision framework and incorporation of conceptual modelling. Important decisions are needed before undertaking a water or sediment quality assessment. These front-end decisions will be delivered in a web interface that considers the user type (planning; licensing and approval; and monitoring, assessment and reporting) and choice of indicators based upon conceptual modelling of activities, stressors and impacts for particular situations.

Integrated monitoring and assessment

The 2000 Guidelines recognised, but did not address effectively, integrated monitoring and assessment. New web delivery will present the user with a mix of physico-chemical and biological (including toxicological) indicators in a weight of evidence (WoE) approach to monitor and assess an issue. This WOE approach recognises that, in many cases, the use of a single line of evidence (eg comparing a toxicant in water to a default trigger value) is insufficient, and that the use of additional (typically biological) lines of evidence will lead to more robust and confident assessments of water quality issues.

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RECOMMENDED REVISIONS OF THE AUSTRALIAN AND NEW ZEALAND WATER QUALITY GUIDELINES FOR TOXICANTS

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Over a decade since the last revision of the ANZECC/ARMCANZ Australian and New Zealand Guidelines for Fresh and Marine Water Quality (the Guidelines), the Working Group responsible for Toxicants and Sediments in the current revision of the Guidelines, with input from stakeholders, has identified a number of priority tasks. These included:

(i) revising trigger values (TVs) for key contaminants, including nitrate (freshwater), boron (freshwater), zinc (freshwater), manganese (marine), and salinity (marine);

(ii) re-evaluating other TVs where the number of data points was small and the fit of the species sensitivity distribution (SSD) was poor, including a “quick fix” solution that involves supplementing chronic data with acute data to yield guidelines of moderate reliability;

(iii) prioritising organic contaminants where TVs were absent and needed, including endocrine disrupting chemicals and pharmaceuticals;

(iv) updating the TV derivation process, including re-assessing appropriate endpoints and new statistical approaches; and

(v) revising the sediment quality guidelines and introducing a weight of evidence assessment framework.

Many of these tasks will be completed as part of Phase 1, while others will commence in 2011 as Phase 2 projects.

This presentation will provide an overview of current and proposed toxicant and sediment guideline revision activities. Limitations identified with some existing toxicant TVs, together with progress towards interim revised TVs will be discussed.

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PROPOSED CHANGES TO METHODOLOGY FOR THE DERIVATION OF TOXICANT GUIDELINE TRIGGER VALUES

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Over a decade since the revision and 2000 publication of the benchmark *ANZECC/ARMCANZ Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, a new revision is underway. One of the key changes from the 2000 Guidelines will be a revised methodology for calculating toxicant trigger values (TVs). This presentation will discuss in detail the proposed changes to the methodology. These include:

- new definitions of acute and chronic exposure and toxicity tests;
- improving the BurrliOZ statistical software to fit both the log-logistic and Burr Type III distributions to the data (depending on the number of data available);
- increasing the transparency of TV calculations by modifying BurrliOZ to numerically and graphically present the 95% confidence intervals of the TVs, and indicating the type of organism and data used in the BurrliOZ plots;
- revised data inclusion rules;
- changing the priority of using different statistical estimates of toxicity to derive TVs to favour no and low percentage of effects data;
- guidance on new experimental designs to reflect the preferred data types;
- increasing the flexibility of types of data that can be used to derive TVs;
- data manipulation rules that yield the single value for each species; and
- using unpublished data provided they meet the data quality criteria and can be made publically available.

We seek your input on the proposed changes.

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ZINC TOXICITY TO THE ESTUARINE EPIBENTHIC AMPHIPOD *MELITA PLUMULOSA* INCREASES WITH GRAZING AND BREEDING ON SILICA SUBSTRATE

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Melita plumulosa is an epibenthic amphipod native to eastern Australia that has been adopted as a test organism for toxicity evaluations of estuarine contaminated sediments. In the present study, artificial substrates consisting of fine milled silica with or without a-cellulose were evaluated for their capacity to support amphipod survival, growth and fecundity. There were no significant differences in the survival and fecundity of adult amphipods cultured for up to 13 days on natural sediment, silica-only or silica/a-cellulose substrate when fed two algal foods, Sera® micron and Rotiselco®-ALG. However, growth among juveniles cultured on the silica/a-cellulose mixture was significantly inhibited over 14 days compared to natural sediment. Addition of a microencapsulated shrimp feed, Frippak® to the algal foods, improved juvenile growth over 28 days, but still didn't match the nutritive value of natural sediment. Fine silica without cellulose was subsequently used in acute and reproductive toxicity tests with waterborne zinc. With feeding, a 10-d LC50 of 140 µg Zn/L and a 10-d NEC of 80 µg Zn/L were obtained for juvenile survival on silica. In contrast, a 10-d LC50 of 200 µg Zn/L and a 10-d NEC of 180 µg Zn/L were for juveniles in water-only exposures. Similarly, exposure of non-gravid adult females to zinc without feeding on silica compared to water-only treatment gave a 10-d LC50 of 380 and 490 µg Zn/L, and 10-d NECs of 130 and 370 µg Zn/L, respectively. The reproduction test showed significant adult mortality at 92 µg Zn/L and significantly reduced fecundity at 22 µg Zn/L. We concluded that the toxicity of waterborne zinc to *M. plumulosa* increased when cultured on nutrient-depleted silica compared to water-only exposure as a consequence of increased energy expended through foraging and amplexus behaviour when mating, in concert with an increased exposure to Zn via the digestive tract and gills.

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A PILOT SURVEY OF THE GENOTOXICITY OF VICTORIAN WWTP EFFLUENTS USING A HIGH SPEED LUMINESCENT *UMU* TEST

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Chemical analysis can not provide a measure of the toxicity of complex mixtures. Toxicity testing provides complementary information to chemical analysis on the sum of micropollutants present in treated effluent. A battery of bioanalytical methods is available, including the *umu* test method, which can rapidly assess genotoxicity. In 2007 we conducted a pilot survey of the genotoxicity of treated effluent from 39 WWTPs located across Victoria sorted by treatment type (lagoon-based plants and those with activated sludge-based processes). Each sample was filtered to remove particulate matter, and then subjected to solid phase extraction and elution of analytes. For all samples, elution protocols separated the extract into three fractions, first a 3:1 hexane: dichloromethane fraction (H/D), second a 1:9 acetone:dicholoromethane fraction (A/D), and finally a methanol fraction (MeOH). For each sample, we measured sample genotoxicity on each fraction using a high-throughput luminescent *umu* test method using *Salmonella typhimurium* TL210 strain, with and without addition of a commercially available metabolic activation system (+S9/-S9). A genotoxic response was observed in half of the samples tested without metabolic activation system (-S9; N.R. – 0.19 ng/L 4-nitroquinoline-N-oxide EQ), almost ways in either the H/D and /or A/D fraction. The type of WWTP had no effect on genotoxicity. On addition of metabolic activation system (+S9), 75% of samples elicited a genotoxic response, with the majority of the responses stronger and in the A/D and MeOH fractions (N.R. - 2.97 ng/L benzo[a]pyrene EQ). The data suggests the wastewaters contained compounds that are, in and of themselves, genotoxic, and chemicals whose biodegradation products are genotoxic. However, in this study, the causal chemicals inducing genotoxicity were not identified, and there is a need to further investigate their occurrence, fates, and ecotoxicity to assess the ecological significance of the data.

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EFFECTS OF NUTRITION AND CONTAMINANTS ON CROCODILIAN THYROIDAL REGULATION

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Crocodilians are excellent sentinels for thyroidal disruption in wildlife because they are top predators. Additionally, their thyroid gland morphology is similar to most vertebrates and thyroid hormone structures are identical among vertebrates. We examined three American alligator populations from Florida (USA) with varying environments and levels of contamination to determine if differences in developmental nutrition and contaminant exposure are associated with permanent or transitory changes in thyroid activity. Lake Woodruff National Wildlife Refuge (WO) is a relatively pristine, freshwater reference site, Lake Apopka (AP) is a freshwater site highly contaminated with agricultural contaminants, and Merritt Island National Wildlife Refuge (MI) is an estuarine site surrounding Kennedy Space Center. Eggs were incubated under controlled conditions and a subset was necropsied at one week post hatching to determine initial thyroidal status. The remaining animals were raised for 10 months with ad libitum food and artificial heat and light. Growth measurements were recorded every 2 weeks, plasma thyroid hormone concentrations were obtained at one week, one month, and 10 months, and thyroid histology was observed at one week and 10 months. Initially, AP neonates were smaller, grew slower and had hypothyroid glandular morphology and thyroid hormone profiles compared to WO neonates. MI neonates were smaller but grew faster and exhibited hyperthyroid glandular morphology and thyroid hormone profiles compared to WO which could be due to high iodide concentrations in the yolk from a maternal estuarine diet. After 10 months, however, thyroid hormone profiles were normal for all sites but AP juveniles continued to grow slower. Therefore, freshwater and ideal conditions can return some aspects of thyroid hormone regulation to normal levels in crocodilians, but more complex endpoints such as growth can remain affected.

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INFLUENCE OF THE SEDIMENT PARTICLE SIZE AND PARTICULATE ORGANIC CARBON ON DISSOLVED AND PARTICULATE EXPOSURE PATHWAYS AND CHRONIC EFFECTS OF COPPER IN SEDIMENTS

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A substantial amount of literature addresses the importance of metal uptake from sediment particles as major exposure route for benthic organisms. Nevertheless, the significance of different sediment components or properties such as particulate organic carbon (POC) and particle size is still poorly understood when chronic toxicity is evaluated using metal-spiked sediments. To evaluate toxic effects to reproduction of the epibenthic amphipod *Melita plumulosa* and the copepod *Nitocra spinipes*, sublethal 10-day whole-sediment tests were applied to copper spiked sediments that were formulated with varying POC content (0.5, 3.3 and 7%) and/or fraction of fine particles (10 to 90% <63 μm). EC_{50}s were calculated based on the number of total offspring per female for each species, derived using POC-normalization copper concentration of the <63 μm sediment fraction. Series of experiments with different grain size distribution showed (i) a strong linear relationship between the EC_{50}s based on particulate copper concentration and sediment particle size, and (ii) that EC_{50}s based on dissolved copper concentration were much lower than the effects thresholds measured for water–only exposures of the same duration. These results supported the hypothesis that particulate phase is the major exposure route and cause of the toxicity. The EC_{50}s also increased with increasing POC (same particle size) and this was attributed to the strong copper-binding capacity of POC and also role this component plays in lowering the bioavailability of dissolved copper.

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A FRAMEWORK FOR PREDICTING AND MANAGING WATER QUALITY IMPACTS OF MINING ON STREAMS IN NEW ZEALAND.

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Coal and gold mining are important economic activities in New Zealand, and the West Coast of the South Island and Southland, for example, have long histories of mining. The process of mineral extraction inevitably results in environmental impacts, but few tools exist to help mining companies and regulators assess and predict environmental impacts of mining operations.

This paper describes a framework that utilises research on rock geochemistry, aquatic chemistry, freshwater ecology, aquatic toxicity, and management and treatment techniques for mining to provide a process for data collection and decision making. The framework focuses on water quality issues associated with coal and gold mining, specifically pH, metals and, to a limited extent, suspended solids. Specifically the framework provides information on collection of the water, rock and biological information used to (a) predict water quality prior to mining, (b) monitor discharges from mines, and (c) identify mining-related impacts. In addition, the framework includes information on state of the art techniques for *prevention* of poor water quality in mine drainages and optimal strategies for *management* of mine waste or overburden and *treatment* of mine drainages if necessary. The appendices also include information on the management of suspended solids (an issue common to all mining operations) and discussion on the impact of extreme events on mining operations.

The main body of the framework outlines the process, including data required, methods of collection and interpretation of those data. A series of appendices provide the more-technical and scientific results that underpin the processes and decision trees used in the document.

The framework is written for a wide audience – regulators, mining companies, landholders, and the community – with a focus on assisting with regulatory processes and for internal decision-making by mining companies, and is available on-line.

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THE EFFECT OF COPPER ON THE FERTILISATION SUCCESS OF THE SEA URCHIN *HELIOCIDARIS TUBERCULATA* : IS SPERM PRE-EXPOSURE REALLY NECESSARY?

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Fertilisation assays have been developed to assess the effects that contaminants may have on the fertilisation success of broadcast spawning marine invertebrates, such as sea urchins and bivalves. These assays typically involve exposing sperm to a contaminant for a set period of time, following which the ability of the sperm to fertilise non-exposed eggs is determined. The sperm are pre-exposed to the contaminant for up to 1 hour prior to fertilisation, as it is commonly assumed that contaminants affect sperm cell function (e.g. through impairment of mitochondrial function and/or damage to the membrane) and not egg viability or the fertilisation process itself.

We conducted experiments to determine the most critical exposure period of the sea urchin *Heliocidaris tuberculata* fertilisation assay to copper (Cu). Both sperm and eggs were exposed independently to copper and fertilisation trials were subsequently conducted using the following combinations of gametes: (i) non-exposed sperm and non-exposed eggs; (ii) non-exposed sperm and Cu-exposed eggs; (iii) Cu-exposed sperm and non-exposed eggs; and, (iv) Cu-exposed sperm and Cu-exposed eggs. Fertilisation success was assessed for each of these treatment combinations in seawater with and without the presence of copper. Fertilisation success was significantly reduced in the presence of copper, irrespective of whether the sperm were pre-exposed to copper or not. In addition, there was no significant difference in fertilisation success between Cu-exposed sperm and non-exposed sperm when fertilisation took place in the absence of copper. Pre-exposure of eggs to copper did not affect fertilisation success. These results suggest that the inhibitory effects of copper on sea urchin fertilisation are most critical at the time of fertilisation.

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DETECTING ENDOCRINE DISRUPTING CHEMICALS AND CHARACTERISING THEIR EFFECTS ON BENTHIC MOLLUSCS IN DARWIN HARBOUR

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Wastewater effluent is a major source of endocrine disrupting compounds (EDCs) in aquatic environments due to the large number of chemicals present in this effluent, and the incomplete removal of these by conventional sewage treatment methods. Studies reported in both Australian and international literature have shown adverse impacts due to the exposure of aquatic organisms to EDCs. To investigate the risk posed by EDCs to aquatic organisms, reliable environmental analysis of EDCs is required. Most analytical efforts to date have focused on the determination of EDCs in aqueous matrices. However, many EDCs in aquatic environments have a high affinity for organic and mineral matter and so become concentrated in soil or sediments, thereby acting as environmental reservoirs. From these sinks they have the potential to bioaccumulate, and cause endocrine disruptions to benthic invertebrates and enter the food chain. Limited study has been devoted to the analysis of EDCs from solid samples because of the complexity of sample processing and requirement of low detection limits, and at present, neither sediment or biota are being analysed for EDCs in Australia. We aim to develop quantitative methods for accurately measuring EDC levels in sediment and biota. We will screen for a selected suite of EDCs in sediment and in the benthic-feeding shellfish *Telescopium telescopium* from wastewater outfalls located in Darwin Harbour, Northern Australia. We will outline some of the challenges faced in the development of these methods, and present initial results. Results will be discussed in terms of the potential effects of EDC levels in marine sediments on the aquatic biota in Darwin Harbour.

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OCCURRENCE OF SEXUAL HORMONES IN SEDIMENTS OF MANGROVE IN BRAZIL AND THEIR ECOTOXICOLOGICAL EFFECTS.

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The presence of sexual hormones (female estrogens) was assessed in sediments of a mangrove located in the urban region of southern Brazil. The estrogens are involved in human sexual reproduction. They act as the chemical messengers and they are classified as natural and synthetic. The estrogens inputs in the environment are from treated and untreated sewage. The presence of estrogens in sewage is excretion from the female due to natural production and use of contraceptives (synthetic estrogens). With the indiscriminate release of sewage into the environment, estrogens can be found in rivers, lakes, and even in oceans. In this work the presence of Estrone (E1), 17- a -Estradiol (E2), and 17- b -Ethynilestradiol (EE2) was investigated in eight sedimentary stations in Itacorubi mangrove located on Santa Catarina Island, in south of Brazil. Historically, the Itacorubi mangrove has been impacted by anthropogenic activities because the mangrove is inserted in urban area of the city of Florianopolis. The estrogen EE2, used as contraceptive, had the highest concentration in mangrove sediment, 129.75 ng/g. Also, E2 was found, its concentration ranged from 0.90 to 39.77 ng/g. Following the mechanism, under aerobic or anaerobic conditions, E2 will first be oxidised to Estrone (E1), which is further oxidised to unknown metabolites and finally to CO_2 and water (mineralised). EE2 is oxidized to unknown metabolites and also finally mineralised. Theoretically, under anaerobic conditions EE2 can be reduced to E1 even in environments such as mangrove, which is essencially anerobic. Also, the ecotoxicological effects on fish were assessed and the results showed that in this range concentrations feminization of fish were observed.

(1) Arnon et al. Environmental Science and Technology (2008), 42(15), 5521–5526.
(2) Isobe et al. Environmental Pollution (2006), 144(1), 632-638.
(3) Larsson et al. Aquatic Toxicology (1999), 41(1), 91-97.

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COMPARISON OF THE MICROBIAL DIVERSITY AND FUNCTION IN THE SEDIMENT OF FRESHWATER STREAMS ASSOCIATED WITH WASTEWATER TREATMENT PLANT DISCHARGES

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The discharge of effluent from wastewater treatment plants (WWTPs) has major detrimental effects on the health of aquatic ecosystems. Although assessments of river health are widely based on the use of fish and macroinvertebrates as indicators, bacteria and other microorganisms may also be informative of the condition of aquatic ecosystems due to effluent discharges. Bacteria are responsible for biogeochemical transformations, such as nitrification and denitrification, and thus, the impacts of stress and disturbance upon microbial communities can have implications for ecosystem functions and processes as well as biodiversity and aquatic community structure. In this study, we investigated the effects on bacterial communities at two WWTP sites- a freshwater stream with low effluent dilution (Site T) and a high effluent dilution stream (Site W). Samples of in-stream sediments were collected from six locations along the sites T and W. The sampling locations were approximately 500 m upstream of the WWTP outfall (inferred as a reference site), at outfall and then progressively at 10 m, 50 m, 100 m and 1000 m downstream the outfall. PCR denaturing gradient electrophoresis (DGGE) of 16S rRNA genes was used to assess the impact on community structure in the sediments of these two freshwater streams. Due to the importance of nitrification in reducing the environmental impact of ammonia in effluent, the abundance of functional genes associated with nitrogen cycling, including those involved in nitrogen fixation (nifH), nitrification (amoA), and denitrification (narG) using real-time quantitative PCR (qPCR) were also assessed. Our data indicated a strong cause-and-effect relationship between the loading of carbon and nitrogen into the creek from the WWTP outfall and the major responses in bacterial abundance, community structure, and function. The results suggested that the dilution based stream attenuation can provide a protective barrier for potential detrimental effects on the microbial health of aquatic ecosystems receiving WWTP discharges.

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SETTING ENVIRONMENTAL QUALITY CRITERIA FOR GROUNDWATER: A COMPARISON OF CURRENT APPROACHES

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Environmental quality criteria for groundwater have to date been largely based on guidelines for surface water protection, drinking water standards, or the analytical detection limits of some pollutants, with little consideration of the inherent value and protection of groundwater ecosystems per se and their unique biota. Importantly, risk-based approaches, such as species sensitivity distributions, that are widely advocated and used for setting surface water criteria have not been used for setting criteria for groundwater ecosystems, largely because of the lack of toxicity data specifically for groundwater biota.

Using toxicity data derived for groundwater invertebrates and microbial assemblages from aquifers in eastern Australia, we derive environmental quality criteria for three common groundwater contaminants using a risk-based approach. We compare the degree of protection offered by the various approaches for criteria setting discussed above, compare our criteria for groundwater against existing criteria used in Australia and Europe, and consider future directions for groundwater ecosystem protection in light of the paucity of relevant toxicity data now and into the future.

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DETERMINATION OF MRNA EXPRESSION OF *DMRT93B*, *VITELLOGENIN*, AND *CUTICLE 12* IN *DAPHNIA MAGNA* AND THEIR BIOMARKER POTENTIAL FOR ENDOCRINE DISRUPTION

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We explored the use of molecular genetic biomarkers for endocrine disruption in *Daphnia magna* after the exposure to fenoxycarb (FOC), a model juvenile hormone analog. For this purpose, the mRNA expression patterns of *DMRT93B* (DMRT, sex determination), *cuticle 12* (CUT, molting), and *vitellogenin* (VTG, embryo development) were determined in *D. magna*. Furthermore, these results were compared with developmental abnormality and reproduction performance. The fold changes of CUT and VTG mRNA expression showed significant dose-response relationship with FOC exposure. Relative mRNA expressions of DMRT and CUT showed notable changes at as low as 1 ng/L FOC. After chronic exposure FOC significantly delayed the first day of reproduction and decreased the number of young and growth rate even at 10 ng/L of FOC. A concentration-dependant trend in reproduction effect was also observed. Developmental abnormality such as poorly developed second antennae and curved or unextended shell spines were observed. These results suggest that the three mRNAs, i.e., DMRT, CUT, and VTG can be used as biomarkers of endocrine disrupting effects in *D. magna*.

Keywords: juvenile hormone analog; sex determination; vitellogenin; molting; developmental abnormality

Acknowledgement: This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education, Science and Technology (No. 2010-0017289)

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CAN CARBON NANOTUBES ACT AS A CARRIER VEHICLE TO ENHANCE UPTAKE AND TOXICITY OF OTHER XENOBIOTICS IN FISH?

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Research on the adsorptive capacity of carbon nanotubes (CNTs) for organic pollutants is extensive. Many studies have showed a high absorptivity of organic pollutants by CNTs, suggesting that CNTs have immense potential to serve as an environmental remediation tool. Conversely, such properties of CNTs may also signify an enhanced route for environmental contaminants to gain entry into living organisms if the pollutant-associated CNTs can enter the circulatory and cellular systems of an organism and subsequently release the pollutant. In this way, CNTs may facilitate an increased uptake of the pollutant leading to a greater toxicity. This study specifically tests the hypothesis that the presence of CNTs can increase the uptake and toxicity of two common xenobiotic pollutants, benzo[*a*]pyrene (B[*a*]P) and triphenyltin (TPT), in the marine medaka fish *Oryzias melastigma* via intraperitoneal injection with the chemicals dissolved in corn oil with or without CNTs. The half-lives of B[*a*]P and TPT in the fish tissues were determined using gas chromatography-mass spectrometry. Molecular biomarkers such as cytochrome P450 1A (CYP1A), superoxide dismutase (SOD), and heat shock protein 70 (HSP 70) were employed to assess the sublethal toxicities of the test chemicals to *O. melastigma*. The results of this study will address whether or not CNTs can act as a carrier vehicle to enhance the uptake and toxicity of other xenobiotics in fish.

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A NEW METHOD FOR MEASURING THE METALLOTHIONEIN INDUCTION IN METAL-EXPOSED *CHIRONOMUS TEPPERI*

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Biomarkers (changes in the biological functioning of an organism) have potential application in assessing the presence of pollutants in the environment including heavy metals. Metallothionein (MT) is a small, cysteine rich protein involved in detoxification and regulation of heavy metals in many species. It has previously been shown that exposure to metal contamination results in an increase in MT levels in a number of invertebrates. MT has therefore been suggested for use as a biomarker of metal contamination. This study compares three methods for the detection and quantification of MT in the non-biting midge *Chironomus tepperi*. The methods were Western transfer followed by immunoblotting using a specific antibody, a well established mercury saturation assay and the Brdicka differential pulse voltammetry (DPV) method. Tissue was collected from *C. tepperi* larvae following exposure to copper sulphate at sub-lethal concentrations in water, and controls exposed only to artificial water were run alongside exposed larvae. The immunoblotting method showed a clear difference in concentrations between two MT standards as well as in tissue from larvae exposed to different copper concentrations. As far as we are aware this is the first time a Western Blotting immunological method has successfully detected MT in chironomids. Results compared favourably with those from the well-established mercury saturation assay which uses mercury as a surrogate to MT. The Brdicka DPV method showed a clear difference between MT standards and was able to quantify MT in tissue at the higher contamination level, however polarographic peaks were indistinct. The immunoblotting technique may represent a relatively straightforward way of determining MT concentrations in aquatic invertebrates exposed to metals.

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ESTIMATION OF BIOAVAIBILITY OF POLYCYCLIC AROMATIC HYDROCARBONS IN RIVER SEDIMENTS.

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Polycyclic aromatic hydrocarbons (PAHs) are widespread in the environment. Because of their carcinogenic and mutagenic properties, these compounds have been intensively studied in the various compartments of the environment. Owing to their hydrophobic character, these neutral organic compounds tend to rapidly adsorb to sediment particles and therefore sediments can be considered as a pollution reservoir. Determine and direct measurement of bioavailability is not a easy task. Research into the bioavailability of pollutants in soil is rapidly intensifying, and the number of articles concerning the bioavailability of PAHs in soil and sediments is increasing every year (Bergknut et al., 2007). However, the concept of bioavailability lacks a formal definition and there is little agreement on what bioavailability means, how it should be measured, and how it should be calculated. The bioavailable fraction of persistent organic pollutants (POPs) in sediments is envisaged as the fraction of POPs in the matrix that can be taken up

by organisms. The most widely accepted theory concerning the uptake of chemicals by organisms in the soil is the equilibrium partitioning (EP) theory, i.e. that the bioavailability of POPs is controlled by equilibrium partitioning between the soil, water and the organisms (Sijm et al., 2000). Some deviations from expected EP results have been observed, which are usually attributed to sequestration of pollutants in the soil, the effects of feeding and biotransformation. Here, it was investigated the presence of PAHs in sediments and also the individual PAHs bioavailable. The concentration of total PAHs, in sediments samples, ranged from 238.0 to 745.1 ng/g, meanwhile the concentration of PAHs extracted by 1-butanol was a quite lower, ranged between 132.6 to 456.3 ng/g, most of them represented by acenphthene, fluorine, phenanthrene, anthracene and pyrene.

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MEASUREMENT OF METHYL MERCURY AND MERCURY (II) IN FISH TISSUES AND SEDIMENTS BY HPLC-ICPMS

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A procedure for the extraction and determination of methyl mercury and mercury (II) in fish muscle tissues and sediment samples is presented. The procedure involves extraction with 5% v/v 2-mercaptoethanol, separation and determination of mercury species by HPLC-ICPMS using a Perkin-Elmer 3 µm C8 (30 mm x 3 mm) and a mobile phase containing 0.5% v/v 2-mercaptoethanol and 5% v/v CH_3OH (pH 5.5) at a flow rate 1.5 ml min^{-1} and a temperature of 25^0C. Calibration curves for methyl mercury (I) and mercury (II) standards were linear in the range of 0 -100 mg l^{-1} (r^2 = 0.9990 and r^2 = 0.9995 respectively). The lowest measurable mercury was 0.4 mg l^{-1} which corresponds to 0.01 mg g^{-1} in fish tissues and sediments. Methyl mercury concentrations measured in biological certified reference materials, NRCC DORM - 2 Dog fish muscle NRCC Dolt - 3 Dogfish liver NIST RM 50 Albacore Tuna and IRMM IMEP-20 Tuna fish and sediment reference material ERM CC 580 were in agreement with the certified values

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POLICY AND PEOPLE: HOW NATURALLY OCCURRING ARSENIC SULPHIDES AFFECT THE CHEMISTRY OF MINERAL SPRING WATER CONSUMED IN REGIONAL VICTORIA.

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The Central Victorian Mineral Springs Region covers approximately 100 carbonated mineral water springs, several of which are in close proximity to gold mining by-products (mine waste, mullock heaps or tailings) and gold bearing materials. The mineral spring aquifers occur within a Palaeozoic sandstone-shale sequence containing accessory minerals including arsenic sulphides with respective average concentrations of 26.7 times that of typical lithospheric values. Arsenic and other metalloids commonly occur together in localised elevated concentrations in Earth's crust, particularly where gold mineralisation has taken place. Metalloids such as Arsenic and Antimony have a similar chemical behaviour, geochemistry, phytotoxicity and toxicity to higher organisms. The potential for aquifer contamination by surface and near-surface metalloids associated with mining and mining products is investigated.

Mineral spring water is often promoted for the therapeutic and medicinal qualities that it is believed to provide. In 2003, five of 36 samples taken from the Mineral Springs Region recorded Arsenic concentrations in excess of the Australian Drinking Water Guideline of 0.007 mg/L, with a maximum of 0.038 mg/L recorded at a popular tourist site. Such results have been recently repeated. This is of concern because long term exposure to Arsenic in drinking water causes bladder, lung and skin cancer, and may cause kidney and liver cancer. Despite this, the Central Victorian Mineral Springs water source points remain largely accessible to the public. Arguably, the need for good public policy is in conflict with the real need for tourist income in an area. The debate is further complicated by only modestly elevated Arsenic values in waters consumed by people who believe it is therapeutic. Such people may be physically compromised and hence be at elevated risk. The policy domain remains open and conflicted.

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ENVIRONMENTAL MONITORING OF EPHEMERAL STREAMS ON BASE METAL MINES IN THE QUEENSLAND DRY TROPICS – DERIVED WATER QUALITY CRITERIA FOR HEAVY METALS.

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Default trigger values for national, regional and subregional areas provided in ANZECC (2000) and the Queensland Water Quality Guidelines (DERM 2009) are generally considered inappropriate for ephemeral streams, which may experience exceptional variation in water quality in accordance with their high flow variability. Waters in the dry tropics and inland regions of Queensland are

particularly subject to extreme flows. Environmentally relevant activities (such as mining) operating in these environments are required to be monitored for impacts. The detection of ecologically significant impacts is hampered by the lack of locally-relevant trigger values for water quality in these ephemeral systems.

In the last ten years, NRA has undertaken seasonal compliance monitoring, involving biological (macroinvertebrate) and physio-chemical, water quality parameters, at over 30 sites on ephemeral streams on four base metal mining leases in the dry tropics of Far North Queensland. Using ecotoxicological data for aquatic species relevant to the sites being studies, we defined the maximum allowable limits for heavy metals (As, Cd, Cu, Pb, and Zn) and provided management triggers from statistical distributions of water quality data from reference sites. Findings from the monitoring program were then used to adjust the derived water quality criteria to local conditions. This study demonstrates how biological indicators and ecotoxicological information can be combined with water quality datasets to derive trigger values adapted to the hydrology and local chemistry of ephemeral systems.

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(2) DERM 2009. Queensland Water Quality Guidelines, Department of Environment and Resource Management, Brisbane.

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DEVELOPMENT OF A MARINE CHRONIC TOXICITY TEST USING THE MARINE AMPHIPOD *ALLORCHESTES COMPRESSA*

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Data from chronic toxicity tests can be used to estimate the effect of a substance to which aquatic organisms are exposed continuously during an entire reproductive life cycle or a significant portion of the organisms' life span. Chronic toxicity is favoured for deriving species' sensitivity distributions, to avoid the application of acute-to-chronic ratios. This is because chronic toxicity tests can provide a more sensitive measure of chemical toxicity than acute toxicity tests. The data from experiments with the marine amphipod *Allorchestes compressa* are used to illustrate the use of chronic toxicity tests for assessing the chronic toxicity of substances. *A. compressa* is a marine amphipod naturally occurring around Tasmania, Victoria, South Australia and Western Australia Waters. It has been successfully cultured in the laboratory and routinely used for toxicity assessments of chemicals and effluents. A chronic toxicity test with *A. compressa* encompasses the amphipods' reproductive cycle including fertilisation and embryo development, with the primary endpoint being fecundity. A chronic toxicity test was investigated and the following observations were made during the amphipods' reproductive cycle: (i) time taken for pairs to amplex, (ii) length of copulation period, (iii) the ratio of males to females required to obtain a breeding pair, and (iv) development of eggs and time to hatch. Preliminary results demonstrate that a 28-d test may be required. Fecundity is determined by counting the number of juveniles present. Additional endpoints also being explored include; the ability of reproducing adults to recover after stress, and the survival of juvenile amphipods post hatch. The proposed toxicity test is expected to be a useful tool for future water quality assessments.

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THE SPINY DAMSEL *ACANTHOCHROMIS POLYACANTHUS*: A POTENTIAL TEST ORGANISM FOR ECOTOXICITY TESTING?

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Toxicity testing with larval marine fish in Australia has been greatly restricted by the limited availability of species suitable for testing. Although pink snapper, yellow-tail kingfish and barramundi have been commonly used, there are a number of inherent problems associated with testing with these species. Firstly, they are difficult to breed in most laboratories due to the large size of breeding adults and the need for hormone induction to induce spawning. Secondly, these species generally exhibit seasonal spawning cycles, meaning larval fish are only available during certain times of the year. Finally, the larval fish have a low survival rate and intense rotifer cultivation is required to provide food to the larvae, making longer-term, chronic exposures difficult. Given these limitations, there is an urgent need to identify further fish species that can be readily adopted into ecotoxicity testing programmes in Australia.

The spiny damsel, *Acanthochromis polyacanthus*, is a tropical damselfish that may be a suitable test organism for ecotoxicity testing in Australia. This species can be easily maintained in the laboratory and can breed throughout the year without the need for hormonal induction. Adults form breeding pairs which will defend a nest site or substrate upon which eggs are laid and fertilised. Each breeding pair will lay around 300-400 eggs per clutch. Hatching occurs around 10-14 days after laying and hatching success and subsequent larval survival rate are very high compared to other fish species. Moreover, larval fish can be raised on newly-hatched brine shrimp, eliminating the need for rotifer cultivation. The entire life-cycle of the spiny damsel has been completely closed in the laboratory, making this species an ideal candidate for long-term, chronic toxicity testing.

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RESIDUAL EFFECTS OF TREATED MINE WATERS ON FIVE TROPICAL FRESHWATER SPECIES

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Water treatment is being increasingly used to remove potentially toxic contaminants from mine waters prior to discharge to the receiving environment. Water treatment at Ranger Uranium Mine, in the wet-dry tropics of northern Australia, commenced in 2005, firstly for Pond Water (PW; typical pH – 7.8; EC –1200 µS/cm; SO_4 –700 mg/L; U – 5 mg/L; NH_3 _N – 0.1 mg/L), then in 2009 for Process Water (PrW; typical pH – 3.9; EC – 26,000 µS/cm; SO_4 – 34,000 mg/L; U – 27 mg/L; NH_3_N – 900 mg/L). This study assessed the residual toxicity of treated PW and PrW on five tropical freshwater species (alga, macrophyte, cladoceran, hydra, fish). If effects were observed additional testing was done to attempt to determine the cause/s.

Water treatment resulted in the removal of the majority of major ions/metals in PW (pH – 6.2; EC – 20 µS/cm; SO_4 – 5.3 mg/L; U – 4 µg/L; NH_3_N – 0.015 mg/L) and PrW (pH – 8.3; EC – 91 µS/cm; SO_4 – 2.4 mg/L; U – 0.07 µg/L; NH_3_N – 6.8 mg/L). However, for treated PrW, residual ammonia still represented a potential ecotoxicological concern.

Treated PW exhibited toxicity only to the cladoceran, with an IC50 (reproduction) of around 100% (i.e. undiluted) treated PW. Additional experiments suggested the response was due to a nutrient/mineral limitation and/or a lack of dissolved organic carbon increasing U bioavailability in the treated PW. Significant effects of treated PrW were observed for all species above a concentration of 12.5% treated PrW. The responses ranged from growth stimulation (alga; 10-20% growth stimulation) to moderate toxicity (hydra IC50 – 26%, cladoceran IC50 – 78%). The effects, including the algal stimulatory response, are potentially due to the residual ammonia. Alternatively, or in addition, the low concentrations of nutrients (other than N) and essential trace elements may also have contributed to observed adverse effects. The findings of additional work to investigate this will be presented.

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COMPARISON OF DEGRADATION RATES BETWEEN INDIGENOUS AND SPIKED ORGANIC COMPOUNDS IN A BIOSOLIDS AMENDED SOIL

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Studies on degradation of organic compounds in soils are often conducted by spiking soils with compound(s) to higher than normal concentrations to facilitate detection. This spiking approach may not be suitable when considering degradation of organic compounds that are added to soils via biosolids application. This is because spiked compounds may sorb differently to solid particles compared to indigenous forms of the compounds that are present in biosolids. The aim of this study was to compare degradation rates of spiked and indigenous forms of selected organic compounds in a biosolids amended soil over 24 weeks. The compounds selected were 4-nonylphenol (4NP), 4-t-octylphenol (4tOP), triclosan (TCS) and bisphenol A (BPA). For 4tOP and 4NP, spiking was done by adding additional analytical grade material of the same compound, whereas for TCS and BPA, labelled surrogates were used (TCS $^{13}C_{12}$ and BPA d_{16}). For all compounds except TCS, the degradation rate of the spiked compounds was faster than for the indigenous compounds. After 8 weeks, all spiked 4NP and 4tOP had degraded, but approximately 20% of the indigenous compounds remained. For TCS, the total amount of the spiked (i.e. TCS $^{13}C_{12}$) and indigenous TCS that degraded was essentially the same (i.e., 61% and 67% respectively) after 24 weeks. In contrast, for BPA, the total amount of spiked compound (i.e. BPA d_{16}) that degraded was greater than that of the indigenous BPA (i.e., 89% and 70% respectively). This study indicates that both the rate and total amount of degradation of spiked compounds can differ from that of indigenous compounds. Therefore, use of spiked degradation data for these compounds (and potentially others) may not be suitable when assessing their persistence following land application of biosolids.

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CHRONIC TOXICITY AND DELAYED EFFECTS OF EXPOSURE TO METAL CONTAMINANTS IN A COMMON ANTARCTIC OSTRACOD

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While concentrations of contaminants in Antarctic marine waters are typically low, there are a number of near-shore sites in Antarctica, such as those adjacent to past waste disposal sites at research stations that have increased levels of contaminants, including the metals Cd, Cu, Pb, and Zn. To assess the risk associated with the mobilisation of these metals in melt-water streams into the marine environment, the chronic toxicity of metals to a common Antarctic ostracod (fam Hemicytheridae) were examined in non-renewable static tests. Ostracods were exposed to metals for 10 weeks at 0°C with daily observations of behaviour and survival for the first week followed by weekly observations for the remainder of the experiments. The ostracods exhibited sub-lethal behavioural responses in the first week of exposure; however, there was no significant impact on survival until 10 days (Cu LC50 >1000 µg/L). Toxicity increased with exposure time, with average LC50 values for Cu of 240 µg/L at 5 weeks and 120 µg/L at 10 weeks, concentrations more closely aligned with those reported for related temperate species after only 10 days exposure. The

sensitivity of ostracods increased in tests conducted at higher temperatures of 2 and 4°C. The response of Antarctic ostracods to metals was therefore delayed at 0°C, and may in part be attributed to reduced metabolic rate that is characteristic of Antarctic marine invertebrates living at constant low temperatures.

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ANALYSIS OF PERFLUORINATED COMPOUNDS IN HUMAN URINE : APPLICATION FOR HUMAN EXCRETION

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Perfluorinated compounds (PFCs) are ubiquitous in humans, however, no study assess human excretion to these compounds due to analytical method of PFCs in urine is limited. In this study, a rapid and reliable analytical method was developed and validated based on comparison of three extraction methods (i.e., Oasis WAX SPE, Oasis HLB SPE, ion-pair extraction), four clean-up procedures (i. e., Oasis WAX SPE, Oasis HLB SPE, Environ-carbon, Dionex OnGuard II), and two type of calibration curves (i.e., pure solvent calibration curve, matrix-matched calibration curve), for the determination of perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and other 7 PFCs in human urine. For the combined objectives of complete recovery and reduce matrix effects, we have chosen: (1) internal standard spiking prior to extraction; (2) extraction with Oasis WAX column; (3) clean-up with Environ-carbon particle; (4) analysis by ultra performance liquid chromatography with tandem quadrupole mass spectrometry (UPLC-MS/MS); (5) calculation with matrix-matched calibration curve. Mean recoveries of the target analytes based on matrix spikes, at different spike levels (0.02 to 0.2 ng/mL in urine), ranged from 60% to 148%. Relative standard deviations (RSDs) were in the range of 1% to 15% at different spike levels. The limit of quantification (LOQ) range 0.002 to 0.008 ng/mL. To our knowledge, this is first study to report analytical method of PFCs in urine.

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PERFLUORINATED COMPOUNDS IN HUMAN BLOOD, FRESHWATER FISH AND SEAFOOD FROM CHINA: REGIONAL AND GLOBAL IMPLICATIONS FOR HUMAN EXPOSURE

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Despite the growing public interest in perfluorinated compounds (PFCs), very few studies have reported the sources and pathways of human exposure to these compounds. In this study, concentrations of PFCs were measured in human blood (n=93) and freshwater fish and seafood (n=73) samples collected from China to determine residue levels, dietary intakes, regional differences in human exposures, and risk associated with ingestion of PFCs from a primary food source for the Chinese population. The highest mean perfluorooctane sulfonate (PFOS) concentration in human blood was 12.5 ng/mL (from Tianjin), and 25.4 ng/g wet wt (or 0.92 ng/g wet wt after excluding an outlier value) in freshwater fish and seafood. An anomalously high concentration of PFOS was found in a crucian carp collected from Wuhan at 1610 ng/g wet wt. The daily intake of PFOS, perfluorooctanoic acid (PFOA), and perfluoroundecanoic acid (PFUnDA) via fish and seafood consumption ($EDI_{fish\&seafood}$) ranged from 0.10 to 2.51, 0.13 to 0.38, and 0.16 to 0.32 ng/kg bw/d, respectively, for different age groups (i.e., toddlers, adolescents and children, and adults) from selected locations (i.e., Tianjin, Nanchang, Wuhan, Shenyang). The daily dietary PFC intake values increased ($p < 0.05$) with age. Comparison of $EDI_{fish\&seafood}$ values with the modeled total dietary intake (TDI) of PFCs by adults from Tianjin, Nanchang, Wuhan and Shenyang, showed that contributions of fish and seafood to TDI of PFOS varied depending on the location. Fish and seafood accounted for 6%, 25%, 80%, and 85% of PFOS intake in Nanchang, Shenyang, Wuhan and Tianjin, respectively, suggesting regional difference in human exposure to PFOS. Based on the export of fish and fishery products from China in 2009, the outflow of PFCs was estimated to range from 0.22 (perfluorohexane sulfonate, PFHxS) to 3.42 kg (PFOS); the outflow of PFOA, PFUnDA and sum of PFCs was 0.87, 0.84, and 6.59 kg, respectively.

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AIMS is a Commonwealth statutory authority established by the *Australian Institute of Marine Science*

Act 1972. To ensure that it is meeting the challenges facing marine ecosystems and the requirements of stakeholders, AIMS surveys and documents marine life from microbes to whole-of-ecosystems, and the processes that sustain them; monitors changes and identifies trends in the marine environment; and develops molecular tools and ocean technologies.
Fisheries, offshore oil and gas, mining, reef tourism and aquaculture industries have all benefited from AIMS research that is geared towards the protection and sustainable development of marine resources. These benefits will underwrite protection of Australia's marine biodiversity and new areas of the economy into the future.

SUPPORTERS

NRM
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Email: david.mussared@emailmedia.com.au
Web http://www.nrmjobs.com.au
NRMjobs.com.au advertises job vacancies in the environment, water and natural resource management field.
NRMjobs, founded in 1998, includes:
- an email bulletin which is sent to more than 24,000 subscribers each week
- a website which receives more than 60,000 visits per month

NRMjobs is targeted at people who work in the environment, water and natural resource management field in Australia and New Zealand.

Ecotox
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Email: rkrassoi@ecotox.com.au
The Ecotox Services Australasia (ESA) laboratory is an independent, NATA endorsed toxicity testing facility specifically designed to offer state-of-the-art testing facilities for the assessment of effluents, leachates, ground waters, receiving waters, chemicals and sediments using Australasian test species. The test organisms include marine, estuarine and freshwater species, both tropical and temperate. A key specialty of the ESA laboratory is its ability to identify actual causes of sample toxicity using Toxicity Identification Evaluation (TIE) procedures. ESA offer short lead times, rapid turnaround times and cost effective toxicity testing solutions.

EXHIBITORS

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Envirolab Services is a privately owned Australian company. The laboratory located in Sydney offers analytical testing services to the environmental sector nationwide.
The laboratory offers a wide array of analytical testing services to support environmental investigations focused on environmental chemistry, asbestos in soil and building material such as fibro and vinyl tiles, lead in paint and acid sulphate soils.

MEP
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MEP Instruments Pty Ltd is a joint venture company formed by scientific instrument manufacturers Metrohm (Switzerland) and Anton Paar (Austria) to market their respective products in Australia and New Zealand. Metrohm is the world leader in ion analysis using electrochemical techniques and the range of density and concentration instrumentation from Anton Paar is considered to be state of the art.

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SGS is the world's leading inspection, verification, testing and certification company. Recognised as the global benchmark for quality and integrity, we employ over 55 000 people and operate a network of more than 1 000 offices and laboratories around the world.
We help governments and industry integrate environmental management into their operations by providing a comprehensive international network of laboratories and environmental experts who deliver analytical and data interpretation services at both a global and local level.

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