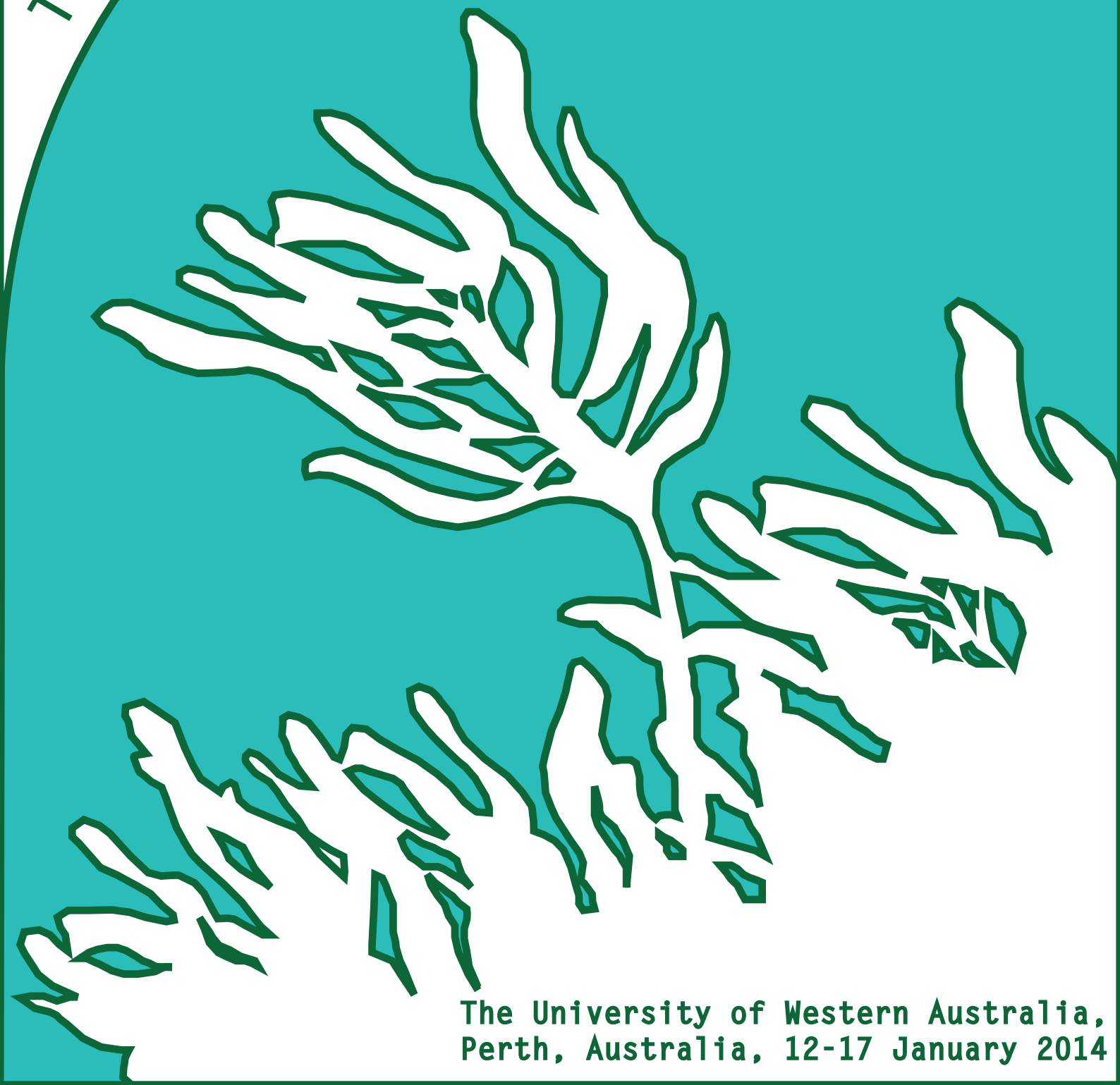
10th International Temperate Reefs Symposium

Abstract Book



The University of Western Australia,
Perth, Australia, 12-17 January 2014

Welcome to the 10th International Temperate Reefs Symposium!!

We are delighted that you could join us in Perth, for what is sure to be another fantastic ITRS, showcasing the best temperate reef science from around the globe. This year's event is very special, as we celebrate the 10th ITRS, since its inception in 1990 and host over 190 delegates from 24 countries, making it one of the biggest ITRS' to date.

The 10th ITRS will be hosted by the University of Western Australia through the Oceans Institute and the School of Plant Biology. The organising committee would like to acknowledge the Traditional Owners of the land hosting our conference, the Nyoongar People. We would like to pay respect to their Elders both past and present and extend that respect to other indigenous Australians.

The overarching theme for the 10th ITRS is *Ecological Transitions*. This theme captures the intention to explore diverse spatial, temporal, environmental and biotic transitions in temperate reef ecosystems in an inclusive way. The theme also recognizes that a key challenge for the future is linking mechanistic ecology with approaches that address global questions.

Inside this book you will find a detailed program of the conference, abstracts from all the oral and poster presentations and contact details of all the delegates.

Please feel free to come and chat to any of the organising committee if you need information on anything throughout the week.

Sincerely,

Thomas Wernberg, Gary Kendrick, Scott Bennett, Thibaut de Bettignies, Paul Lavery, Mat Vanderklift
10th ITRS Organising Committee

10th International Temperate Reefs Symposium

The University of Western Australia 12-17 January 2014

Thank you to our Sponsors!

The 10th International Temperate Reefs Symposium, would not be possible without the generous support of our sponsors; The University of Western Australia, CSIRO, the Government of Western Australia Department of Fisheries, Oceanica, CSIRO publishing and Edith Cowan University.

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Contents

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Detailed Program

Sunday 12 January 2014

Registration	
1500 - 1800	Registration, welcome beers and games
Room	UWA GUILD: REFECTORY

Oral Presentations, Monday 13 January 2014

800 – 830	Registration, Tea & Coffee (in front of Willsmore & Tattershalle LT's)	
Welcome		
Room	WILLSMORE LECTURE THEATRE	
830 – 930	**Thomas Wernberg** – ITRS Organising Committee, **Len Collard** – Nyoongar People, Welcome to Country, **Lyn Beazley** – Chief Scientist of Western Australia, **Paul Johnson** – Vice Chancellor of UWA **Glenn Shiell** – BMT Oceanica, welcome sponsor	
Plenary		
Room	WILLSMORE LECTURE THEATRE	
930 – 1030	*The value of a long-term perspective in understanding short-term dynamics of giant kelp ecosystems.* **Dan Reed**, University of California Santa Barbara, USA	
1030 – 1110	**Morning Tea (Refectory)**	
	Session 1: Global change biology and ecology	**Session 2: Environmental and biological drivers of ecological function**
Room	WILLSMORE LT	TATTERSHALLE LT
Chair	**Gray Williams**	**Gee Chapman**
1110 - 1140	**Theme Keynote:** *How long is too short: are we currently overestimating the potential effects of climate change?* **Bayden Russell**, The University of Adelaide, AUSTRALIA	**Theme Keynote:** *Implications of mechanisms of succession to rockweed communities of the northwest Atlantic Ocean.* **Steve Dudgeon**, California State University Northridge, USA
1140 - 1200	*In a high CO2 world, herbivores do not lose their appetites.* **Kathryn Anderson**, University of British Columbia, CANADA	*Functional roles and compensatory potential at regional scales: range shift in intertidal grazers and consequences for community composition.* **Moisés Andres Aguilera Moya**, Centro De Estudios Avanzados En Zonas Áridas (CEAZA), CHILE
1200 - 1220	*Changes in macrophyte chemistry alters herbivory along a natural gradient of CO2.* **Pippa Moore**, Aberystwyth University, UNITED KINGDOM	*Strong impacts of small arthropods on algal epiphytes in subtidal coralline turf.* **Anna Berthelsen**, The University of Auckland, NEW ZEALAND
1220-1240	*Phytobenthic community development under static and diurnally fluctuating pH.* **Catriona Hurd**, University of Tasmania, AUSTRALIA	*Influence of light on the interactions between Ascophyllum nodossum and Littorina littorea and L. obtusata.* **Sergio Coelho-Souza**, Universidade de Santo Amaro, BRAZIL
1240-1300	*Role of macroalgal canopies in ameliorating the effects of ocean acidification on coralline algae.* **Christopher Cornwall**, IMAS, University of Tasmania, AUSTRALIA	*Comparison of the ecological functioning of mussels between upwelling and non-upwelling areas.* **Victoria Cole**, University of Western Sydney, AUSTRALIA
1300-1420	**Lunch (Refectory)**	

Continued: Oral Presentations, Monday 13 January 2014

	Session 3: Global change biology and ecology	Session 4: Environmental and biological drivers of ecological function
Room	WILLSMORE LT	TATTERSHALLE LT
Chair	**Pippa Moore**	**Jeong Ha Kim**
1420-1440	*Why are phase-shifts uncommon and will they become more common in the future?* **Sean Connell**, The University of Adelaide, AUSTRALIA	*Deposition on a biogenic reef and the impact of temperature.* **Flora Kent**, Heriot-Watt University, UK
1440-1500	*Where will Macrocystis be in tropicalized oceans?* **Mike Foster**, Moss Landing Marine Laboratories, USA	*Patterns of grazing, landscape structure and assemblage structure along a latitudinal gradient in ocean climate.* **Joao Franco**, CIIMAR, Universidade do Porto, PORTUGAL
1500-1520	*Ecological consequences of extreme events in marine ecosystems* **Dan Smale**, Marine Biological Association of the UK, UNITED KINGDOM	*Does who you are or where you are determine your orientation?* **Clarissa Fraser**, The University of Sydney, AUSTRALIA
1520 - 1540	*Recovery of grazed kelp forests in northeast Atlantic - the influence of climate change and environmental factors.* **Eli Rinde**, Norwegian Institue for water research (NIVA), NORWAY	*Sea otter recolonization and conflict with shellfish fisheries in southern Southeast Alaska.* **Zachary Hoyt**, University of Alaska Fairbanks, USA
1540 - 1600	*Resistance to change: could kelp forests limit the effects of modified climates and nutrient pollution?* **Laura Falkenberg**, The University of Adelaide, AUSTRALIA	*Organic matter supply in European kelp forests: temporal variations and consequences on community structures.* **Jean-Charles Leclerc**, UPMC - Station Biologique Roscoff, FRANCE
1600 - 1640	**Afternoon Tea (Refectory)**	
	Casual Plenary	
Room	WILLSMORE LECTURE THEATRE	
Chair	**Lisandro Benedetti-Cecchi**	
1640 – 1720	*Looking back and looking forward: the role of surveys, experiments and importance of natural history in temperate reef ecology* **Steve Hawkins,** Centre for Biological Sciences, University of Southampton, UK	
1720 - 1730	**Group Photo**	
1730 – 1900	**Icebreaker (Refectory)**	

Oral Presentations, Tuesday 14 January 2014

815 – 845	Registration, Tea & Coffee (in front of Willsmore & Tattershalle LT's)		
845 – 900	House Keeping (Willsmore LT)		
	Plenary		
Room	WILLSMORE LECTURE THEATRE		
900 – 1000	*Cusps and butterflies: multiple stable states in marine systems as catastrophes.* **Peter Petraitis**, University of Pennsylvania, USA		
1000 – 1040	**Morning Tea (Refectory)**		
	Session 5: Thresholds of change	**Session 6: Human impacts**	**Session 7: General temperate reef science**
Room	WILLSMORE LT	TATTERSHALLE LT	SIMMONDS LT
Chair	**Sean Connell**	**Andy Davis**	**Gary Kendrick**
1040 – 1110	**Theme Keynote:** *Phase shifts and stressor-driven dynamics in kelp beds* **Craig Johnson**, IMAS, University of Tasmania, AUSTRALIA	**Theme Keynote:** *Artificial coastal defences: enhancing biodiversity using sensitive design.* **Louise Firth**, National University of Ireland Galway, IRELAND	**Theme Keynote**: *Simple patterns can emerge from complex interactions: habitat segregation between indigenous and invasive mussels.* **Christopher McQuaid**, Rhodes University, SOUTH AFRICA
1110 – 1130	*Experimental evidence of critical slowing down and early warning signals of regime shifts in rocky intertidal assemblages.* **Lisandro Benedetti-Cecchi**, University of Pisa, ITALY	*Building-in beneficial features: artificial rockpool case study.* **Ally Evans**, Aberystwyth University, UNITED KINGDOM	*Convergent corallines: material strength in independently evolving geniculate lineages.* **Kyra Janot**, University of British Columbia, CANADA
1130 – 1150	*Ecological limits to acclimation: Seaweed responses to latitudinal translocation* **Scott Bennett**, The University of Western Australia, AUSTRALIA	*Engineering structural complexity for enhancing biodiversity on seawalls.* **Lynette Loke**, University of Singapore, SINGAPORE	*Distributional patterns of urchin barrens and correlation between urchins and macroalgae in the rocky coast of Korea.* **Jeong Ha Kim,** Sungkyunkwan University, SOUTH KOREA
1150 - 1210	*Can top down multitrophic interactions be important drivers for the observed recovery of kelp in previously grazed areas in northeast Atlantic?* **Hartvig Christie**, Norwegian Institue for water research, NORWAY	*The effects of contaminants on ecosystem functioning.* **Mariana Mayer Pinto**, University of New South Wales, AUSTRALIA	*Anti-predator responses of the mussel Perna perna to single and combined predators with different attack modes.* **Maria Soledad Lopez**, Universidade de São Paulo, BRAZIL
1210-1230	*Loss of kelp forests and the tropicalisation of a temperate marine ecosystem* **Thomas Wernberg**, The University of Western Australia, AUSTRALIA	*Benthic productivity on artificial structures: maximising the benefit of marine renewable energy.* **Sally Rouse**, Scottish Association for Marine Science, UK	*Sex on the beach: a cocktail of behavioural repertoires which drive size-assortative mating in rocky shore littorinids?* **Terence Ng**, The University of Hong Kong, CHINA
1230-1250	*Global phase-shift dynamics of catastrophic sea urchin overgrazing.* **Scott Ling**, IMAS, University of Tasmania, AUSTRALIA	*Classifying benthic biotopes and reef fish assemblages on continental shelf reefs in SE Queensland: how useful are abiotic surrogates?* **Tim Stevens** Griffith University, AUSTRALIA	*An innovative statistical approach to constructing a readily comprehensible food web for a temperate demersal fish community.* **Ben French**, Murdoch University, AUSTRALIA
1250-1410	**Lunch (Refectory)**		

Continued: Oral Presentations, Tuesday 14 January 2014

	Session 8: Thresholds of change	Session 9: Human impacts	Session 10: General temperate reef science
Room	WILLSMORE LT	TATTERSHALLE LT	SIMMONDS LT
Chair	**Catriona Hurd**	**Steve Swearer**	**Paul Lavery**
1410 - 1430	*Compounded perturbations: effects of climate-related mechanical disturbance and nutrient enrichment on rock pool assemblages in N Portugal.* **Iacopo Bertocci,** CIIMAR, Universidade do Porto, PORTUGAL	*Restoring underwater forests: temporal and spatial variability.* **Ezequiel Marzinelli**, University of New South Wales, AUSTRALIA	*The Wheeler North Reef as a test case for the production vs. attraction hypothesis for reef fish.* **Stephen Schroeter**, University of California Santa Barbara, USA
1430 – 1450	*How water motion, canopy density and shading interact to effect canopy saturation state.* **Kathryn McMahon**, Edith Cowan University, AUSTRALIA	*Two decades of surveys in Tasmanian marine reserves reveal single species to system wide effects of fishing, resistance to species invasion and responses to climate change.* **Neville Barrett**, IMAS, University of Tasmania, AUSTRALIA	*Distribution of urchin barrens on Australia's east coast: Latitudinal trends in maximum depth revealed with an AUV.* **Nicholas Perkins**, IMAS, University of Tasmania, AUSTRALIA
1450 - 1510	*The ecological consequences of disturbance to the ecosystem engineer Ascophyllum nodosum on the south British coast.* **Jacqui Pocklington**, Museum Victoria, AUSTRALIA	*Luderick, Girella tricuspidata, exhibit strong site fidelity and higher abundance within marine sanctuaries.* **Adrian Ferguson**, The University of Western Australia, AUSTRALIA	*Thermal sensitivity and behavior's role in driving the output of an intertidal predator-prey interaction.* **Cristian Monaco**, University of South Carolina, USA
1510 - 1530	*Disturbance-oriented tactics of a coastal invader and its contribution to diversity and production of low-shore communities.* **Paul South**, University of Canterbury, NEW ZEALAND	*Drawing lines at the sand: evidence for functional vs. visual reef boundaries in temperate Marine Protected Areas.* **Emma Sheehan**, Plymouth University Marine Institute, UNITED KINGDOM	*Population structure and phylogeography of Pterocladiella capillacea (Gelidiales, Rhodophyta) based on plastid rbcL and mitochondrial cox1 and cob.* **Ga Hun Boo**, Chungnam National University, SOUTH KOREA
1530 - 1550	*Can compensatory mechanisms counter-balance the effects of increasing multiple stressors?* **Giulia Ghedini**, The University of Adelaide, AUSTRALIA	*Strong direct and inconsistent indirect effects of fishing found using stereo-video: testing indicators from fisheries closures.* **Tim Langlois**, The University of Western Australia, AUSTRALIA	*The influence of habitat characteristics on the abundance of three key herbivorous fish species (Kyphosidae) in temperate waters.* **Aldo Turco**, Edith Cowan University, AUSTRALIA
1550 - 1610	*Heritability of fitness traits in Ecklonia radiata.* **Chris Mabin**, Australian Maritime College, University of Tasmania, AUSTRALIA	*Developing long-term monitoring programs in offshore waters with little prior knowledge: Applying a novel sampling design to inventory biological assets.* **Nicole Hill**, IMAS, University of Tasmania, AUSTRALIA	*Coralline turf - fucoid interactions: impacts of sedimentation and implications for macroalgal assemblage function.* **Tommaso Alestra**, University of Canterbury, NEW ZEALAND
1610 - 1900	**Poster Session (Refectory)**		

Oral Presentations, Wednesday 15 January 2014

815 – 845	Registration, Tea & Coffee (in front of Willsmore & Tattershalle LT's)		
845 – 900	House Keeping (Willsmore LT)		
	Plenary		
Room	WILLSMORE LECTURE THEATRE		
900 – 1000	*Zooming in on climate change: ecological modulation at biological relevant scales.* **Martin Wahl**, GEOMAR, GERMANY		
1000 – 1040	**Morning Tea (Refectory)**		
	Session 11: Global change biology and ecology	**Session 12: Human impacts**	**Session 13: Ecology in the 21st century**
Room	WILLSMORE LT	TATTERSHALLE LT	SIMMONDS LT
Chair	**Adriana Vergés**	**Jonne Kotta**	**Neville Barrett**
1040 – 1110	**Theme Keynote:** *Impacts of climate change on temperate and subtropical coastal species.* **Elvira Poloczanska**, CSIRO, AUSTRALIA	**Theme Keynote:** *Experimental evidence for invasion impacts on temperate reefs.* **Mads Thomsen**, University of Canterbury, NEW ZEALAND	**Theme Keynote:** *The Big Sea Survey: Involving the community in monitoring change in coastal environments.* **Heather Sugden**, Newcatle University, UNITED KINGDOM
1110 – 1130	*Competition with filamentous algae obscures the negative effects of ocean acidification on Hydrolithoideae crustose coralline algae.* **Jessie Short**, The University of Western Australia, AUSTRALIA	*Disturbance does not always promotes invasion success on shallow rocky reefs.* **Fabio Bulleri**, Università di Pisa, ITALY	*How to mobilise gen-millennium: engaging educators in marine citizen science.* **Geraldine Davis**, Earthwatch Institute Australia, AUSTRALIA
1130 – 1150	*Effects of a submarine eruption on the performance of two brown seaweeds.* **Fernando Tuya**, Universidad de Las Palmas de G.C., SPAIN	*Effect of the receiving assemblage on habitat invasibility.* **Ana Bugnot**, The University of Sydney, AUSTRALIA	*Timing your run: Exposure to fishing of Snapper (Pagrus auratus) migrating to and from an annual spawning aggregation site.* **Brett Crisafulli**, Department of Fisheries Western Australia, AUSTRALIA
1150 - 1210	*Ecological responses to ocean acidification by marine fouling communities undergoing ascidian invasion.* **Norah Brown**, University of British Columbia, CANADA	*Managing the risk of sea urchin barrens in eastern Tasmania.* **Martin Marzloff**, IMAS, University of Tasmania, AUSTRALIA	*A unique opportunity to study the recruitment, growth and ecology of juvenile WA dhufish in situ, utilising 21st century techniques.* **Paul Lewis**, Department of Fisheries Western Australia, AUSTRALIA
1210-1230	*Sex ratios at range edges of protandric patellid limpets: what are the roles of density dependence and recruitment?* **Steve Hawkins**, University of Southampton, UNITED KINGDOM	*Environmental management of benthic macro-algal communities: is hypothesis testing an appropriate management tool?* **Glenn Shiell**, BMT Oceanica, AUSTRALIA	*Breathing life into fisheries stock assessments through citizen science.* **David Fairclough**, Department of Fisheries Western Australia, AUSTRALIA
1230-1250	*Impacts of climate change on biogenic habitat-forming seaweeds in southeastern Australia.* **Emma Flukes**, IMAS, University of Tasmania, AUSTRALIA	*Effect of canopy removal on intertidal biodiversity and ecosystem functioning: a long-term experiment on the commercial seaweed Ascophyllum nodosum.* **Dominique Davoult**, UPMC - Station Biologique Roscoff, FRANCE	*A short crepuscular changeover period in a temperate reef fish assemblage in Western Australia.* **Elisabeth Myers**, The University of Western Australia, AUSTRALIA
1250-1410	**Lunch (Refectory)**		

Continued: Oral Presentations, Wednesday 15 January 2014

	Session 14: Global change biology and ecology	Session 15: Human impacts	Session 16: Ecology in the 21st century
Room	WILLSMORE LT	TATTERSHALLE LT	SIMMONDS LT
Chair	**Scott Bennett**	**Glenn Shiell**	**Nicole Hill**
1410 - 1430	*Tropicalisation of temperate marine ecosystems: Herbivore-mediated phase-shifts from kelp to coral in eastern Australia?* **Adriana Vergés**, University of New South Wales, AUSTRALIA	*Effects of copper exposure on early life stages of Macrocystis pyrifera and Undaria pinnatifida (Laminariales, Phaeophyceae).* **Pablo Leal Sandoval**, University of Otago, NEW ZEALAND	*Modeling an inscrutable species: A case study of the Western Rock Lobster.* **Renae Hovey**, The University of Western Australia, AUSTRALIA
1430 – 1450	*Taking the acid test: Mediterranean limpets face up to climate change.* **Gray Williams**, The University of Hong Kong, CHINA	*Can management of local anthropogenic stressors improve the resilience of threaten habitats to global climate change?* **Elisabeth Strain**, University of Bologna, ITALY	*Spectral or spatial variability in remote sensing signal – which is the best indicator of benthic species richness?* **Tiit Kutser**, University of Tartu, ESTONIA
1450 - 1510	*Transcriptomics to ecosystems approach reveals response mechanisms of temperate reef species to multiple stressors.* **Nova Mieszkowska**, Marine Biological Association of the UK, UNITED KINGDOM	*A method for estimating the potential impact of desalination plant ocean intake on nearshore larval fish populations.* **John Steinbeck**, Tenera Environmental Inc, USA	*Remotely studying shifts in dominant marine species through the eyes of robots (AUVs)* **Gary Kendrick**, The University of Western Australia, AUSTRALIA
1510 - 1530	*Physiological responses of habitat forming seaweeds to increase in ocean temperatures.* **Bijo Arackal**, The University of Western Australia, AUSTRALIA	*Marine litter: we know a lot less about it than we should.* **Gee Chapman**, The University of Sydney, AUSTRALIA	*Building open source software tools for cost effective habitat mapping of temperate shallow subtidal reefs.* **Jared Kibele**, The University of Auckland, NEW ZEALAND
1530 - 1610	**Afternoon Tea (Refectory)**		

Continued: Oral Presentations, Wednesday 15 January 2014

	Session 17: General temperate reef science	Session 18: Environmental and biological drivers of ecological function	Session 19: Ecology in the 21st century
Room	WILLSMORE LT	TATTERSHALLE LT	SIMMONDS LT
Chair	**Jeff Wright**	**Fernando Tuya**	**Dan Smale**
1610 - 1630	*Estimating productivity in marine environments: acoustic propagation modelling and in situ acoustic measurements in Ecklonia radiata kelp forests*. **Jo Randall**, IMAS, University of Tasmania, AUSTRALIA	*Effect of light, zoospore density and understory algae on Ecklonia radiata recruitment.* **Masayuki Tatsumi**, Australian Maritime College, University of Tasmania, AUSTRALIA	*The big picture: imaging and mapping intertidal rocky shores with a remotely piloted aircraft.* **Michael T. Burrows**, Scottish Association for Marine Science, UNITED KINGDOM
1630 - 1650	*A novel system for measuring kelp productivity and studying climatic stressors on kelp forest ecosystems* **Kirsten Rodgers**, The University of Auckland, NEW ZEALAND	*The influence of frequency and intensity of disturbance on kelp recovery and community dynamics.* **Paul Carnell**, The University of Melbourne, AUSTRALIA	*Running too hot: satellite-derived high resolution sea surface temperatures (HRSST) largely miss near-shore upwelling.* **Fernando Lima,** CIBIO, Universidade do Porto, PORTUGAL
1650 - 1710	*Phenotypic plasticity in morphology and physiology in marginal versus central populations of the habitat-forming macroalga, Hormosira banksii.* **Jennifer Clark**, University of Technology, Sydney, AUSTRALIA	*Bioengineering by oysters across climatic gradients.* **Dominic Mcafee**, Macquarie University, AUSTRALIA	*Growing blue-green cyanobacteria-based biofilms on experimental sandstone units.* **Sonia Brazao**, The University of Sydney, AUSTRALIA
	Casual Plenary		
Room	WILLSMORE LECTURE THEATRE		
Chair	**Mike Foster**		
1710 - 1750	*From there to here: a journey through the Middle Earth of temperate reef science over the ITRS years* **David Schiel**, Marine Ecology Research Group, University of Canterbury, NZ		
1750 - 1830	**Debrief (Refectory)**		

	Public Forum
Room	University Club
1900 – 2000	*The forgotten coast: the state and future of Australia's temperate reefs*

Oral Presentations, Thursday 16 January 2014

815 – 845	Registration, tea & coffee (in front of Willsmore & Tattershalle LT's)	
845 – 900	House keeping (Willsmore LT)	
	Plenary	
Room	WILLSMORE LECTURE THEATRE	
900 – 1000	*What will managers need from temperate reef scientists to manage under climate change?* **Alistair Hobday**, CSIRO, AUSTRALIA	
1000 – 1040	**Morning Tea (Refectory)**	
	Session 20: Long time series and broad spatial scales	**Session 21: Environmental and biological drivers of ecological function**
Room	WILLSMORE LT	TATTERSHALLE LT
Chair	**Mat Vanderklift**	**Ross Coleman**
1040 – 1110	**Theme Keynote:** *Causes of change in intertidal assemblages: analyses of 30 years of observation and experiments.* **Tony Underwood**, The University of Sydney, AUSTRALIA	**Theme Keynote:** *Environmental change and marine disease: are disruptions to macro-micro interactions contributing to declines of habitat-forming macroalgae?* **Alexandra Campbell**, University of New South Wales, AUSTRALIA
1110 – 1130	*Spatial variation of the dietary regime of two filter feeders along the South African rocky coast: fatty acid and stable isotope approaches.* **Eleonora Puccinelli**, Rhodes University, SOUTH AFRICA	*Wave-exposure rapidly induced changes in morphological seaweed traits that modify trophic interactions with grazers.* **Markus Molis,** Alfred-Wegener Institut, GERMANY
1130 – 1150	*Continental-scale patterns and environmental drivers of population ecology of a ubiquitous habitat-forming kelp (Ecklonia radiata)* **Thibaut de Bettignies**, The University of Western Australia, AUSTRALIA	*Inter-specific variation of monthly recruitment rates in two biological models of rocky shores: spatial consistency of the temporal trends.* **Ronaldo Christofoletti,** Universidade de São Paulo, BRAZIL
1150 – 1210	*Long term patterns in assemblage structure on intertidal rock platforms at Rottnest Island, Western Australia.* **Jane Prince**, The University of Western Australia, AUSTRALIA	*Endophytic infection in a habitat-forming macroalga: a potential contributor to recent decline?* **Tamsin Peters**, University of New South Wales, AUSTRALIA
1210 – 1230	*How has a changing coastal climate affected the long-term dynamics of habitat-forming algae and their associated communities?* **Stacie Lilley**, University of Canterbury, NEW ZEALAND	*The first reproducing crab species in the Baltic Sea – the invasion and impacts of Rhithropanopeus harrisii.* **Jonne Kotta**, Estonian Marine Insitute, University of Tartu, ESTONIA
1230 – 1250	*Latitudinal patterns in temperature, aren't.* **Rui Seabra**, CIBIO, Universidade do Porto, PORTUGAL	*The role of chemical defences of kelp in fighting disease.* **Rebecca Neumann**, University of New South Wales, AUSTRALIA
1250-1410	**Lunch (Refectory)**	

Continued: Oral Presentations, Thursday 16 January 2014

	Session 22: Long time series and broad spatial scales	Session 23: Environmental and biological drivers of ecological function
Room	WILLSMORE LT	TATTERSHALLE LT
Chair	**Scott Ling**	**Thibaut de Bettignies**
1410 - 1430	*The abiotic context for ecological change in coastal waters of New Zealand: a changing coastal climate over the past several decades.* **David Schiel**, University of Canterbury, NEW ZEALAND	*Who and here: social interactions as an explanation for grouping in limpets .* **Ross Coleman**, The University of Sydney, AUSTRALIA
1430 – 1450	*Using Niche Modelling and different paleo-scenarios to explain the antitropical distribution of Sargassum subgenus Bactrophycus* **Lydiane Mattio**, University of Cape Town, SOUTH AFRICA	*Predation risk outweighs effects of climate change on grazer activity.* **Nicole Mertens**, The University of Adelaide, AUSTRALIA
1450 - 1510	*Longitudinal variation and effects of habitat on biodiversity of Australasian temperate reef fishes.* **Helen Smith**, Massey University, NEW ZEALAND	*Herbivory by Parma mccullochi (Pomacentridae): its diet and impact on temperate algal-dominate reef.* **Federico Vitelli**, Edith Cowan University, AUSTRALIA
1510 - 1530	*Do the marine bioregions predict patterns of biodiversity? A test of the marine bioregional boundaries of Australia using gastropod assemblages as a model fauna.* **Rodrigo Rodolfo Roman Pena**, EICC, The University of Sydney, AUSTRALIA	*Indirect facilitation of herbivores by suspension feeding mussel Mytilus trossulus in a brackish water benthic community.* **Velda Lauringson**, University of Tartu, ESTONIA
1530 - 1610	**Afternoon Tea (Refectory)**	
	Session 24: Long time series and broad spatial scales	**Session 25: Environmental and biological drivers of ecological function**
Room	WILLSMORE LT	TATTERSHALLE LT
Chair	**Jane Prince**	**Tim Langlois**
1610 - 1630	*Spicule armament and defense in temperate zone sponges: a transcontinental comparison.* **Andy Davis**, University of Wollongong, AUSTRALIA	*Realizing connectivity- the influence of early life history on the dynamics of marine metapopulations.* **Steve Swearer**, University of Melbourne, AUSTRALIA
1630 - 1640	*The role of food limitation on reproductive capacity and larval recruitment in purple sea urchins.* **Daniel Okamoto**, University of California, Santa Barbara, USA	*Deconstructing marine metapopulation persistence: dynamic modelling reveals key biological and physical drivers.* **Eric Treml**, University of Melbourne, AUSTRALIA
1640 - 1700	*The effects of the environment on the reproduction and early performance of the habitat-forming kelp Ecklonia radiata.* **Margie Mohring**, The University of Western Australia, AUSTRALIA	*Mechanisms enhancing ecosystem function in diverse macroalgal assemblages.* **Leigh Tait**, University of Canterbury, NEW ZEALAND

ITRS Conference dinner & diso	
1830 – 2130	University Club
2130 - 2400	Refectory Disco Bar

Oral Presentations, Friday 17 January 2014

	Late start; check-out	
1000 – 1030	**Registration & Morning Tea (Refectory)**	
1030 - 1040	House Keeping (Willsmore LT)	
	Session 26:Environmental and biological drivers of ecological function	**Session 27: Global change biology and ecology**
Room	WILLSMORE LT	TATTERSHALLE LT
Chair	**Vicky Cole**	**Kathryn McMahon**
1040 – 1100	*Effects of predator and competitor presence on larval settlement preference behaviour in intertidal mussels.* **Charles von der Meden**, South African Environmental Observation Network, SOUTH AFRICA	*Effect of nitrogen source on nutrient uptake and pH change at the surface of Macrocystis pyrifera blades.* **Pamela Fernandez Subiabre**, University of Otago, NEW ZEALAND
1100 – 1120	*Responses to habitat-loss: complex, complicated or both.* **Miguel Matias**, CIBIO, Universidade do Porto, PORTUGAL	*Direct and indirect effects of ocean acidification and warming on predator-prey dynamics.* **Ben Harvey**, Aberystwyth University, UNITED KINGDOM
1120 – 1140	*Population and harem dynamics of a marine isopod.* **Pablo Munguia**, The University of Adelaide, AUSTRALIA	*The adaptive potential of Heliocidaris tuberculata to ocean warming and ocean acidification: effects of climate change on the proteome.* **Shawna Foo**, The University of Sydney, AUSTRALIA
1140 - 1200	*Interactive effects of larval history, location and habitat on juvenile performance in a temperate reef fish.* **Anna Smith**, URS, AUSTRALIA	*Grazers influence the trophic dynamics of tropical rocky reefs: carbon use and ecological thresholds in alternate community states.* **Tak-Cheung Wai**, City University of Hong Kong, CHINA
1200-1220	*Different host, different guests? Effects of the presence of the invasive seaweed Undaria pinnatifida on native epifaunal communities.* **Rocio Suarez Jimenez,** Univeristy of Otago, NEW ZEALAND	*Can Septifer virgatus survive in a warming world? A Dynamic Energy Budget model approach.* **Luk In Michelle**, Swire Institute of Marine Science, University of Hong Kong, CHINA
1220-1240	*Effects of anthropogenic pressures on the structure of Cystoseira assemblages in the northern Adriatic Sea.* **Ljiljana Iveša**, Center for Marine Research Rovinj, CROATIA	*Factors driving the biogeographical distribution of two temperate Australian damselfishes and ramifications for range shifts.* **Ronen Galaiduk**, The University of Western Australia, AUSTRALIA
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	Session 28: Environmental and biological drivers of ecological function	Session 29: Global change biology and ecology
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1400 - 1420	*Coastal processes, turbulence and behaviour: a preliminary bio-physical integration of larval distribution from a 24-hour survey.* **Francesca Porri,** South African Institute for Aquatic Biodiversity (SAIAB), SOUTH AFRICA	*Is baldie moving south? Evidence for southern range expansion in WA endemic baldchin groper (Choerodon rubescens).* **Katherine Cure**, The University of Western Australia, AUSTRALIA
1420 – 1440	*Effects of isolation and habitat size are mediated by species dispersal ability.* **Gustavo Martins**, CIIMAR, Universidade do Porto, PORTUGAL	*The Physiological Adaptions of Intertidal Gastropods to a Highly Variable Thermal Environment.* **Yunwei Dong**, Xiamen University, CHINA
1440 - 1500	*How far to feed? Central-place foraging of the sand-bubbler crab Scopimera intermedia.* **Hui Tin Yan**, Swire Institute of Marine Science the University of Hong Kong, CHINA	*The impact of ocean acidification on the predation of populations of the Pacific oyster Crassostrea gigas.* **John Wright**, University of Western Sydney, AUSTRALIA
Closing of the 10th ITRS		
Room	WILLSMORE LECTURE THEATRE	
1500 - 1550	Prizes, announcement of next ITRS	

1600 – 1900	**Kelp Ecosystems Ecology Network (KEEN) workshop** Convenors: Jarrett Byrnes & Thomas Wernberg
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Facing the heat: does body orientation reduce desiccation and thermal stress in limpets? **Clarissa Fraser**, The University of Sydney, AUSTRALIA	4
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Environmental correlates of isotopic variation in primary producers and consumers within a temperate coastal ecosystem. **Andrew Mackey**, Edith Cowan University, AUSTRALIA	7
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Morning plenaries

What will managers need from temperate reef scientists to manage under climate change?

Alistair Hobday[1]

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Temperate reef systems around the world have provided clear and uncontested evidence for the impacts of climate change in the oceans, including species-level distribution, abundance, physiological and phenology changes and community-level ecosystem changes. Recent examples of dramatic change in response to extreme weather events also provide insight into possible reef futures and raise the profile of marine impacts with coastal managers and policy makers. The focus on climate as a driver of reef changes follows much historical work on the effects of pollution, fisheries, and natural climate variability, and as such, many of the observational and experimental techniques have not been greatly modified to accommodate the climate focus. However, the pervasive and diffuse nature of climate change differs from these historical, often point-source, drivers. Thus, while detection of impacts on reefs was relatively easy, as documented in recent IPCC summaries, clear attribution of change is more difficult as patterns, processes and interactions have global, regional and local scale contributions from both climate and non-climate drivers. As a result, an adaptive management approach has been advocated, in which large scale "experimental" approaches may provide evidence that can support ongoing management actions to reduce the impacts of climate change. However, large-scale experiments, perhaps taking advantage of natural laboratories such as global warming hotspots, represent only part of the strategy to develop wise adaptation options, particularly given political imperatives for safe outcomes, and recent awareness of the prevalence of antagonistic drivers in marine systems. A spectrum of approaches, underpinned by observing systems, small and large-scale experiments, simulation modelling, data sharing, and partnership with management agencies to foster knowledge transfer will be needed to see temperate reefs managed such that ecosystems services continue to be provided under somewhat gloomy climate projections.

Cusps and butterflies: multiple stable states in marine systems as catastrophes

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Ecologists usually view smooth threshold-like shifts and sudden discontinuous jumps in stable states as an either/or proposition. This need not be the case, and using only graphs and no equations, it will be shown how it is possible to have a single model containing one, two or three stable points. This is not a new idea and the basics, known as catastrophe theory, were developed in the 1960s, and are well known to engineers and physicists. Systems with two stable points, which are known as cusp catastrophes, and those with three points, which are known as butterfly catastrophes, will be introduced without equations. It has also been well known since the 1960s that there are nine hallmarks of catastrophes, which will be discussed. These hallmarks can be placed into three groups: the shape of the equilibrium surface (modality and inaccessibility), the behavior of the equilibrium points as conditions change (discontinuous jumps, hysteresis, divergence and one-jump paths) and transient behavior near cusps and folds (critical slowing down, anomalous variances and nonlinear responses). There are two caveats. Discontinuous jumps and hysteresis may not occur in systems if there is noise in the system, and unusual transient behavior is not unique to systems with catastrophes and can be found in systems with smooth threshold-like shifts. I will suggest that the two-state system of rockweeds and mussels in the Gulf of Maine is an example of a cusp catastrophe, and the three-state systems of corals, seaweeds and turfs may be an example of a butterfly catastrophe. In closing, I will speculate why ecologists have overlooked and then re-invented catastrophe theory and re-discovered its hallmarks.

Key words: Alternative stable states, rocky intertidal shores, coral reefs, theory.

The value of a long-term perspective in understanding short-term dynamics of giant kelp ecosystems.

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Many ecological processes play out over longer time scales and larger spatial scales than those that can be studied in a traditional 2-4 year grant cycle. Uncertainties in future funding hinder efforts to implement comprehensive research programs that integrate coupled time series observations of physical variables and ecological responses, manipulative experiments and synthetic analyses over the long term. Such research is essential for advancing our understanding of ecological changes and the physical and biological processes that control them. Long-term ecological research networks have been established around the globe in the last several decades to address this research need. Sustained funding through the US National Science Foundation's Long-Term Ecological Research Network has allowed the Santa Barbara Coastal LTER to develop an integrated research program aimed at developing a predictive understanding of local and regional controls of community structure and ecosystem dynamics of giant kelp forests in California. This highly productive ecosystem shows tremendous spatial and temporal variability in resource supply, consumer control and physical disturbance across spatial scales of meters to hundreds of kilometers and temporal scales of hours to decades. Climatic variability resulting from multi-year (ENSO) and multi-decadal (PDO, NPGO) oscillations, coupled with local and regional differences in oceanography and fishery management, lead to dynamic and spatially complex patterns that are difficult to explain with short-term, small scale studies. Results obtained to date by the Santa Barbara Coastal LTER highlight the value of a long –term perspective in understanding the causes and ecological consequences of short-term dynamics of giant kelp forests in five core research areas shared by all sites in the US LTER Network: primary production, trophic structure, nutrient supply, fate of organic matter and disturbance.

Zooming in on climate change: ecological modulation at biological relevant scales

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Climate change scenarios are usually developed for large spatial (open ocean) and temporal (decades) scales. In coastal habitats, however, organisms experience an environment where large scale climate and oceanography are overlain by medium to small scale events (upwelling, tides, seasons, etc) and biological processes (plankton blooms, microbial re-mineralization, etc.).

As a result, while coastal regions will follow the general global trends, the time window and the microhabitat a given coastal organism or a particular life-stage of it experience may deviate very substantially from global conditions and may offer more benign or more stressful, but certainly, more variable conditions. These may represent both a challenge and a chance (e.g. refuges, pre-adaptation) for organisms.

The usual experimental approach to climate change investigations using steady conditions and off-shore predictions are, thus, unsuited to evaluate impacts on coastal communities.

We present a novel mesocosm technology which allows investigating climate change in an ecologically realistic setting i.e. incorporating fluctuations at different spatial and temporal scales as well as biological interaction shifts.

First results of an ongoing multifactorial/ multivariate experiment run in different seasons and in different biogeographic regions will illustrate the strengths but also the challenges of this conceptually novel approach.

Key words: climate change, biologically relevant scales, fluctuating condition, mesocosms, ecological refuges

Afternoon casual plenaries

Looking back and looking forward: the role of surveys, experiments and importance of natural history in temperate reef ecology

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Temperate reefs are a superb tractable system for testing ideas in ecology. There is a rich history of experiments stretching back over 100 years. These have made some major contributions to general ecological theory as well as providing better understanding of how intertidal and shallow water systems work by linking pattern with process. Over the last 50 years much chicken wire, many dog bowls and pan scourers, tiles and chunks of rock have been screwed or stuck to reefs with various degrees of success and occasionally with too few degrees of freedom. A brief résumé of some of the unsung heroes of experimental ecology is given to celebrate our rich heritage.

As a community we generally do well designed experiments and test well formulated hypotheses. Increasingly large data sets are being collected, collated and subjected to complex meta-analyses and used in modelling. These data sets (often made freely available) do not happen spontaneously – the burgeoning subject of macro-ecology would only be possible because of the efforts of dedicated natural historians whether it be birds, butterflies or barnacles. High quality natural history and old fashioned field craft enable surveys or manipulative experiments to be properly stratified (i.e. replicates are replicates not a random bit of rock) and leads to more insightful hypotheses. So (in OF fashion):

- Know your plants and animals
- Get the ratio of time in the field and time at the computer in balance
- Combine macro-ecological approaches with scaled-up local experimentation
- Embrace new technology – but do not forget old fashioned elegant improvisation
- Do not forget the older work – even if inconveniently published in French.

Above all have fun – it is a privilege to be a paid-up rock pooler and experimental natural historian.

From there to here: a journey through the Middle Earth of temperate reef science over the ITRS years

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ITRS has existed for 23 years, a significant period in the relatively young history of experimental marine ecology. Despite considerable evidence to the contrary, ITRS does not stand for InTemperate Reef Scientists but instead represents a loose association of marine scientists who have come together as a coalition of the willing to discuss their science since 1990. From small beginnings in Melbourne in ITRS 1, the 'symposia' have grown to include hundreds of delegates from many countries. In polling previous participants in 2006, most responded that they did not want ITRS to devolve into "just another conference". Instead, they wanted debate and discussion about topical issues and a good representation of the world's temperate reef ecologists. Accordingly, ITRS talks have ranged from more local-scale experimental studies in the 1990s, discussions of the relevance of our science to solving problems, through MPAs, to global change issues in the last symposium in Plymouth. I was asked to give a 'casual plenary' on a "celebration of the journey of temperate reef ecology". Fortunately, my own career spans the period of ITRS meetings, and I have previous conference programs, and quite a collection of photos as visual aids (in case former conference participants forget what they may have got up to at conference dinners). Which loops back to the alternate translation of ITRS above.

Oral Presentations

General temperate reef science

Coralline turf - fucoid interactions: impacts of sedimentation and implications for macroalgal assemblage function

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As a result of anthropogenic habitat degradation, coastal ecosystems worldwide are increasingly dominated by low-lying turf-forming species, especially geniculate coralline algae. These are often described as alternative states to macroalgal beds and are linked to anthropogenic disturbance, such as increasing sedimentation. Little is known, however, about the impact of sediment accumulation within the turfs and the functional consequences of the switch from fucoid canopies to coralline turfs. We tested the impacts of sediment on interactions between turf-forming coralline algae and the fucoid *Hormosira banksii* and the effects on assemblage productivity. The percent cover of coralline algae was experimentally altered in conjunction with sediment deposition to assess impacts on *H. banksii* recruitment. Although *H. banksii* was not completely eliminated by coralline algae, its highest abundance was recorded on unoccupied substrates maintained free from sediment accumulation, indicating that increased sedimentation combines with space pre-emption by algal turfs to affect the development of fucoid beds. In a separate experiment, net primary productivity (NPP) of coralline algae alone and of full assemblages (coralline + *H. banksii* canopy) was assessed in the presence and absence of sediment. NPP of coralline algae was much less than that of the overlying canopy and was reduced further by sediment accumulation. NPP of full assemblages also declined with irradiances above 1500 µmol m^{-2} s^{-1} in the presence of sediment. Sediment loading of corallines causes impairment of photosynthesis and elevated rates of heterotrophic respiration. When devoid of sediment, however, coralline algae were able to enhance assemblage NPP beyond that of *H. banksii* canopy alone, confirming the importance of synergistic interactions among the components of multi-layered autotrophic assemblages in optimizing light use. Our findings augment extensive research addressing the global loss of macroalgal canopies and provide new insight into the impacts of altered sediment dynamics on coastal ecosystems.

Key words: benthic assemblages, ecosystem shifts, habitat-forming species, intertidal, New Zealand, photorespirometry.

Population structure and phylogeography of *Pterocladiella capillacea* (Gelidiales, Rhodophyta) based on plastid *rbc*L and mitochondrial *cox*1 and *cob*.

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Pterocladiella Santelices et Hommersand is a red algal genus comprising 16 species that are distributed from tropical to cold temperate regions around the world. Members of this genus are economically important as food and for the production of agar in Korea and Japan. *Pterocladiella capillacea* is a suitable species for studying the phylogeography of marine organisms because of its broad global distribution. However, our understanding of the taxonomy of this species is hampered by its great morphological variability. To explore the current distribution of *P. capillacea* and population differentiation within it, we analyzed plastid *rbc*L to confirm the species-level identification and mitochondrial *cox*1 and *cob* to determine phylogeographic patterns. We collected more than 350 specimens from East Asia, Australasia, Europe, North Pacific America, and Southwest America. The *rbc*L analysis showed that all *P*. *capillacea* samples fell within a single monophyletic clade. The combined *cox*1+*cob* (2,041 bp) data revealed 153 polymorphic sites and 70 haplotypes. Our mt haplotype (*cox*1+*cob*) network consisted of seven distinct groups: group I from Korea and Japan; II from USA (California) and Mexico; III from New Zealand and Korea; IV from France, Italy, Greece, and Spain; V from Brazil; VI from USA (Hawai'i), and VII from East Japan. We compared haplotypes and nucleotide diversities of these seven groups. Additional geographic sampling may further our understanding of the current distribution pattern of *P*. *capillacea*.

Key words: agarophyte, global sampling, haplotype network, phylogeny, red algae

Phenotypic plasticity in morphology and physiology in marginal versus central populations of the habitat-forming macroalga, *Hormosira banksii*.

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Marginal populations have been suggested to be at the physiological threshold of a species' distribution. These populations can often be smaller, geographically isolated or fragmented and experience suboptimal environmental conditions. Latitudinal differences in climate are an important factor controlling these geographic borders, and changes in temperature associated with global warming may result in altering life-history attributes. Persistence of these marginal populations is dependent on whether there is adequate phenotypic plasticity to cope with the immediate future, as well as whether there is heritable genetic variation and sufficient genetic connectivity for evolutionary adaptation in the long-term. This study compared east coast populations of the habitat-forming macroalga *H. banksii,* from its most northern marginal populations with centrally located populations. It assessed the performance of plants in terms of their internal temperature, water loss and photosynthetic health as they relate to morphology using a calibrated thermocouple, and *Chl-a* fluorometer. Results indicate that plasticity in morphology and position on the vertical shore play important roles in desiccation and temperature tolerance. Frond and vesicle morphology was variable within populations along the latitudinal gradient. However, significant differences in morphometrics between marginal and central populations were found. Morphological differences between high and low shore fronds were also significant, with differences between surface area to volume ratio and wall thickness. Due to the difference in morphology, water loss was greater in lower shore plants, which desiccated faster than higher shore fronds. This suggests that photosynthetic efficiency is greater with enhanced ability to retain higher water content. *H. banksii* phenotypes in marginal populations showed elevated temperature and desiccation tolerance, suggesting that populations towards the lower latitudes may be more resilient to changes in climate regimes. Ongoing population genetic analysis will allow us to assess whether genetic diversity and connectivity overlaps with these phenotypic patterns.

Key words: Range-shifts, microsatellite markers

An innovative statistical approach to constructing a readily comprehensible food web for a temperate demersal fish community

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Many food webs are so complex that it is difficult to distinguish the relationships between predators and their prey. We have therefore developed an approach that produces a food web which clearly demonstrates the strengths of the relationships between the predator guilds of demersal fish and their prey guilds in a temperate coastal ecosystem. Subjecting volumetric dietary data for 35 abundant predators along the lower western Australia coast to cluster analysis and the SIMPROF routine separated the various species x length class combinations into 14 discrete predator guilds. Following nMDS ordination, the sequence of points for these predator guilds represented a 'trophic' hierarchy. This demonstrated that, with increasing body size, several species progressed upwards through this hierarchy, reflecting a marked change in diet, whereas others remained within the same guild. A novel use of cluster analysis and SIMPROF then identified each group of prey that was ingested in a common pattern across the full suite of predator guilds. This produced 12 discrete groups of taxa (prey guilds) that each typically comprised similar ecological/functional prey, which were then also aligned in a hierarchy. The hierarchical arrangements of the predator and prey guilds were plotted against each other to show the percentage contribution of each prey guild to the diet of each predator guild. The resultant shade plot demonstrates quantitatively how food resources are spread among the fish species and revealed that two prey guilds, one containing cephalopods and teleosts and the other small benthic/epibenthic crustaceans and polychaetes, were consumed by all predator guilds.

Key words: gut contents, predator guilds, prey guilds, multivariate analyses, Australia

Convergent corallines: material strength in independently evolving geniculate lineages

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For upright macroalgae in the wave-swept intertidal and subtidal, the ability to bend over and reduce drag when hit by waves is necessary for survival. While fleshy seaweeds are flexible throughout their thalli, articulated corallines bend only at discrete uncalcified joints along otherwise calcified fronds. These joints, called genicula, must simultaneously resist breakage due to stress while remaining sufficiently flexible to allow whole fronds to bend in flow. The importance of joints to the survival of upright corallines is indicated by the thrice-repeated independent evolution of these structures, which has led to three subfamilies: the Amphiroideae, the Corallinoideae, and the Metagoniolithoideae. While amphiroids and corallinoids are found on exposed coasts worldwide, metagoniolithoids are endemic to Australia. Mechanical tests were performed on representative species from these three groups, in order to compare the material properties of genicula thought to be most relevant to bending performance in waves. Strength was investigated at the level of the whole plant, tissue, and cell wall. Similarities and differences are discussed with reference to previously described development and structure, as well as chemical components currently being investigated. Overall mechanical performance of the three groups is put in context of their success in hydrodynamically stressful habitats.

Key words: biomechanics, seaweed

Distributional patterns of urchin barrens and correlation between urchins and macroalgae in the rocky coast of Korea

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Urchin barrens has been a major issue of rocky coastal ecosystem in the temperate regions. In Korea, the east coast and Jeju Island have particularly been focused because the area of barren ground increases in spite of continuous efforts of installing artificial reefs. This study, which is the beginning of a long term ecological monitoring program approaching the urchin barrens issue in Korea, presents a distributional pattern of crustose coralline algae along the east coast and correlational analysis of urchin and macroalgal abundance. Six locations with latitudinal gradient along the east coast have been selected for distribution pattern of crustose corallines (from north to south; Gonghyunjin, Yungrang, Anhyun, Simgok, Jangho, Geoil). Coverage of crustose corallines was highest in Geoil and lowest in Gonghyunjin, and the highest abundance of folious algae was recorded in the spring time at Gonghyunjin. This indicates that urchin barrens reflects sea water temperature in this coast. Seasonal patterns of corallines versus folious algae show that the coverage of folious algae was relatively higher than that of corallines in spring time for all six locations, but in summer time the opposite pattern was observed. What about sea urchins? We picked Jangho (37^{o} 17.064' N, 129^{o} 19.353' E) for correlational analysis of urchins and macroalgae. Subtidal sites were classified into three groups according to the average density of urchins (Group I=0, Group II=4, Group III=>8/m^{2}) to evaluate community characterization. Average urchin density in Jangho was 4.7 ind./m^{2} consisting of two species (3.5 ind./m^{2} for *Strongylocentrotus nudus* and 1.2 ind./m^{2} for *S. intermedius*), and a total of 57 macroalgal taxa were visually identified (6 greens, 13 browns, 38 reds). From Group I to Group III, total species number (50, 44, 40), species diversity index (2.358, 1.948, 1.736) and evenness (0.621, 0.515, 0.471) were decreasing, but dominance index (0.161, 0.284, 0.365) was increasing. Algal species with negative correlation were *Grateloupia divaricate, Polysiphonia morrowii, Chondracanthus intermedia, Cryptopleura membranacea, Desmarestia viridis,* and positive correlation with crustose corallines, *Sargassum horneri.* Other species were not significantly correlated with urchin density. The former group of algae assumed urchins favorable foods, and various feeding experiments with urchins behavioral patterns are in process.

Anti-predator responses of the mussel *Perna perna* to single and combined predators with different attack modes

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Inducible defences are relevant traits developed by organisms in response to cues that signal risk of consumption. Most studies on the topic have focused on prey responses to single predator species. Anti-predator responses for prey that face multiple predators can be a challenge as defences often involve energetic constraints. We compared defensive responses of the mussel *Perna perna* to single and combined cues from two predators with different attack strategies, the whelk *Stramonita haemastoma* and the crab *Eriphia gonagra*, as well as cues delivered from damaged conspecifics. We also studied whether mussel responses were effective in reducing their consumption by these two predators. Mussels reared with whelks, crabs and a combination of these predators' cues formed heavier shells than mussels exposed to only seawater or damaged conspecifics, and their shells were also thicker at the center. Other traits such as shell shape, size of the adductor, and thickness at the lip margin and umbo regions did not differ among treatments. Mussel growth and clearance rate were lower in the presence, separately or jointly, of these two predators, compared to individuals exposed to damaged conspecifics and a control treatment. In contrast, the RNA:DNA ratio was not different among treatments. Interestingly, individuals exposed to combined crab-whelk cues had higher final tissue dry weight and also presented higher development of gonads. Only mussels that were previously exposed to single cues from whelks seemed to gain some advantage from the anti-predator responses as small whelks spent more time handling them. These results suggest that (i) the strength of predator-prey interactions for each of these two carnivores are similar, (ii) the presence of crabs and whelks in combination are perceived by mussels as a more dangerous environment, (iii) eventual alarm cues released by other mussels do not accurately signal predation risk, and (iv) the anti-predator responses developed during this experiment were not effective in deterring mussel predation by the predators which elicited them.

Key words: phenotypic plasticity, trade-off, predation risk, prey susceptibility, multiple predators

Simple patterns can emerge from complex interactions: habitat segregation between indigenous and invasive mussels

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Many patterns in nature are relatively simple, yet, their responses to external forcing or changing conditions are often difficult to predict. This may arise because we assume that simple patterns imply simple drivers, yet this is often not the case. Here we describe a simple pattern of partial habitat segregation (along the coast and within shores) between an indigenous South African mussel, *Perna perna*, and the aggressively invasive mussel *Mytilus galloprovincialis.* Coastal topography (bays versus headlands) has an effect on the abundances of both species, but the effects are stronger for *Mytilus*. Within shores, *Perna* dominates the lower mussel zone, while *Mytilus* occupies the upper shore, extending the overall mussel zone higher upshore than before its establishment. This simple pattern emerges as a consequence of interactions among multiple factors. These include the effects of parasites, species differences in physiological tolerances, behaviour and recruitment, and direct interactions between the two mussels that range from competition to facilitation. Although one of these effects may predominate in particular conditions or places, no single factor has an over-riding influence under all circumstances. Rather the observed pattern emerges as a consequence of all these effects and their interaction, making predictions about the consequences of changes to just one factor difficult if not impossible.

Key words: species interactions, invasive species, physiological constraint, environmental stress, habitat segregation, recruitment

Thermal sensitivity and behavior's role in driving the output of an intertidal predator-prey interaction

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Individual based mechanistic models are rising as promising tools for predicting natural systems' responses to changes in environmental drivers. Notably, however, species do not live in isolation; thus, our efforts should ideally target more than one player in the community. Environmental Stress Models provide a predictive framework for evaluating responses of interacting species to underlying levels of environmental stress (e.g. temperature). Predictions stemming from these models depend upon which species is more sensitive to the stressor. Characterizing and contrasting their sensitivity requires (1) considering species-specific strategies for coping with stress (e.g. behavior), and (2) assessing the relative effects on fitness-related traits (e.g. growth). Depending on the system, integrating these elements can sometimes prove logistically challenging. The intertidal predator-prey system of *Pisaster ochraceus* (sea star) and its prey *Mytilus californianus* (mussel) is one of those cases. While *Mytilus* is sessile, and its body temperature can be predicted based on weather data, *Pisaster* moves between microhabitats, precluding precise estimates of body temperature, and consequently fitness. Here I show results of a modeling approach used to evaluate the importance of accounting for *Pisaster*'s movement on fitness-related traits (growth and reproduction). Based on Dynamic Energy Budget models independently developed for both *Pisaster* and *Mytilus*, and biomimetic temperature loggers deployed in different microhabitats, I modeled the dynamics of underlying physiological processes that ultimately drive ecological performance. Simulations revealed that, assuming no sheltering behavior, *Pisaster*'s relative performance is lower than Mytilus'. However, allowing the predator to refuge during low tides prevents encountering extreme, potentially harmful temperatures, along with achieving temperatures closer to optimal. These modeling outputs, accompanied by indicators of physiological (body mass index) and ecological (abundance) performance collected at two sites located >600 km apart, provide evidence that both behavior and physiology interact to modulate the output of this predator-prey interaction.

Sex on the beach: a cocktail of behavioural repertoires which drive size-assortative mating in rocky shore littorinids?

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Size-assortative mating occurs in a wide range of animal taxa and sexual selection is one of the major hypotheses proposed to explain the formation of this distinctive mating pattern. The rationale is that male mate preference for large, more fecund females, along with male-male competition (i.e., a physical advantage of large over small males in competing for large females), will result in a positive correlation between the sizes of mating males and females. This paradigm has been assumed to hold true for species of rocky shore littorinids, many of which exhibit size-assortative mating, despite any rigorous test of the model. This hypothesis was, therefore, tested in three littorinids: *Echinolittorina malaccana*, *E. radiata* and *E. vidua* on rocky shores at Cape d' Aguilar, Hong Kong. Males of the three species generally trail followed, mounted and copulated with females similar or larger than their own body sizes (a form of size-dependent male mate preference); and copulated with larger females for longer durations. The males mating preference seems to be specific to their own body size (i.e., they selected females which were larger than their own size), which is a more dynamic approach than the traditional belief that all males simply prefer 'large' over small females. All three species also demonstrated male-male competition in the form of 'pushing' behaviour, where large males usually had a size advantage over small males in obtaining females to mate with. These findings support recent studies on mangrove littorinids and suggest that size-dependent male mate preference, along with male-male competition, may play an important role in driving size-assortative mating in littorinids and other animals that exhibit male mate choice.

Key words: *Echinolittorina*, male-male competition, mate choice, mating pattern, sexual selection

Estimating productivity in marine environments: acoustic propagation modelling and *in situ* acoustic measurements in *Ecklonia radiata* kelp forests

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Kelp forests, with distinctive canopies primarily of brown laminarian algae (northern hemisphere), or laminarian and/or fucalean algae (southern hemisphere) dominate the coastal reefs of the world's temperate marine habitat. South eastern Australia has experienced ocean warming at nearly four times the global average and there is now evidence that seaweed communities are retreating in a manner consistent with ocean warming. Estimating primary production across assemblages at ecologically relevant scales is essential to quantify ecosystem functioning and services, and in monitoring change in kelp forests in the face of climate change and other significant anthropogenic stressors. Research on acoustic remote sensing of the ocean has developed considerably in recent years, resulting in the possibility of sophisticated new acoustic techniques which should allow large-scale, continuous monitoring of primary productivity in seaweed based systems, integrating across all species simultaneously. While the successful use of acoustics in measuring primary production in seaweed systems would be greatly advantageous for ecological management and research in these communities, it may also have implications for the validity of estimates of seaweed production based on more traditional techniques if a significant quantity of oxygen is in non-dissolved form. This research follows from a three-week experiment under en in February 2012. For this period an array of acoustic sources and receivers mounted on supporting structures was deployed on the seafloor in a dense *Ecklonia radiata* community in Fortescue Bay, Tasmania. Early analysis of environmental acoustic data, together with ray-based acoustic propagation models, indicate a small yet significant oxygen gas void fraction during times of peak productivity in the environment. Here we present propagation modelling of the Fortescue Bay environment with results of acoustic data processing. Whilst work remains to quantify oxygen production in the environment, it is clear that acoustics shows promise as a powerful new tool for large-scale primary production measurements in seaweed environments.

Key words: primary productivity, seaweed, macroalgae, sound speed, coastal, temperate

A novel system for measuring kelp productivity and studying climatic stressors on kelp forest ecosystems

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Kelp are a major contributor to carbon budgets in temperate reef systems but until recently quantifying photosynthetic rates of kelp has been largely unfeasible in the field (or restricted to juvenile plants), and typically restricted to small pieces of tissue in the laboratory. Measuring photosynthetic rates of kelp in situ is critical for more accurate productivity modeling and for predicting the broader effects of changing climate on temperate rocky reef ecosystem functioning. In this study we use a novel chamber system to compare the photosynthetic parameters of the kelp *Ecklonia radiata* in the field and in the laboratory. This photo-respirometry system can be used in both the field and the laboratory to determine photosynthesis-irradiance curves for entire adult kelp plants. Maximum net photosynthesis (P_{max}) was found to be 47% (±3%) lower under laboratory conditions, and the light intensity needed for gross photosynthesis to compensate the oxygen demands for respiration (E_c) was higher, indicating that photosynthetic performance in the laboratory was considerably reduced. This suggests that productivity estimates based on laboratory-derived photosynthetic measurements will greatly underestimate in situ productivity of this important habitat-forming Australasian kelp species. This system is also being used in laboratory mesocosm experiments to investigate the effects of potential future environmental conditions (warmer water temperature and reduced light) on photosynthesis and productivity of the kelp *E. radiata*.

Key words: macroalgae, photo-respirometer, primary production, climate change

The Wheeler North Reef as a test case for the production vs. attraction hypothesis for reef fish.

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Debate over whether artificial reefs serve as centers for attraction or production of reef biota, particularly for mobile reef fishes is longstanding and largely unresolved. One of the few examples of an experimental study addressing this question found evidence of production for octopus but not mobile reef fish on a large artificial reef in Japan. We present data from an analysis of a time series of fish standing stock biomass on the Wheeler North Reef (WNR) and two natural reference reefs: an impact reef near WNR (the San Mateo reef) and a control reef far away (the Barn reef). Data were collected at both the near (Impact) and far (Control) natural reefs seven years prior to the construction of the WNR and at all three reefs four years after construction. These were used to: 1) examine changes in standing stock at all three reefs before and after the construction of WNR, and 2) to conduct a BACIP analysis to examine the influence of the WNR on reef fish standing stock in the near control reef (i.e. San Mateo reef). We found that overall standing stock in the combined WNR and San Mateo reefs declined slightly from the before to the after period. In addition, the BACIP analysis showed a substantial relative decline in fish standing stock biomass at the San Mateo reef from the Before to the After period. Although ongoing studies indicate that reef fish production is occurring on WNR, the BACI results indicate substantial attraction of fish from San Mateo to WNR.

Key words: artificial, reef, attraction, versus, production

The influence of habitat characteristics on the abundance of three key herbivorous fish species (Kyphosidae) in temperate waters.

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Kyphosids are an important family of mainly herbivorous fishes distributed worldwide in both tropical and temperate reefs. Despite their high abundances and wide distribution, very little is still known about their role and interactions in temperate marine systems. For this study, we determined the environmental factors that influence the abundances of juveniles and adults of *Kyphosus sydneyanus, K. gladius* and *K. cornelii*, the three most common species in the temperate waters of Western Australia. Abundance of fish was assessed at 20 inshore and offshore sites with high and low structural relief using UVC twice in a year period. Environmental data characterising each site (i.e. depth, number and dimension of shelters, abundance of algae, and number of adult *Parma mccullochi*) were also collected. Higher abundances of juveniles and adults *Kyphosus sydneyanus, K. gladius* and *K. cornelii* were present on high relief reefs. Variation in abundances was explained predominantly by the number of Drop Offs in a reef. This confirms that topographic complexity, and in particular vertical relief, plays a major role in influencing kyphosid abundances. Drop offs within high relief reefs are an index of high complexity and thus indicate an environment likely to provide refuge from predators for these large schooling fish. Since herbivorous fishes play an important role in the removal of algae and transfer of nutrients within and beyond the reef ecosystem, our results suggest key environmental factors, such as large structural attributes need to be considered especially in the process of planning and managing marine protected areas.

Key words: fish ecology, kiphosids, herbivory, reef structure, fish abundance.

Thresholds of Change

Experimental evidence of critical slowing down and early warning signals of regime shifts in rocky intertidal assemblages

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Anticipating critical transitions in complex systems such as financial markets, the climate and ecosystems is crucial for human well-being. Recovery from small perturbations should decrease in complex systems approaching a tipping point, a phenomenon known as critical slowing down. This theoretical expectation has led to the proposition of early warning signals of impending regime shifts, such as rising temporal autocorrelation and variance of state variables. Laboratory experiments with microbial populations have shown how recovery rates reflect the proximity to a tipping point along a gradient of degrading environmental conditions, providing strong empirical support to critical slowing down. Implementing such stringent tests in natural ecosystems is a daunting task and real-world experiments of critical slowing down remain rare. Here, we challenge the theory using data from a long-term (7 years) ecological experiment in a rocky intertidal community where reduced biomass of algal canopies promotes invasion of turf-forming algae, ultimately driving understory assemblages towards collapse. Our results show how recovery of the system from small perturbations decreased along the gradient of canopy degradation, whereas temporal autocorrelation, variance and skewness increased as predicted by theory. These results illustrate the suitability of the proposed early warning signals to anticipate regime shifts in natural populations and pave the way for further experimental evaluation of critical slowing down in real ecosystems.

Key words: Resilience, tipping point, disturbance, autocorrelation, variance.

Ecological limits to acclimation: Seaweed responses to latitudinal translocation

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Habitat-forming seaweeds are being adversely affected by climate change throughout temperate marine ecosystems globally. Despite this it remains unclear what capacity these foundation species have to physiologically acclimate or genetically adapt to warming temperatures. Here we translocated a habitat forming fucoid, *Scytothalia dorycarpa*, to multiple locations along a latitudinal temperature gradient, representing different magnitudes of absolute temperature and relative warming anomaly for the translocated populations. Productivity, health, reproductive development and physiological acclimation were monitored over 12 months. *Scytothalia* populations from different climatic regimes responded very differently to translocation, indicating that origin plays an important role in the absolute temperature tolerance of this species. Whilst absolute temperature per se did not drive the observed effects, relative temperature anomalies of 2.5 ^{o}C and greater were found to be the threshold beyond which loss of ecological function and mortality became prevalent. This threshold is consistent with the impacts of the 2011 marine heatwave, where *Scytothalia* populations were wiped out at locations where anomalies exceeded 2.5^{o}C, yet survived anomalies less than 2.5^{o}C. Incidentally the anomaly threshold appears to be independent of its temporal duration. Physiological acclimation of *Scytothalia* to changes in climatic conditions was observed by a relative reduction in respiration rates of individuals grown in anomalous conditions relative to individuals living in normal conditions. Despite this, fundamental ecological responses, such as reproductive development and resistance to epiphytic invasion were severely reduced under anomalous conditions >2.5 ^{o}C, indicating that physiological acclimation was insufficient to maintain ecological function over the 12 months. Results from this study suggest that local adaptation plays an important role in regulating the absolute temperature tolerance of seaweed populations, however, temperature anomalies of 2.5 ^{o}C and greater can have catastrophic effects on seaweed populations irrespective of climatic origin.

Compounded perturbations: effects of climate-related mechanical disturbance and nutrient enrichment on rock pool assemblages in N Portugal.

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The effects of anthropogenic modifications to natural systems are a focus of increasing interest for ecologists, policy-makers and the general public. Current and predicted climate change and eutrophication due to human activities, in particular, are key drivers of patterns of distribution, abundance and diversity of marine populations and assemblages of global relevance. A manipulative experiment was carried out, between February 2012 and September 2013, to test hypotheses on the combined effects of changes in mean intensity and temporal variability of climate (storm)-related mechanical disturbance and nutrient enrichment on algal and invertebrate assemblages from tide pools along the rocky coast of N Portugal. Temporal variability of disturbance was manipulated by arranging the same total number of five events in different ways, i.e. one where these were homogenously distributed over the period of the study (low variability) and one where these were clustered in short periods, separated by prolonged periods without experimental disturbance (high variability). The higher level of temporal variability was replicated in two different sequences in order to separate the effect of temporal variability per se from those of the specific pattern of events used to produce the desired level of variability. Each level of variability was crossed with two levels of intensity of disturbance. Nutrient enrichment was performed by deploying slow-release fertilizing pellets in rock pools assigned to that treatment. Multivariate and univariate techniques were performed to examine average responses over the period of the experiment of whole assemblages and individual taxa to each combination of treatments. Preliminary results indicated a lack of any significant effect on the structure of assemblages, while individual taxa showed specific responses likely depending on their particular life traits. Present findings have implications to understand and predict possible responses of intertidal organisms to present and forecasted scenarios of environmental changes due to human activities.

Key words: Storminess, eutrophication, mean intensity, temporal variance, rocky intertidal.

The influence of frequency and intensity of disturbance on kelp recovery and community dynamics.

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One of the big themes of ecology over the last 30 years has been the influence of disturbances on biodiversity and ecosystems. With coastal systems under increasing pressure from anthropogenic stressors (e.g. harvesting, exotic species, urbanization, eutrophication and climate change), we need to understand the properties that maintain ecosystem resilience to change and conversely, what pushes them over the edge. We conducted a manipulative experiment on shallow sub-tidal reefs in Port Phillip Bay, Victoria, Australia, to investigate the role of frequency and intensity of disturbance on kelp (*Ecklonia radiata*) recovery and the subsequent effect on algal species dynamics. Specifically, we disturbed the kelp canopy by either reducing it by 50% or removing it entirely (100%), but did so as either one large disturbance or three smaller disturbances over the course of three months. We followed this experiment for 18 months. Surprisingly, the greatest number of kelp recruits occurred in those plots that experienced a less severe *and* gradually implemented disturbance. This was contrary to our initial hypothesis and previous experiments, where the most disturbed plots received the highest recruitment. One contributing factor could lie in the fact that a large number of sea urchins (*Heliocidaris erythrogramma*) moved through the reef over the initial period of the experiment. Here, it seemed that the adult kelp plants aided kelp recruit survival. In this example, we see evidence for how an unexpected event (intense herbivory) can influence kelp recovery from disturbance to produce unexpected outcomes.

Key words: Resilience, recruitment, *Ecklonia radiata*, sea urchin

Can top down multitrophic interactions be important drivers for the observed recovery of kelp in previously grazed areas in northeast Atlantic?

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Previously grazed kelp forest along more than 1500 km of coastline in Mid and North Norway is currently subjected to large-scale impact factors that may explain regional differences in recovery of kelp forests. Qualitative and quantitative field sampling the last two years in the southern, middle, and northern part of the grazed area provide new knowledge of differences in recruitment rate and in sea urchin behavior in areas experiencing different regimes in temperature and predator pressure. In the southernmost area sea urchin juveniles as well as the density of adults is low, but sea urchin dominance still occur in patches. Further north, sea urchins dominate totally and high densities of juveniles are found, except for the northernmost areas where a mosaic pattern of kelp reforestation is emerging in spite of high number of recruits. In these areas sea urchins are mainly found in predator refuge habitats (cobble stones) while kelp recover on more open hard substrate. Both in north and in south the decline of sea urchins correlates with a dramatic increase in mesopredators; in north the invasive red king crab migrating westward from Russia, and in soth the edible crab is moving northwards. The increase of both these predators correlates with decrease of the top predator coastal Atlantic cod and is probably favoured by this predator release effect. In south, the sea urchins are negatively affected by increased temperatures while the edible crab is favored by the changing climate and extends its distribution northwards in high densities. Temperature is still low and favorable for sea urchins in north. The resilience of the alternate states in the south, mid and northern areas is discussed and related to different responces to ocean warming and the strength of top down regulations.

Key words: sea urchins, kelp, regime shift, predator control, temperature

Can compensatory mechanisms counter-balance the effects of increasing multiple stressors?

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Natural systems are exposed to multiple stressors which can drive ecosystem change by modifying the outcome of species interactions. As subordinate species may take advantage of altered environmental conditions, ecosystems can shift to a contrasting state. A well-known example is provided by kelp forests, where kelp are normally the dominant species, but can be competitively displaced by turf-forming algae when environmental conditions are altered (e.g. eutrophication). As disturbances commonly occur in nature, ecosystems may have compensatory mechanisms that counter-balance the effects of stressors. We hypothesise that such compensatory mechanisms would become stronger as the levels of stress on the system increase, up until a point. After this point the compensatory responses are unable to counter-balance the stressors, leading to an abrupt or gradual ecosystem shift, according to the trajectory and strength of the response, which would likely be contingent on local conditions. To test this hypothesis, we explored how herbivory by gastropod grazers could potentially act as a compensatory mechanism, controlling turf growth in kelp forests under increasing levels of stress. Specifically, we quantified grazing rates under kelp canopies and in canopy-gaps, which naturally occur within kelp forests, under a crossed combination of elevated and ambient levels of CO_2, nutrients and temperature. We predicted that grazers would be able to compensate for the increased turf growth occurring under altered environmental conditions, i.e. having greater grazing rates where stressors are present compared to ambient conditions. Moreover, within each combination of stressors, grazing rates would be greater in gaps than under kelp canopies as greater turf growth occurs outside canopies. This compensatory response may, however, fail under elevated levels of stress. If such compensatory processes exist, the implications for management are profound, as specific stressors may be managed to reinforce the natural response of systems to environmental change.

Key words: disturbance, stability, community, threshold

Phase shifts and stressor-driven dynamics in kelp beds.

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The talk will present an analysis of change in kelp bed systems conducted by a recent NCEAS working group. Phase shifts in subtidal kelp beds are a global phenomenon, and the working group identified two different kinds of underlying mechanisms: (1) consumer-driven shifts (usually sea urchins) in which overgrazing mediates a shift from high macroalgal cover to 'barrens' habitat, or (2) competition-driven shifts where one species of kelp is replaced by another or by turfing algae. We developed simple models of both systems and showed that they can be applied broadly, providing a strong theoretical underpinning of the phase shift phenomenon in kelp systems. These models indicate that consumer-driven phase shifts are discontinuous, so that the system demonstrates alternative persistent states and hysteresis under identical environmental conditions, while competition-driven phase shifts can be either continuous (no hysteresis or alternative persistent states) or discontinuous. We are exploring how model parameters are likely to change with climate change and other stressors, and how this will alter the behaviours of the models.

A second approach to understanding impacts of climate change and other stressors is through qualitative modelling of network dynamics. These analyses show that while there are broadly similar responses of kelp beds to climate change globally, the particular dynamics in a given region, and whether other stressors exacerbate the effects of climate change, depend on network structures.

Key words: kelp bed, phase shift, hysteresis, alternative persistent states, climate change, multiple stressors.

Deposition on a biogenic reef and the impact of temperature

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Biogenic reefs, such as those formed by horse mussels (*Modiolus modiolus*) are biodiversity hotspots, and therefore recognised for their conservation importance in Marine Protected Areas of the North West Atlantic (eg EU Habitats Directive). Highlighting and quantifying the services provided by different marine ecosystems shows the value of different habitats and species to society, which can support decision making and marine spatial planning. The objectives of this study were to measure sedimentation *in situ* and then to test if *M. modiolus* biodeposition rates (faeces and pseudofaeces) were modified by an increase in temperature. A method was developed to collect sediment and biodeposits on a *M. modiolus* reef using portable experimental units that were deployed and recovered by SCUBA diving. Control units accounted for background sediment deposition and the effect of the experimental units. The passive and active processes were separated using live mussels and dead mussels shells held together. In the laboratory, Vortex Resuspension Tanks (VoRTs) were used to maintain *M. modiolus* under controlled conditions where the seawater temperature could be adjusted, and the natural feeding environment was otherwise simulated. The results provide the first evidence of the scale at which *M. modiolus* are able to provide ecosystem services, such as water filtration and sediment sequestration in the North East Atlantic. Increased seawater temperature can modify the function of *M. modiolus*, and therefore change the way that biogenic habitats provide benefits to society.

Key words: water quality, ecosystem function, complex habitat

Global phase-shift dynamics of catastrophic sea urchin overgrazing

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A pronounced, widespread and persistent phase-shift among marine landscapes is observable on temperate rocky reefs as a result of sea urchin overgrazing. Here we empirically define phase-shift dynamics for this grazing system which transitions between productive macroalgal beds and impoverished urchin barrens. Catastrophic in nature, urchin overgrazing in a well studied Australian system demonstrates a discontinuous regime shift, which is of particular management concern as recovery of desirable macroalgal beds requires reducing grazers to well below the initial threshold of overgrazing. Generality of this phase-shift dynamic is explored across temperate rocky reefs worldwide by compiling available survey and experimental data. The globally emergent pattern clearly shows urchin grazing to cause a discontinuous "catastrophic" regime shift, with hysteresis effect ~1 order of magnitude in urchin abundance between critical thresholds of overgrazing versus recovery. Different life-history traits appear to create asymmetry in the pace of overgrazing versus macroalgal recovery. Once shifted, strong feedback mechanisms provide resilience for each alternative state thus defining the catastrophic nature of this phase-shift. Importantly, human-derived stressors can act to erode resilience of desirable macroalgal beds while strengthening resilience of urchin barrens, thus exacerbating the risk, spatial extent and irreversibility of an unwanted regime-shift on temperate rocky reefs.

Key words: Hysteresis, kelp beds, sea urchin barrens, alternative stable states, transition rate, resilience.

Heritability of fitness traits in *Ecklonia radiata*.

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Kelp-based ecosystems are pervasive around southern Australia and support high temperate reef biodiversity. While population-level genetic diversity may characterise resilience to climate change, genetic variance (heritability) of key fitness traits indicates the potential for an adaptive response to the novel selective pressures to occur. Phenotypic plasticity is well known in kelp but the capacity of kelp to adapt to climate change stressors over short time scales is unknown. Here we studied the widespread kelp, Ecklonia radiata, and used a series of lab and field experiments to assess the heritability of key life-history and physiological traits in microscopic haploid and diploid stages, and macroscopic juveniles. Preliminary results indicate family-level variation in an important reproductive trait (oogonia size) which indicates genetic variation between families and thus the potential for a response to selection.

How water motion, canopy density and shading interact to effect canopy saturation state.

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Amphibolis griffithii, is a temperate seagrass growing in energetic environments on and among temperate reefs. Human activities expose it to a variety of stressors including light reduction. Management of seagrass habitat incorporates the use of thresholds for light, but these are usually set based on the amount of light at the top of the seagrass canopy. There is an interaction with seagrass canopies and light: they attenuate light, with greater attenuation as canopy density increases, and with light reduction events, seagrass canopies reduce density. We investigated this interaction of light reduction and canopy density under different canopy positions due to water motion to assess the canopy saturation state of seagrasses. The aim was to develop light thresholds that incorporate canopy-scale processes. A 3D canopy model was combined with an optical model to predict the amount of light reaching the leaf surface in every 0.5 cm^2 of the canopy. From this model the variables instantaneous canopy saturation state (% canopy above saturating irradiance) and a new metric, the accumulated daily saturation state was derived. A model experiment where LAI (5 levels), shading (9 levels) and canopy position (2 levels) was run and these variables calculated. The instantaneous canopy saturation state declined with LAI and there was an interaction with canopy position, at low LAI flattened canopies had a similar saturation state to upright canopies, but at high LAI's a greater proportion of the canopy was below saturating state. Shading also reduced the saturation state, but there was no interaction with position. In contract these was a complex, non-linear interaction between LAI, shading and canopy position for the accumulated daily saturation state. This model experiment has highlighted the potential use of the daily-accumulated saturation state as a threshold metric. Implications for the use of this threshold are discussed.

The ecological consequences of disturbance to the ecosystem engineer *Ascophyllum nodosum* on the south British coast.

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The intertidal canopy-forming alga *Ascophyllum nodosum* has, in previous studies, been identified as a habitat creating species on many northern hemisphere rocky shores. This alga is found on sheltered shores in the UK, though its biogeographical range is restricted by water temperature to the south where other species dominate. In contrast to intertidal canopy forming algae found in Australia (such as *Hormosira banksii*), *A. nodosum* co-occurs with several other intertidal canopy-forming algae which can also provide habitat for associated species. In this study, the strength of the facilitative relationship between *A. nodosum* and associated organisms was explored by undertaking a canopy thinning experiment at a rock platform in Looe, southern England. Changes in environmental conditions and species assemblages occurred in response to thinning of the canopy, these results will be discussed.

Key words: disturbance, ecosystem engineer, community, marine

Disturbance-oriented tactics of a coastal invader and its contribution to diversity and production of low-shore communities

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Disturbance experiments in perennial algal canopies along an intertidal gradient in southern New Zealand have shown there is significant facilitation in mid- and upper shore regions and much greater competitive exclusion in the lower tidal zone. This is particularly the case where the large fucoid *Durvillaea antarctica* is dominant, and both shades and batters species in the understory. A species that has proved to be adept at 'hit and run' tactics is the invasive annual kelp *Undaria pinnatifida*, which blooms seasonally where the *Durvillaea* canopy has been disturbed. Unusually for low-shore species, *Undaria* is also facilitated by coralline turfs in which native fucoids recruit poorly. Invasive species are generally considered to have negative impacts on native communities, but here we explore some of the wider ramifications of *Undaria's* presence. From experimental data, we discuss 'interactive effects' of changes in communities with and without *Undaria*, and 'subsidy effects' of its contributions to coastal productivity. Together these give a broader view of a species that is expanding geographically but comes and goes in local communities.

Loss of kelp forests and the tropicalisation of a temperate marine ecosystem

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Habitat-forming species play a critical role in defining the ecological properties of ecosystems. Kelp forests are some of the most productive and charismatic marine ecosystems in the world, and they are key habitats in temperate waters along ~25% of the world's coastlines. Here we document the complete transformation of marine communities along >100 kilometres of coastline following a decade of steadily increasing ocean temperatures capped by an extreme heat wave in 2011. Complete loss of kelp forests and other temperate seaweeds have transitioned the system to one dominated by turf algae and seaweeds of warm-water affinity. Reef fish communities have changed, with substantial increases in warm-water herbivores, and typical temperate mobile invertebrates have disappeared while warm-water ones have started appearing in greater abundance. At the same time there is evidence of increased coral recruitment where kelp forests were previously abundant. Based on changes in seaweed biomass, multi-trophic models of the system predict a 25% decrease in the biomass of rock lobsters, the focus of Australia's most valuable single-species fishery, and up to 40% decline in reef fishes, many of which are commercially and recreationally important. While it is still too early to know for sure, it seems inevitable that this 'tropicalisation' of the temperate marine community will have massive implications for the provision of ecosystem goods and services to the region.

Key words: Warming, phase shift, threshold, alternate state, flow-on effect, range shift.

In a high CO2 world, herbivores do not lose their appetites.

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Ocean acidification is predicted to be one of the most wide reaching threats facing marine biota. Given this expectation, how do we prioritize what biological impacts of ocean acidification to study? As many organisms respond to stress by altering their metabolism, it seems reasonable to expect trophic interactions to vary in response to this environmental stressor. Here we present data from a series of feeding trials with multiple marine herbivores (crustacean, echinoderm, and gastropod) exposed to either ambient or elevated CO_2 levels. In all feeding trials, we found no evidence of variation in feeding rates between herbivores exposed to elevated CO_2 and those exposed to ambient conditions. We propose that this series of null results is indicative of an overall trend: marine herbivores will likely not respond to increased CO_2 by directly altering their grazing rates. However, we draw attention to other mechanisms by which the total magnitude of herbivory may change owing to the combined effect of mass-specific feeding rates (larger herbivores eat more) and lower growth rates under conditions of elevated CO_2. We propose that the sharing of null results such as these is integral in continuing to generate new and innovative hypotheses, while streamlining research efforts

Key words: Kelp, British Columbia, Urchins, Crabs, Isopods, Climate Change

Physiological responses of habitat forming seaweeds to increase in ocean temperatures.

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Global warming has had a significant impact on distribution of species worldwide. Although a number of studies have documented the distributional limits of species, the physiological responses to increase temperature, tolerance and adaptation is not completely understood, especially for seaweeds. In this study we compared the physiological performances of three large brown algae namely *Ecklonia radiata*, *Scytothalia dorycarpa*, *Sargassum* sp. distributed along the South-western coast of Australia to adapt in scenarios of increase in ocean temperature. Photosynthesis, respiration and chlorophyll content were measured against increments in temperature (10-30°C) from specimens collected along the latitudinal gradient from Hamelin Bay to Kalbarri (~900 km coastline). Results suggest that cool acclimated seaweeds are very sensitive to temperatures exceeding their usual temperature range evidenced by a sharp increase in respiration and decrease in photosynthesis. Warm acclimated species showed signs of adjusting their metabolic rates to increase in temperature observed from lower Q10 values for photosynthesis and respiration. Photosynthetic-light curves showed that *Sargassum* sp. had a higher photosynthetic capcity (NP_{max}=26°C) than the other two studied species. Cellular chlorophyll content showed a gradual decrease from the cooler Hamelin Bay to the other warmer locations.

Ecological responses to ocean acidification by marine fouling communities undergoing ascidian invasion

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Increasing levels of CO_2 in the atmosphere will affect ocean chemistry, causing increased acidification (i.e., lower pH). Differential responses to changes in pH, based on interspecific and ontogenetic variation in physiology, could produce changes in structure and diversity at the community level. To test the effects of ocean acidification on mixed assemblages of native and invasive species, we conducted two studies in field-deployed flow-through mesocosms using subtidal marine fouling communities. Bare recruitment plates were suspended in mesocosms and subjected to ambient or elevated CO_2 by bubbling in air or air enriched with ~600 ppm CO_2 to create a 0.35 pH difference between treatments (n=24). In the first experiment (2012), after ten weeks, acidification significantly altered community structure. This change was driven by changes in relative abundances of recruiting native species, as diversity decreased by 40% but species richness remained unchanged. There were significantly fewer mussel (*Mytilus spp.*) and hydroid (*Obelia dichotoma*) recruits in the elevated CO_2 treatment than in the ambient treatment after six weeks. Conversely, the percent cover of bryozoan colonies (*Mebranipora membranacea*) increased by 20 % under acidic conditions. In 2013, invasive ascidians (*Botryllus schlosseri*) were weeded from one of two tiles in each mesocosm. After ten weeks, there was a strong effect of botryllid presence but no effect of acidification on community structure. Communities with botryllids were 15% less diverse and took up 50% more space than those without. In addition, botryllid presence decreased recruitment of bottle animalcules (by 75%) and *M. membranacea* (by 35%). Importantly, there was no effect of acidification on abundance of *B. schlosseri*. We demonstrate that acidification can have negative impacts on native communities, while invasive species may be resistant to acidification. As a consequence, the ecological impacts of invasive species may increase in an acidified ocean.

Key words: Climate change, tunicate

Why are phase-shifts uncommon and will they become more common in the future?

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Observations of systems shifting from one state to another are relatively uncommon, but they have occurred throughout most kelp systems of the world. Whilst the types of stressors involved and the mechanism of change are diverse, an NCEAS working group identified the internal characteristics on which stressors act; revealing two kinds of phase-shift (i.e. consumer-driven and competitor-driven; see talk by Johnson et al.). Will these shifts be more common under future CO_2 and temperature? I will discuss our work on identifying mechanisms of future stasis and change (see talk on stability by Falkenberg et al.) and our working concept of stability (i.e. compensatory effects; see Ghedini et al. talk). This work seeks to account for the net effects of our mesocosm studies; i.e. the sum of effects of interactions within trophic levels (i.e. competition and facilitation) between trophic levels (i.e. variance in strength of trophic-cascades and producer-driven effects). To date, mesocosm studies of community change focus on net effects and the direct effects of climate. We show that the indirect-effects of climate are disproportionately large and have contrasting effects depending on whether the kelp system is more vulnerable to competitor-driven or consumer-driven shifts.

Key words: kelp forest, temperature, CO_2, ocean acidification, warming

Role of macroalgal canopies in ameliorating the effects of ocean acidification on coralline algae

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Anthropogenically-modulated shifts in pH, termed Ocean Acidification (OA), pose a major threat to the physiological performance, stocks, and biodiversity of calcifying organisms and consequently may devalue their ecosystem services. Recent debate has focussed on the need to develop approaches to arrest the modification of calcifier-dominated ecosystems by OA. Such alteration of ecosystem functioning is particularly threatening in temperate regions where calcifiers dominate multiple trophic levels and provide three-dimensional habitats and settlement substrate for a variety of organisms. Here, we demonstrate the role of macroalgal canopies in increasing the thickness of a discrete (i.e. diffusion) boundary layer (DBL), formed at the surface of understorey coralline algae, that can buffer them from the negative effects of OA. The fucoid macroalga *Carpophyllum maschalocarpum* reduced seawater velocity through and beneath its canopies, which resulted in large changes in the DBL thickness around the understorey coralline algae below. This DBL is thin but biologically-significant, and acts as a buffer under slow flow conditions (such as within canopies of macroalgae), where it allows a chemical micro-environment to form which is conducive to higher net calcification. Thus, macroalgal beds may enhance the subsistence of calcifiers by creating localised hydrodynamic conditions that ameliorate the negative impacts of OA.

Is baldie moving south? Evidence for southern range expansion in WA endemic baldchin groper (*Choerodon rubescens*)

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Evidence for range shifts as a result of warming temperatures and strengthening of pole-ward flowing currents continues to accrue across a variety of taxa in coastal ecosystems around the world; particularly at subtropical and temperate locations. Recent reports of changes in the abundance of baldchin groper (*Choerodon rubescens*) along the Rottnest-Mandurah region which lies on the southern range edge of the species, warrant consideration of whether the species is shifting southwards. We surveyed shallow water habitats (outer reef, lagoon and seagrass) along this region via underwater visual census and long swims, to assess the density and size structure of juvenile *C. rubescens*, as well as the habitats they were associated with. Surveys were complemented via collections of selected fish in order to gather age data for individuals surveyed, by analysis of daily growth increments in otoliths. We found two distinct size and age classes in the region, providing evidence for two separate recruitment events at locations where the species was previously absent or in very low abundances. Juvenile baldchin groper preferred weedy lagoonal habitats of low structural complexity and with high proportions of sand and rubble. Recruitment events coincided with abnormally high temperatures in the region since a 2011 heat wave, and the strengthening of the pole-ward flowing Leeuwin Current. Baldchin groper juveniles along the southern end of their range have successfully settled in high abundances, overwintered and survived, indicating the potential for a southern range expansion of the species. Such shift has important management implications for this fisheries target species of restricted geographic range, and raises important questions related to geographic range size expansion vs. contraction.

The Physiological Adaptions of Intertidal Gastropods to a Highly Variable Thermal Environment

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Intertidal animals live in a highly variable thermal environment, and temperature is one of the most important factors determining intertidal zonation. Significant changes in intertidal communities have been recorded, based on long-term in situ observations, during the past several decades. By virtue of experiencing highly variable and extreme temperatures, the physiological adaptations of rocky intertidal organisms, including mechanisms to conserve energy during prolonged rest at high temperatures, are distinct from the adaptations of oceanic marine ectotherm from relatively thermally stable environments. To cope with the harsh thermal environment in intertidal zone, intertidal animals developed diverse physiological adaptations for sustaining metabolism and for directing energy toward repair of thermally induced damage. The expressions of genes encoding metabolic sensors are sensitive to thermal stress and these biomarkers indicate both an increase in overall energy requirement and an increase of catabolic metabolism. It also suggests that more energy is allocated into maintenance and less energy into growth and reproduction. Such a change of energy budget can affect organisms' fitness and thus its population dynamics. In situ high-resolution temperature data shows that environmental temperature frequently exceeds upper temperature limits of some intertidal organisms in summer. Increase of thermal stress in the scenario of climate change will have significant impacts on the changes of biochemical pathways, energy budget and the population dynamics in some species inhabiting the intertidal zone.

Key words: Intertidal community, climate change, metabolism, molecular marker, thermal limit

Resistance to change: could kelp forests limit the effects of modified climates and nutrient pollution?

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The presence of key species, such as kelp, is often critical in determining ecosystem composition and function. These species exert influence not only by forming biological habitats whose physical environment facilitates their own recruitment, but also by dominating competitors that would otherwise inhibit this process (i.e. turf-forming algae). As human activities modify abiotic conditions there is potential, however, that interacting taxa may have contrasting responses which could modify the outcome of their competition such that the probability of phase-shifts is increased. This research, therefore, considered the response(s) of these interacting taxa (i.e. kelp and turf) to experimentally-manipulated conditions (carbon dioxide, temperature, nutrients) and assessed whether kelp could continue to inhibit algal turfs under forecasted scenarios. We identified that while elevated carbon dioxide, temperature and nutrients positively affected turfs in the absence of kelp, these effects were largely inhibited where kelp canopies were maintained. Quantification of conditions within the experimental mesocosms suggested turf inhibition was likely due to an effect of kelp on physical (i.e. shading) rather than chemical conditions. Such results indicate that maintenance of intact populations of foundation species may enable environmental conditions to be moderated such that the historical ecosystem state persists, even under forecasted conditions otherwise anticipated to increase the likelihood of their loss.

Key words: Ecosystem shift, eutrophication, multiple stressor, ocean acidification, pollutants, warming

Effect of nitrogen source on nutrient uptake and pH change at the surface of *Macrocystis pyrifera* blades

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Inorganic nitrogen (Ni) availability plays an important role in the productivity of ecosystems and in the physiology of marine algae. The most common sources of Ni to algae are NO_3^- and NH_4^+.The transport of nutrients from the bulk seawater to the seaweed blade surface occurs across the diffusion boundary layer (DBL). Therefore, the DBL plays an important role in the flux of ions and molecules (*e.g.* Ci: CO_2; HCO_3^- or N: NO_3^-; NH_4^+) to/from the thallus surface. Under slow flow (thicker DBL) the chemistry of seawater near to thallus surface could be influenced by the different charges of ions due to the efflux of dissolved metabolic materials, which may modify the pH within the DBL. Physiological processes such us photosynthesis and NO_3^- uptake could increase the pH within of the DBL whereas respiration and NH_4^+ uptake could reduce it. In this study, we hypothesized that (1) NO_3^- uptake will increase the pH within of the DBL under slow flow conditions whereas NH_4^+ uptake will decrease it, (2) under a low pH simulating ocean acidification (OA, pH=7.6) the pH will be more affected than under today's seawater pH (pH=8.1) due to a higher nutrient uptake and photosynthetic rate. After a short nutrient uptake experiment (75 min) there was no significant effect of Ni source on the pH within the DBL, with pH increasing for both nutrient sources (NO_3^- and NH_4^+). However, the change in pH (ΔH^+) within the DBL was always higher under OA conditions than at pH 8.1. NH_4^+ uptake was significantly higher under OA conditions. Overall, carbon acquisition was significantly affected by pH treatment but not by Ni source. CO_2^- consumption was higher at pH 7.65 than at pH 8.1 whereas HCO_3^- consumption was the same under both pH treatments. Our findings suggest that the main changes in pH within the DBL are due to photosynthesis rather than nitrogen uptake. The increased availability of CO_2 at pH 7.65 could stimulate NH_4^+ assimilation to support higher photosynthetic rate under OA.

Key words: Nutrients uptake, Ocean acidification, Kelp, Carbon uptake, Diffusion boundary layer.

Impacts of climate change on biogenic habitat-forming seaweeds in southeastern Australia

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Temperate reef ecosystems worldwide are increasingly threatened by global climate change. Warming ocean temperatures and oligotrophy resulting from extension of nutrient-poor water masses are predicted to impact on the growth and survival of seaweeds critical to ecosystem functioning. Large brown macroalgae are an important structural component of shallow rocky reefs, and in southeastern Australia are expected to be affected by ocean warming at a rate of ~3.8 times the global average. Our work assesses the effects of climate change on three of Australia's key habitat-forming brown seaweeds; *Ecklonia radiata*, *Phyllospora comosa*, and *Macrocystis pyrifera*. Here we report on complementary *in situ* techniques (PAM fluorometry, pigment analysis, C:N and stable isotope measurements) used to assess seasonal productivity of these species across depth and latitudinal (NSW vs Tasmania) gradients over two years. This work showed strong seasonality in the physiological performance of algae, which was closely related to a number of environmental variables. Algae in the south of their range were exposed to greater seasonal fluctuations in light climate, water temperature and nutrient availability than their northern counterparts due to the periodic displacement of Southern Ocean water masses by the EAC over summer. These algae showed evidence of physiological stress during this time, which decreased in severity with increasing water depth. In a multifactorial laboratory experiment, responses of *P. comosa* to increasing temperature and declining nitrate concentrations were found to be strongly affected by temperature, with nitrate levels having minimal detectable effect on algal growth. Responses were similar in individuals collected from the northern (NSW) and southern (Tasmania) extent of the species' range indicating a high degree of physiological plasticity; however, Tasmanian algae were more sensitive to elevated temperatures, suggesting that predicted increases in summer water temperatures may negatively impact on this algae at the southern extent of its range.

The adaptive potential of *Heliocidaris tuberculata* to ocean warming and ocean acidification: effects of climate change on the proteome

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Predicting effects of rapid climate change on populations depends on measuring the effects of climate stressors on performance, and potential for adaptation. Adaptation to stressful climatic conditions depends on heritable genetic variance for stress tolerance present in populations. We quantified genetic variation in tolerance of early development of the ecologically important sea urchin *Heliocidaris tuberculata* to near-future (2100) ocean conditions projected for the southeast Australian global change hot spot. Multiple dam-sire crosses were used to quantify the interactive effects of warming (+3°C) and acidification (-0.3-0.5 pH units) across 16 family lines. Overall, there were no significant effects of acidification or warming on development up until the gastrulae stage however success at both stages was significantly affected by male/female compatibility. There were no separate male and female interactions with stressors indicating the important of compatibility in determining progeny outcome. Furthermore, gastrulae from each treatment were collected and pooled across genotypes to identify differences in protein expression. Over 300 spots were detected in all gels and a subset was chosen for identification.

Key words: quantitative genetics, sea urchin, proteomics, climate change stressors

Where will *Macrocystis* be in tropicalized oceans?

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Macrocystis pyrifera is a widely distributed kelp that occurs along shores in both hemispheres from the subtropics to temperate seas. With few exceptions it presently occurs where average sea surface temperatures are around 20^0C or less and at latitudes less than 57^0 N and S. The temperature (and associated nutrient) limits correspond with the known physiological responses of the species, and it is likely that the poleward latitudinal limit results from lack of sufficient light in winter. These relationships, combined with global projections of a 2 - 3^0C rise in average sea surface temperature, indicate that the present distribution of giant kelp will shrink from losses in the subtropics but make no gains towards the poles. Local effects of increased storms and run-off, and decreased upwelling may reduce abundance and alter distributions within its tropicalized range. While there may be effects from altered biological interactions, the historical spread of giant kelp into a variety of different communities in the southern hemisphere suggests the effects of such interactions will be local.

Key words: 20^0C, latitude, ocean warming, subtropics, temperate seas

Factors driving the biogeographical distribution of two temperate Australian damselfishes and ramifications for range shifts.

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The distribution and abundance of marine organisms is determined by interactions among numerous abiotic and biotic factors that operate across multiple spatial scales. This study focused on 2 endemic temperate damselfishes *Parma microlepis* and *P. unifasciata,* which have a similar ecology but only partially overlapping (~3° of latitude) biogeographical and depth ranges. The synergistic effects of temperature, competition and habitat use on patterns of abundance, distribution and growth were investigated using a combination of mensurative and manipulative field and laboratory experiments. Evidence suggests that the current ranges of both species are driven largely by latitudinal and depth variations in habitat types and not by thermal regimes. Where the ranges of these 2 species overlap, competitive interactions appear to drive patterns of habitat use, with *P. microlepis* potentially excluding *P. unifasciata* from urchin-grazed barrens habitat. Mesocosm laboratory experiments indicated that the outcome of competitive interactions between these 2 species is temperature-dependent, with *P. microlepis* dominance increasing at higher temperatures. This study clarifies the important role of habitat in determining latitudinal ranges of these 2 species. It also highlights the need to consider temperature-dependent behavioural interactions to properly understand future potential shifts in species ranges that may result from global climate change.

Key words: Range expansion, Biogeographical distribution, Temperate damselfishes, Competition

Direct and indirect effects of ocean acidification and warming on predator-prey dynamics

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Ocean acidification and warming have the potential to greatly impact many calcifying organisms by influencing their metabolic demands, acid-base physiology and calcification mechanisms. Moreover, emerging research suggests that realistic changes in temperature and CO_2 can also indirectly influence predator-prey interactions. These indirect effects may occur through changes in the prey quality, or altered susceptibility to predation. We set out to determine the effect of climatically realistic increases in CO_2 and temperature on the growth, $CaCO_3$ deposition and dissolution, and metabolic rate of the dogwhelk *Nucella lapillus*, and the interaction strength between this predator and their principal prey, the acorn barnacle *Semibalanus balanoides*. Our results indicate that moderate levels of CO_2 negatively affect the growth and net calcification of the dogwhelk, as well as their interaction strength with the acorn barnacle, and moreover, that these effects were exacerbated when combined with warming. The combined stressors also reduced the feeding rate of the dogwhelk, resulting in an energy deficit and subsequent loss of somatic tissue. Since the resilience of any marine organism to combined stressors is fundamentally linked to their ability to obtain and assimilate energy, we suggest that under stressful conditions, changes to the predator-prey dynamic may result in the reallocation of resources, and could have negative consequences for critical biological processes. As such, there is now a need to gain a more ecologically realistic understanding of how the combined effects of temperature and acidification will not only affect marine biota, but also related aspects of their food-web.

Sex ratios at range edges of protandric patellid limpets: what are the roles of density dependence and recruitment?

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Various species of *Patella* exhibit protandry (e.g. *P. vulgata*, *P. ulyssiponensis*) whilst others apparently do not (e.g. *P. depressa*). We compared the sex ratios with size in populations at their range edges with those towards the centre of their range in the well-established protandrous cold-water species *P. vulgata* and the apparently non-protandrous warm-water species *P. depressa*. At its range centre in the British Isles, *P. vulgata* clearly demonstrated population structures consistent with protandry – larger size classes were dominated by females. At its southern range edge this was not the case. In *P. depressa* at its northern range edge in southern Britain size structures were not consistent with protandry as previously reported, but there was a hint of possible protandry in range centre populations. The implications of these results for the processes determining the range edge of species are discussed – does lack of small males due to intermittent recruitment lead to Allée effects in *P. vulgata* in populations at their range edge in Portugal? The role of density dependence in protandry is also considered in the light of manipulative experiments and observations, indicating that *P. vulgata* progresses more rapidly to females in less dense populations. In less dense low recruitment populations in southern Europe, do males progress to females earlier due to relaxation of intra-specific competition, or are there just fewer but larger female limpets?

Phytobenthic community development under static and diurnally fluctuating pH.

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In temperate reefs, the metabolic activity of seaweeds causes the seawater pH to fluctuate diurnally, and pH is higher during the day due to photosynthesis and lower at night due to respiration. In laboratory experiments using an automated pH control system, we tested how fluctuating pH affects the development of a benthic community at today's pH (8.05) and the pH projected for future due to ocean acidification (pH 7.65). An assemblage of fertile articulate coralline *Arthrocardia corymbosa* (Lamarck) Decaisne with associated cryptic symbionts and epibionts was used as the primary source of recruits. There were four experimental pH treatments: static pH 8.05 (today's pH) and static pH 7.65 (future pH), and fluctuating pH 8.05 and fluctuating pH 7.65 in which pH was 0.4 units higher during the day and 0.4 units lower at night thereby mimicking the range of pH observed in kelp beds. After 5 month's laboratory culture, the phytobenthic community composition was quantified. At least 6 species of diatom recruited, including naviculoid (*Navicula*, *Fallacia*), monoraphid (*Cocconeis*, *Achnanthes*), and nitzschioid (*Nitzschia*, *Cylindrotheca*), which were observed across all treatments. There was no effect of experimental treatment on diatom community biomass (chl *a*) nor frustule silica content (Bsi quota). Brown and green turfing seaweed also recruited in all treatments. A range of other species were observed including *Durvillaea* sp., *Desmarestia lingulata*, *Dictyota* sp. Specific growth rates of crustose *Arthrocardia corymbosa* recruits were pH 8.05 static > pH 7.65 static = pH 8.05 fluctuating > pH 7.65 fluctuating. The % $MgCO_3$ in *Arthrocardia corymbosa* recruits was ~1.5% lower in both pH 7.60 treatments compared to both 8.05 treatments. This study is a first step in understanding how pH fluctuations typical of kelp beds affect the development of temperate seaweed communities under seawater pH conditions that are predicted for the future.

Key words: Ocean acidification, seaweed community, pH variability

Can *Septifer virgatus* survive in a warming world? A Dynamic Energy Budget model approach

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The black mussel, *Septifer virgatus,* is a northern species which forms dominant bands in the mid-low levels of exposed shores. In Hong Kong, mass mortalities of *Septifer* were recorded during the summer, with percentage cover decreasing from 82% (~ 1654 ind m^{-2}) in May to 27% (~ 216 ind m^{-2}) in August 2012, when aerial and rock surface temperatures exceeded 33 °C and 50 °C, respectively. Elevated temperatures played an important role in limiting physiological responses of the mussel, including heart rate, oxygen consumption rate and mantle water and haemolymph osmotic concentrations. The upper thermal limit, as indicated by Arrhenius breakpoint temperature, was ~ 41 °C in air, showing that in Hong Kong this species is already living at its thermal limit. The high temperatures and desiccation stress experienced on the shore are likely to invoke high energetic costs for *Septifer*. To better understand *Septifer*'s performance under these environmental conditions, and the energetic implications of thermal stress on its fitness, and hence potential distribution, a Dynamic Energy Budget (DEB) model was constructed to investigate the possible strategies of energy allocation under different thermal scenarios. The model shows that when *Septifer* is stressed, the mussel does not have enough energy reserve to tolerate elevated temperatures, and its growth and reproductive events are reduced. This reduction in performance and fitness, associated with not being able to reach the energy threshold necessary for somatic maintenance, suggests that *Septifer* may experience a northwards range shift in its distribution as environmental temperatures increase.

Key words: Climate change, distributional shifts, intertidal, thermal stress

Transcriptomics to ecosystems approach reveals response mechanisms of temperate reef species to multiple stressors

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Climate-driven shifts in species biogeographic distributions are occurring throughout temperate marine systems globally, and the experimental evidence base of diverse responses of invertebrates and macroalgae to ocean acidification is growing rapidly. The research community, however, has only recently begun to study potential synergistic effects of major climate drivers and the impacts of multiple stressors reflective of real scenarios are mostly unknown. Experimenal research is now challenging the 'central tendency' approach to climate profiling used in many meta-analyses and calls for a rethink in our approach to reporting responses of temperate marine species and communities to anthropogenic stressors and global change.

We present a novel research programme combining mesocosm-based transcriptome level analyses of gene induction and physiological responses to chronic exposure to elevated temperature, CO_2, salinity and nutrients with single-nucleotide polymorphism seascape molecular genetics and the most spatio-temporally extensive intertidal time-series data globally from the MarClim project. This omics to ecosystems approach identifies the biological mechanisms by which organisms acclimate to locally stressful environments and demonstrates how these responses translate through the population, species and community to drive complex and sometimes contradictory impacts of anthopogenic pressures impacting temperate reef systems.

Changes in macrophyte chemistry alters herbivory along a natural gradient of CO_2

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'Space for time' studies, where a gradient of environmental conditions exist that reflect current and predicted future conditions, have provided powerful insights into the likely impacts of future environmental change on the physiology, ecology and structure of marine communities. While most 'space for time' studies have focused on temperature gradients, recently natural gradients of ocean carbonate chemistry have been used to understand how marine communities are likely to respond to ocean acidification. While such systems have provided important insights on likely changes in the structure of marine communities, particularly calcifying organisms, far few studies have investigated how these changes may affect biotic interactions. Using a natural volcanic vent system in Vulcano, Italy, we investigated effects of predicted future carbonate chemistry conditions on the chemical composition of a range of macrophytes (algae and seagrass) and how this altered rates of herbivory and herbivore choice. Macrophyte chemical composition differed between high and low CO_2 locations. Fish abundance did not differ between high and low CO_2 locations, however, there were differences in In-situ rates of herbivory between locations and macrophyte species with lower levels of herbivory of *Cymodocea nodosa* at low CO_2 locations and lower levels of *Padina pavonica* herbivory at high CO_2 locations. Patterns observed for *P. pavonica* in the field were also shown for this species as well as *Dictyota dichotoma, Cystoseira compressa and Caulerpa prolifera* in the lab with grazers preferentially consuming algae collected from low CO_2 locations. Mechanisms driving the observed response by herbivores are discussed in terms of macrophyte chemical ecology.

Key words: Ocean acidification, plant-herbivore interactions, climate change, seagrass, macroalgae, grazers.

Distribution of urchin barrens on Australia's east coast: Latitudinal trends in maximum depth revealed with an AUV

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Autonomous Underwater Vehicles (AUV's) are a relatively recent tool that can provide invaluable ecological information suitable for monitoring the marine environment. They supply high quality data, in the form of digital imagery that is precisely geolocated, allowing repeat spatial and temporal surveys. Also, they can operate at depths below those that have been traditionally surveyed by methods such as SCUBA. We examine the application of AUV data to assess the spatial extent and depth distribution of barrens formed by the range extending urchin *Centrostephanus rodgersii* on the east coast of Tasmania. Global climate change and the resulting strengthening of the East Australian Current have brought the ecologically important grazer into Tasmanian waters over the last 40 years. The transformation of productive macroalgal beds to urchin barrens has significant consequences ecologically, with the potential to impact economically important local fisheries. We demonstrate the usefulness of the AUV as a platform for sampling and monitoring *C. rodgersii* barrens in Tasmania. AUV data from New South Wales is also analysed with respect to *C. rodgersii* barrens, and a comparison between the two data sets reveals a differing pattern of the depth distribution of barrens in the more recently established Tasmanian range. Barrens are found to extend to greater depths in Tasmania than in the urchins native range of NSW, and thus threaten a greater extent of benthic habitat than previously considered. A comparison is also made between a long-established Tasmanian MPA and nearby control sites in order to test the resilience of the MPA to barrens formation. This research highlights the usefulness of AUVs, both in the provision of broad-scale baseline ecological data, and in the power that they can provide in an ongoing monitoring capacity.

Impacts of climate change on temperate and subtropical coastal species

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We present evidence of the impacts of climate change in the Ocean through meta-analysis of 1735 marine biological responses from the peer-reviewed literature. Observations were recorded from every ocean from open ocean to coastal waters. We focus here on 775 observations for fish, benthic invertebrates and plankton from temperate and subtropical intertidal or coastal waters. Of these, 516 showed responses in distribution, phenology, community composition, abundance, or demography, of which 84% were consistent with the direction expected under climate change. Observations included distribution extensions of fish and invertebrates in the north-east Atlantic and south-west Pacific, contraction of macroalgal distributions in Australia and Europe, increased dominance of warm-water fish in north-east Atlantic and western Indian Ocean, declining body size of fish in Tasman Sea and earlier spawning of bivalves in the North Sea, On average, distributions shifted, generally polewards, by 12.3 km dec^{-1} and phenology advanced by 7.3 days dec^{-1}. Of the species that changed distributions, larger shifts occurred in regions with fastest velocity of climate change (speed and direction of isotherm movements). However, 261 of the 775 observations showed no change, suggesting climatic changes were not outside biophysical tolerance limits of the species. However, null responses may also arise from a number of other causes such as poor data resolution, barriers to dispersal or the influence of non-climatic factors. Every study in the subset discussed here, considered regional temperature as the primary driver of observed biological responses. In 46% of cases, authors suggest that other drivers, such as habitat modification, exploitation or sampling error, may have contributed to the observed response, whilst for 13% authors explore and discount the influence of non-climate drivers. For 41% of observations, the influence of alternate drivers of change were not considered. We discuss the attribution of observed changes to global warming and highlight approaches that give strongest confidence for the role (or lack of) of climate change in driving responses.

Key words: climate change, meta-analysis, distribution, phenology

Recovery of grazed kelp forests in northeast Atlantic - the influence of climate change and environmental factors

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Complex spatial patterns for recovery of kelp (*Laminaria hyperborea*) and persistence of (*Strongylocentrotus droebachiensis*) barrens are explained and related to temporal changes in temperature and to other physical factors in a large area in the NE Atlantic. This is an area that used to be barren due to sea urchin grazing. On a large scale, we identified borders for kelp recovery along the north-south gradient (i.e. latitude) and along the southeast-northwest gradient (i.e. along a coast-ocean gradient), both of which could be related to summer temperatures exceeding a threshold value of about 10°C, known to be critical for sea urchin recruitment and development. We suggest that the cold water found in the northern and eastern part of the area enhances sea urchin recruitment and development and reduces kelp growth. Similarly, the warmer water south and west in the area promotes kelp recovery and inhibits sea urchin development. On a finer scale, the recovery of kelp occurs mainly at ridges in outer, wave exposed, saline and warm areas whereas sea urchins still dominate in inner, shallow, and cold areas. The statistical models (GAM and BRT) show high performance and suggest recovery of kelp in at least 45-60% of the study area. Sea urchins still persist in about 20% of the area, whereas 20-35 % of the area is most likely lacking both species. This is one of few examples of large scale recovery of marine species, and the study shows how spatial analysing methods may be used to gain insight into complex patterns of recovery of species or habitats. The results, methods and approaches in this study is of general ecological relevance regardless of ecosystems and species, although they are particularly relevant for understanding and exploring the corresponding changes between algae and grazers in different coastal areas.

Key words: sea urchin grazing, species distribution modeling, BRT, GAM, *Laminaria hyperborea*, *Strongylocentrotus droebachiensis*

How long is too short: are we currently overestimating the potential effects of climate change?

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Over the past decade there has been an exponential rise in the number of experimental studies aimed at understanding the potential effects of changing climatic conditions on marine ecosystems. Some have produced startling and often concerning results which paint a bleak picture of the future. Will these outcomes come to pass? The majority of these studies focus on individual species over short time-scales, and cannot account for the role of acclimation or species interactions in altering the potential outcomes. I will draw together the results of several of our longer-term experiments assessing the effects of elevated CO_2, temperature and nutrients in marine systems across multiple continents to demonstrate that: (1) species interactions (e.g. algal-herbivore) have considerable impact on the predicted outcomes (also see talk by Falkenberg et al.); and (2) short-term experiments may underestimate the ability of species to acclimate and continue to perform their role in the ecosystem. This result does not mean that altered environmental conditions will have no effects, however; systems and species seem to have the ability to adapt to near-future conditions but exposure to 2100 predicted conditions or multiple stressors may still drive change to ecosystem structure and function.

Key words: climate change, ocean acidification, multiple stressors, physiology, acclimation

Competition with filamentous algae obscures the negative effects of ocean acidification on *Hydrolithoideae* crustose coralline algae.

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Crustose coralline algae (CCA) form substrata for the settlement and growth of turfing filamentous algae, and are heavily impacted by this interaction since they are considered subordinate in their ability to compete for space. CCA are among the most sensitive calcifying organisms to ocean acidification, while the growth and metabolism of turfing filamentous algae may increase under high partial pressure of carbon dioxide (pCO_2) indicating that the effects of filamentous turf on coralline algae may be amplified in a high pCO_2 environment. The effects of ocean acidification on coralline algae, however, have not yet been investigated in combination with ecological interactions such as competition with filamentous turfing algae. We conducted a manipulative experiment which combined the effects of ocean acidification and overgrowth by filamentous turfing algae on calcification, photosynthesis and mortality of a temperate *Hydrolithoideae* crustose coralline alga in Perth, Western Australia. The main effect of filamentous turfing algae on coralline health was not solely a negative competitive effect and the interaction between high pCO_2 and turfs indicated a positive effect of algal turfs on CCA calcification but a negative effect on photosynthesis, and this effect was variable over time. Our results have demonstrated the importance of investigating the effects of ocean change on a community scale, considering how inter-species interactions such as competition may change with ocean acidification.

Key words: Coralline algae, ocean acidification, filamentous algae, competition, calcification, photosynthesis

Ecological consequences of extreme events in marine ecosystems

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Extreme climatic events are increasing in frequency and magnitude, most likely as a direct consequence of anthropogenic climate change. The ecological impacts are discrete short-term events are, however, less understood than ecological responses to longer term gradual climatic change. In a preliminary analysis, long-term 'hand-collected' sea temperatures were collated from various regions to examine the frequency and magnitude of short-term anomalous events over the past >80 years. These records suggest that the frequency of anomalous warming events has increased in recent decades in some regions. We then discuss population, community and ecosystem level effects of a marine heat wave which impacted the west coast of Australia in 2011. A range of benthic surveys were conducted along a latitudinal gradient examine temporal variability in seaweed, invertebrate and fish assemblages in response to the warming event. The 2011 warming event off Western Australia was the most-extreme on record and resulted in widespread mortality and consequent range contractions of several cool-water foundation species. In the intermediate term at least, benthic biodiversity and ecosystem services have been degraded by the marine heat wave. Extreme warming events in shallow seas are increasing in severity. Such events can cause step-wise changes in the structure and functioning of benthic ecosystems at large spatial scales, by influencing species interactions, driving range shifts of habitat-forming species and altering the relative abundances of warm and cool water consumers. Ecological responses to extreme climatic events may provide novel insights into likely responses to long-term gradual warming.

Key words: temperature variability, climate change, heat waves, Leeuwin Current, ecosystem structure and functioning, tropicalisation.

Effects of a submarine eruption on the performance of two brown seaweeds

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World oceans are becoming more acid as a consequence of CO_2 anthropogenic emissions, with multiple physiological and ecological implications. So far, our understanding is mainly limited to some species through *in vitro* experimentation. In this study, we took advantage of a recent submarine eruption (from October 2011 to March 2012) at ~1 nautical mile offshore El Hierro Island (Canary Islands, central east Atlantic) to determine whether altered physical-chemical conditions, mainly sudden natural ocean acidification, affected the morphology, photosynthesis (*in situ* Chl-a fluorescence) and physiological performance (photo-protective mechanisms and oxidative stress) of the conspicuous brown seaweeds *Padina pavonica* – a species with carbonate deposition - and *Lobophora variegata* – a species without carbonate on thallus surfaces -, both with similar morphology. Seaweeds were sampled twice: November 2011 (eruptive phase with a pH drop of *ca*. 1.22 units relative to standard conditions) and March 2012 (post-eruptive phase with a pH of ca. 8.23), on two intertidal locations adjacent to the eruption and at a control location. *P. pavonica* showed decalcification and loss of photo-protective compounds and antioxidant activity at locations affected by the eruption, behaving as a sun-adapted species during lowered pH conditions. At the same time, *L. variegata* suffered a decrease in photo-protective compounds and antioxidant activity during the volcanic event, but its photosynthetic performance remained unaltered. These results reinforce the idea that calcareous seaweeds, as a whole, are more sensitive than non-calcareous seaweeds to alter their performance under scenarios of reduced pH.

Key words: volcano, acidification, pH, brown algae, physiology, photosynthesis

Tropicalisation of temperate marine ecosystems: Herbivore-mediated phase-shifts from kelp to coral in eastern Australia?

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In many parts of the world, the intensification of western boundary currents such as the East Australian Current is causing localised warming and the extension of tropical waters and biota into temperate systems. This can lead to catastrophic phase shifts in temperate regions away from productive, complex macroalgae-dominated reefs. We hypothesised that the intrusion of tropical herbivores into temperate areas is one mechanism for such phase shifts and investigated this in the Solitary Islands marine park, a temperate-tropical transition zone in eastern Australia where kelp- and coral-dominated reefs are contiguous. We found that herbivory was more intense on coral-dominated reefs compared to kelp-dominated reefs. Additionally, tropical herbivorous fish species were more abundant on coral-dominated reefs, where levels of herbivory were highest. We also found evidence for higher densities and herbivory by urchins in coral- compared to kelp-dominated reefs. We suggest that higher rates of herbivory by invading and functionally diverse herbivores extending their ranges into temperate regions may be a mechanism facilitating transitions from kelp to coral dominated reefs.

Key words: Climate change, ecosystem impacts, functional diversity, herbivorous fish, macroalgae, range shift

Grazers influence the trophic dynamics of tropical rocky reefs: carbon use and ecological thresholds in alternate community states

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Understanding the mechanisms and thresholds that apply in phase-shifts between alternate community states are important issues in conservation and management of reef ecosystems. While the importance of grazers in determining alternate states of algal assemblages has been widely documented in coral reefs and temperate rocky reefs, their role in tropical rocky reefs is largely unknown. Field surveys in monsoonal Hong Kong, southern China, revealed that rocky reefs are characterized by three distinct community states along a gradient of grazing pressure, either dominated by (1) coralline barrens, (2) macroalgal beds (i.e. seaweeds and crustose brown algae) or (3) a transition state between these two extremes. Spatio-temporal variations in the trophic dynamics of reefs in these communities were examined by measuring variations in carbon use and gonad production of the dominant grazer, the sea urchin *Anthocidaris crassispina*, during wet and dry seasons. Stable isotope analyses (SIA) and fatty acid profiling (FAP) indicated that, in all three community states, urchins assimilated carbon mainly from seaweeds and non-coralline crustose algae, with secondary use of diatoms and detritus from biofilms and deposited fine sediments. Microbial and heterotrophic carbon sources were of greater importance during the summer wet season when seaweed beds died back, particularly in coralline barrens where urchins assimilated diatoms and small barnacles as supplementary foods. The low abundance of seaweeds in coralline barrens was reflected by significant reductions in urchin gonad biomass and lipid content. Changes in the benthic assemblage composition and gonad FAP along a gradient of grazing pressure suggested that ~8 urchins/ m2 (~230 g/ m2) was a threshold urchin abundance for phase-shifts between alternate community states, with coralline barrens associated with urchin abundance above this threshold, while seaweed beds only occurred at lower urchin abundance. Manipulation of urchin densities to affect phase-shift may offer a useful tool for conservation and management reef ecosystems.

Key words: food web; trophic pathways; crustose coralline algae; herbivory; stable isotope; fatty acid profiling;

Taking the Acid test: Mediterranean limpets face up to climate change

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Impacts of climate change involve the interactions of multiple stressors on intertidal organisms, but rarely are the impacts of these stressors examined together. Many tests are also conducted in artificial, controlled laboratory conditions, without making use of natural opportunities to test performance of organisms under different environmental stressors. Given its small tidal range, the Mediterranean Sea provides such an opportunity, with a very fine scale environmental gradient and species living very close to each other over the tidal gradient. The vertical distribution of the limpets, *Patella rustica* and *P. caerulea* overlap in Palermo, Sicily, but despite this they have different thermal windows. The higher shore *P. rustica* had a lower metabolic rate than the mid shore *P. caerulea,* and was also more tolerant of thermal stress, being able to maintain heart function up to 38 °C as opposed to 36 °C in *P. caerulea*. When heat stressed, *P. rustica* also induced heat shock protein expression, whereas expression in *P. caerulea* was very low. Utilizing a natural gradient of seawater pH (caused by CO_2 vents off Vulcano Island, Sicily), the combined effects of ocean acidification and thermal stress were investigated, which revealed an intraspecific gradient in species response. In general both species were more tolerant of thermal stress, maintaining heart rates between 41- 43 °C, but individuals stressed by lower pH were less tolerant as compared to those further from the vent which experienced natural seawater pH. Heat shock protein expression and function of metabolic enzymes were also analyzed. These preliminary findings highlight the need for testing the impacts of multiple stressors, but also the benefits of utilizing naturally occurring habitats to investigate the interactions between environmental stressors.

Key words: *Patella rustica*, *P. caerulea,* multiple stressors, heart rate, Ocean acidification, heat shock proteins

The impact of ocean acidification on the predation of populations of the Pacific oyster *Crassostrea gigas*

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It has been predicted that by the end of this century oceans will acidify because of anthropogenic increases in CO_2. Known as the "other CO_2 problem" ocean acidification is anticipated to have the greatest impact on calcifying marine organisms especially molluscs. Studies on the impacts of ocean acidification have found decreased calcification and increased dissolution of the shell of molluscs. Molluscs with thinner and weaker shells may be more susceptible to predation. It was hypothesised that consumption of the Pacific oyster *Crassostrea gigas* by the Mulberry whelk *Morula marginalba* will increase under elevated CO_2 which may vary among pair-mated family lines. *M. marginalba* were collected from rocky shores and eight family lines of *C. gigas* were exposed to ambient (385 ppm) and elevated (1000 ppm) pCO_2 for a period of six weeks. Following this period, using a fully orthogonal design, *M. marginalba* were transferred into tanks with oysters held at ambient (385 ppm) and elevated (1000 ppm) pCO_2 for a further seventeen days. After 10 days, *M. marginalba* consumed significantly more *C. gigas* when transferred to elevated CO_2 regardless of whether *C. gigas* had been exposed to ambient or elevated CO_2. There was also a trend for whelks at ambient CO_2 to consume more oysters which had been exposed to elevated rather than ambient CO_2. Although there was a significant difference in the number of *C. gigas* consumed among family lines, this was not because of pCO_2. This study found an increase in predation following exposure to near-future predicted levels of estuarine pCO_2 dependent on the origin of oysters and the level of CO_2 which did not differ among family lines. Further work is required to determine if this increase in predation is because of increased metabolic activity and/or changes in shell strength of *C. gigas* under future climate scenarios.

Key words: ocean acidification, predation, oysters

Human impacts

Two decades of surveys in Tasmanian marine reserves reveal single species to system wide effects of fishing, resistance to species invasion and responses to climate change .

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A small network of coastal no-take marine reserves were established in Tasmania, Australia in 1991 as a conservation response to the widely held belief that fishing activities had significantly altered marine communities and some areas should be set aside for marine conservation. A research program was established at the time to evaluate the extent that the biota on rocky reefs in no-take areas change through time following protection. This broadly based study has continued as an annual time-series, tracking the abundance of fishes and invertebrates, and the percentage cover of macroalgae within these areas and at adjacent reference locations, over the past two decades. While some time points were missed in some reserves in some years, the overall dataset provides an invaluable information base from which to understand a range of coastal processes, ranging from single species effects of fishing, through species interactions, to climate mediated shifts in species distributions and abundances (gains of warm affinity species and losses of cool affinity species) and the relative resistance/resilience of protected area to such changes. It has also significantly contributed to our understanding of the temporal stability and variability of many temperate reef species, and the drivers of this, to place shorter term observations in perspective. Within the largest reserve at Maria Island, protection resulted in a rapid increase in the number of large exploited fishes, most notably the net susceptible species *Latridopsis forsteri*. Rock lobster abundance (*Jasus edwardsii*) and biomass also responded rapidly. Through time, the increased in predator biomass resulted in significant declines in prey species such as the common urchin (*Heliocidaris erythrogramma*) and the blacklip abalone (*Haliotis rubra*). Loss of kelp through urchin grazing was minimised in the reserve relative to control sites where barrens formed, and climate mediated invasion by the range extending urchin *Centrostephanus rodgersii* was resisted.

Effect of the receiving assemblage on habitat invasibility

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The study of habitat invasibility in biological introductions is necessary to understand the ecological factors affecting the process of invasion by non-indigenous species. Previous studies showed that resident organisms can either hinder or aid the colonisation by non-indigenous species. The invasive isopod *Cirolana harfordi* (hereafter *Cirolana*) occurs in large densities in oyster-beds in Sydney Harbour. In previous studies, we found no evidence of effects of the introduction of *Cirolana* on the structure of resident assemblages in oyster-beds. Is the opposite also true? Do the organisms in the assemblage of oyster-beds influence the colonisation by *Cirolana*? Living organisms (through interactions), dead organisms (as a resource) or simply organic matter (food) in the assemblage may influence colonisation. To disentangle these possible effects and test the derived hypotheses, four treatments were created: i) patches of oyster-beds with live assemblage (organisms <500µm); ii) patches of oyster-beds with dead assemblage (same organisms after being frozen); iii) patches of oyster-beds with a source of food equivalent to the assemblage; and iv) patches of oyster-beds without assemblage or food. *Cirolana* individuals were introduced in mesocosms composed of 200-L trays containing two replicates of the four types of patches, a seawater flow-through system, a tidal regime and photoperiod simulating natural conditions. After seven days, the abundance of *Cirolana* in each treatment was quantified. The results showed that patches with receiving assemblage (live or dead) facilitated the colonisation by *Cirolana*. In addition, patches with live organisms were less colonised by *Cirolana* than patches with dead organisms, suggesting weak biotic resistance by living organisms. The receiving assemblage played an important role in habitat invasibility for this species. These results show mainly positive interactions between this invasive species and the receiving assemblage, which is opposite to what is usually expected.

Key words: Biological invasions, Invasibility, Oyster-beds, Community ecology

Disturbance does not always promotes invasion success on shallow rocky reefs

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Disturbance has been repeatedly shown to promote the establishment and spread of exotic species by enhancing resource availability. Nonetheless, indirect negative effects on invasion success are expected when disturbance favours the dominance of native species life-history traits that confer resistance to invasion. An experimental study, aiming to assess how a disturbance event removing canopy-forming macroalgae influences the spread of the invasive seaweed, *Caulerpa racemosa*, was performed on shallow subtidal rocky reefs, along the north coast of Croatia (Adriatic Sea). Macroalgal canopies, mainly formed by three species belonging to the genus *Cystoseira*, were manipulated in order to generate different combinations of species richness (0, 1, 2 and 3 species), identity (*C. barbata*, *C. compressa* and *C. crinita*) and cover (50% and 100%). After 2 years, the percentage cover of *C. racemosa* was lower in experimental plots where all the three canopy species were either present or totally removed and in mono-specific stands formed by *C. compressa*. Macroagal canopies richer in species are, therefore, less susceptible to invasion by *C. racemosa*. Disturbances removing macroalgal canopies formed by the three macroalgae, by *C. barbata*, *C. crinita* or a mix of the two would promote resistance to invasion by allowing space dominance by *C. compressa* (i.e., the species more effective in constraining the expansion of *C. racemosa*). These results suggest that the effects of disturbance on invasion success may be not invariantly positive, but dependent on the matching between life-history traits selected within the native pool and those of the invader.

Key words: Biodiversity, *Caulerpa racemosa*, Habitat-formers, Macroalgal canopies, Invasion biology

Marine litter: we know a lot less about it than we should

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Marine litter has been a recognized environmental problem for a very long time. Every year, large numbers of volunteers contribute hours of their time cleaning beaches and recording the quantities of litter. Over the past four decades or so, there have been numerous scientific studies of the problem, intertidally and subtidally and in many different parts of the world. Given the wealth of papers available on the topic, one should expect that we actually have a reasonable idea about quantities of litter at a global scale, its sources and trends in amounts and composition of litter over time. In fact, we know very little. Studies tend to be very local and vary in methodology, making it very difficult to extrapolate or synthesize over space or time. More of a problem are the flaws in the sampling designs used in many studies. These make the results of the individual studies uninterpretable, invalid or meaningless. Yet these are flaws that have been recognized and dealt with in ecological sampling many years ago. Much of this knowledge does not appear to have made it into studies of distribution and abundance of litter. Here, I will present an assessment of the scientific literature on marine litter, outlining many of the ongoing problems and suggesting ways for making better progress in the future.

Key words: synthesis, sampling design, global pattern, temporal trends

Effect of canopy removal on intertidal biodiversity and ecosystem functioning: a long-term experiment on the commercial seaweed *Ascophyllum nodosum*

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The effect of the presence or absence of the canopy and the relationship between the diversity associated to the zone and its functioning has not been tackled much so far. *Ascophyllum nodosum* being a harvested alga, we tested the impact of more or less severe canopy cuts on the algal and animal species and functional diversity as well as on the community metabolism of the zone. These elements were thus measured on (1) an intact control zone, (2) a zone where the canopy was cut at 80 cm from the holdfast, (3) a zone where the canopy was cut at 20 cm (legal size), and (4) a zone without canopy. This six-year survey (still in progress) showed that an 80 cm harvest does not affect either diversity or the metabolism of the zone. On the contrary, a 20 cm harvest affects the biomass and the density of the canopy as well as the animal diversity during the first year only. On the no-canopy zone, a *Fucus vesiculosus* canopy progressively developed and attained 100% cover after nineteen months. The average length, biomass and density of *A. nodosum* together with the average number of macroalgal species were negatively affected during the first years of the study while the density and average numbers of the macrofauna did not show any difference with the control after nineteen months. Finally, the community metabolism is comparable between the non-impacted or weakly impacted zones and the no-canopy zones, showing evidence of functional redundancy between *Fucus vesiculosus* and *A. nodosum*. After 6 years, no recovery of *A. nodosum* occurred in the no-canopy zone, despite the small experimental area located within a large *A. nodosum*-dominated zone.

Key words: Harvest, Algal diversity, Macrofauna diversity, Gross community production, Community respiration

Building-in beneficial features: artificial rockpool case study

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Globally, engineered structures are proliferating in the marine environment in response to anticipated climate change and increasing coastal development. In order to fulfil international marine conservation commitments, such as those laid out in the OSPAR Convention and the Convention on Biological Diversity, governments are prescribing a much more proactive approach to marine planning than previously. For example, the UK's Marine Policy Statement advises that in addition to avoiding harm to marine ecology, developments should also provide opportunities for "building-in beneficial features". However, much remains unknown about the potential for artificial hard structures to deliver secondary ecological benefits and surrogate for natural rocky shore habitat. This study trials habitat enhancement manipulations (artificial rockpools) as an affordable, replicable means of delivering ecological benefit via increasing habitat complexity of coastal defence infrastructure. Deep and shallow artificial rockpools were cored into an intertidal granite breakwater in mid Wales, UK in the spring and autumn of 2012. The pools were monitored regularly, along with surrounding emergent rock surfaces and comparable natural rockpools that had been treated to remove biota and calcareous deposits. Preliminary results (12 months) indicated that the artificial rockpool habitat supported significantly greater species richness than surrounding emergent rock surfaces. However, early species assemblages in the artificial pools were dissimilar to those recorded in the natural pools, largely due to differences in the sessile components of the assemblages, i.e. algae and encrusting fauna. Findings from ongoing monitoring (20 months) will be presented and discussed. Firmer conclusions may be drawn regarding the potential for artificial rockpools to support natural and/or novel assemblages, and their capacity to enhance the ecological value of coastal defence structures. Further, recommendations may be drawn regarding the design (i.e. depth) and timing (i.e. season) of habitat enhancement manipulations on new and existing infrastructure.

Key words: ecological engineering, artificial reef, colonisation, succession

Luderick, Girella tricuspidata, exhibit strong site fidelity and higher abundance within marine sanctuaries.

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The key herbivore, luderick (*Girella tricuspidata*), plays an important ecological role due to its large biomass and associated grazing on temperate rocky reefs. Luderick are also heavily exploited by both commercial and recreational fisheries. Limited data exist on the ecology and behaviour of luderick, but what does exist suggests that they may be highly mobile and exhibit poor site fidelity, therefore considered unlikely to benefit from “no-take” sanctuary zones within marine parks. To evaluate whether this was actually the case we tested the hypotheses that (a) luderick would not exhibit strong site fidelity on shallow subtidal reefs (including within sanctuary zones) and that (b) there would be no difference in the abundance of luderick between sanctuary zones and fished areas. To test these hypotheses we combined the use of acoustic telemetry and diver operated stereo-video (stereo-DOV) to assess fine and broad-scale movements and to quantify the abundance of luderick between sanctuary zones and fished areas in Jervis Bay Marine Park, New South Wales. Contrary to our predictions formed from the initial limited observations, luderick exhibited strong site fidelity on shallow subtidal reefs and were more abundant in sanctuary zones compared to fished areas. These results indicate that sanctuary zones are likely to play a beneficial role for luderick and highlight the need for clear quantitative assessment of abundance and movement patterns at the correct spatial and temporal scales to appropriately assess the effects of marine parks.

Artificial coastal defences: enhancing biodiversity using sensitive design

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Coastal defence structures are proliferating as a result of rising sea levels and stormier seas. With the realisation that most coastal infrastructure cannot be lost or removed, research is required into ways that coastal defence structures can be built to meet engineering requirements, whilst also providing relevant ecosystem services - ecological engineering. This approach requires an understanding of the types of assemblages and their functional roles that are desirable and feasible in these novel ecosystems. We review the major impacts coastal defence structures have on surrounding environments and recent experiments informing building coastal defences in a more ecologically sustainable manner. We summarise research carried out during the THESEUS project (2009–2014) which optimised the design of coastal defence structures with the aim to conserve or restore native species diversity. Native biodiversity could be manipulated on defence structures through various interventions: we created artificial rock pools and on breakwaters and we deployed a precast habitat enhancement unit (the BIOBLOCK) in a coastal defence scheme. Finally, we outline guidelines and recommendations to provide multiple ecosystem services while maintaining engineering efficacy. This work demonstrated that simple enhancement methods can be cost-effective measures to manage local biodiversity. Care is required, however, in the wholesale implementation of these recommendations without full consideration of the desired effects and overall management goals.

Key words: Ecological engineering, urbanisation, biodiversity

Developing long-term monitoring programs in offshore waters with little prior knowledge: Applying a novel sampling design to inventory biological assets

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Australia's declaration of a Commonwealth Marine Reserve (CMR) Network, has resulted in a pressing need to 1) provide quantitative inventories of the species and communities represented within reserves, and 2) develop methods that enable trends in their composition, abundance and distribution to be monitored. These objectives require a general but flexible long-term monitoring framework where sampling is conducted using non-destructive methods such as towed video, baited underwater video and still imagery, and informed by habitat data derived from multibeam acoustics. Here we describe the application of a flexible sampling program tailored for assessing the biodiversity associated with continental shelf habitats in the Flinders CMR, north-east Tasmania. This program is based on a probabilistic and spatially-balanced sampling design called Generalized Random Tessellation Stratified (GRTS). While GRTS has been used for continental and regional-scale monitoring programmes in the United States, its application to marine systems in Australia is new. Within the Flinders CMR, little previous knowledge existed on the spatial distribution of shelf habitats, necessitating a two-phase sampling approach. Firstly, GRTS was applied to gain an understanding of the distribution of shelf habitats across the CMR shelf; secondly, this information was used to design a biological sampling program. Here we 1) discuss the suitability of this method for conducting ship-based sampling programs with little prior information over large spatial scales, and 2) present the first quantitative assessment of the distribution, composition, and abundance of fish and fish assemblages within the Flinders CMR, as determined with baited underwater videos.

Key words: Marine Protected Area, spatial management, survey design

Strong direct and inconsistent indirect effects of fishing found using stereo-video: testing indicators from fisheries closures

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Candidate indicators of the direct and indirect effects of fishing can be developed by investigating fisheries closures. We tested a suite of such indicators in areas open to fishing but with suspected differences in effort, using baited remote underwater stereo-video methods. In particular, we predicted that greater fishing would result in decreased biomass of high risk target species and indirectly increase the biomass of small-bodied non-target species. As predicted, the biomass of target species was found to be greater in areas of lower fishing effort and in deeper waters. However, no indirect effects of fishing were detected and any community-level effects were driven by differences in the biomass of target species. In particular, assemblage length class analysis of covariance (ANCOVA), size spectra analysis and the abundance-biomass comparison (ABC) method did not provide any evidence of indirect effects of fishing. The magnitude of the differences in fishing effort between the two areas sampled, may be sufficient to significantly affect target fisheries species, but insufficient to lead to indirect effects on non-target populations. It is also possible that the predicted indirect effects do not occur in this assemblage, due to weak trophic linkages between species. Differences observed using the ABC method were attributed to variation in the abundance of large herbivorous fishes, which are not fished. We also found assemblage length class ANCOVA and size spectra to be insensitive to the effects of fishing where large numbers of non-target individuals are sampled along with fished species. We suggest diet studies and comparisons across stronger gradients in fishing pressure to further investigate the indirect effects of fishing in this assemblage.

Effects of copper exposure on early life stages of *Macrocystis pyrifera* and *Undaria pinnatifida* (Laminariales, Phaeophyceae)

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Changes in the seawater carbonate system (ocean acidification) that are projected for the future will have flow-on effects that will also alter the speciation and toxicity of trace metals such as copper (Cu(II)). Copper in minute amount is an essential micronutrient for cellular metabolism but in excess it can become extremely toxic, especially to the free-living micro-stages of the organism. The life cycle of algae in the order Laminariales consists of an alteration of generations between large diploid sporophytes and microscopic haploid gametophytes. Micro-stages of algae are more susceptible to environmental stressors than adult stages. The objective of this study was to determine the effect of copper exposure on micro-stages of *Macrocystis pyrifera*, the most widely distributed kelp in the world and the Asian kelp *Undaria pinnatifida* that is also becoming globally widespread as a result of human shipping activities. Zoospores were separately obtained from sporophylls of each species. After settlement, zoospores were exposed to copper (0, 100, 200, 300 and 400 $\mu g \cdot L^{-1}$ Cu(II)) at 12°C and 50 µmol photons$\cdot m^{-2} \cdot s^{-1}$ (12:12 h light:dark of PAR) for 9 days. Germination (%) and germling size (μm^2) were measured. Zoospores germination rates of both species were significantly affected after 9 days of chronic copper exposure. Under control condition (no Cu(II) addition) 95% of zoospores germinated in both species. Under 400 $\mu g \cdot L^{-1}$ Cu(II) exposure, higher reduction in germination rate was observed in *M. pyrifera* (55%) compared to *U. pinnatifida* (33%). Growth of germlings was significantly affected under copper exposure. Gametophyte size was 72-82% lower within the range of copper concentration they were exposed to and the effect of copper concentration on gametophyte size was not significantly different between species. Invasive seaweeds can be abundant in coastal habitats that are subjected to nutrient pollution suggesting that trace metal tolerance and nutrient enrichment may enhance invasion success over native species.

Key words: germination, kelps, life cycle, metals, viability, zoospores

Engineering structural complexity for enhancing biodiversity on seawalls

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Ongoing coastal urbanization has resulted in extensive replacement of natural habitats with man-made ones such as seawalls, jetties and breakwaters. These novel habitats tend to support biological communities with low diversity, partly because they are less structurally complex compared to natural habitats. To simultaneously examine the independent effects of complexity and different structural component types on diversity and community composition, we designed two types of concrete tiles with approximately equal surface areas, one structurally more complex than the other, plus a control tile made of granite. We created four different geometric designs and then used novel software (*CASU*) with a fixed mean value to randomly vary the size, depth and spacing of each component for the "complex" tile design. The "simple" tiles had components with equal size, depth and spacing of the same fixed mean. The concrete tiles (n = 8) were then mounted onto steel frames, which were in turn fixed onto granite seawalls (at two tidal heights) at two islands south of Singapore Island. This created a three-way ANOVA design with 'Site', 'Position' and 'Type' as factors. After 13 months of colonization, all 384 tiles were collected and their assemblages compared. A total of 259,184 individuals of 79 taxa were collected and identified. Our results show that greater complexity can support greater richness, diversity and different communities that is independent of surface area. Furthermore, the type of structure can have an effect on diversity and richness that is independent of complexity. Increasing coastal development and sea level rise will inevitably result in more seawalls globally. There is clearly an opportunity to ecologically engineer these structures to enhance their capacity to harbour biodiversity. Incorporating complexity is potentially the most efficacious way to achieve this goal.

Key words: artificial substrates, habitat structure, reconciliation ecology, restoration, spatial heterogeneity, topography.

Restoring underwater forests: temporal and spatial variability

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Degradation of coastal areas by human activities is a major cause of the loss of biodiversity. Despite some extensive conservation efforts, most impacted habitats remain in a degraded state. Thus, there is a need to go beyond conservation to restoration. The fucoid alga *Phyllospora comosa* forms extensive beds that provide habitat and other resources, supporting diverse assemblages, including economically important species. *Phyllospora* was once common on shallow subtidal reefs around Sydney, but disappeared in the 1980's, coincident with heavy sewage outfall discharges. Preliminary experiments showed that Sydney is now suitable for the survival and reproduction of this alga. In addition, comparisons of biodiversity associated with this alga and other key habitat-forming algae suggested that *Phyllospora* is not functionally redundant. These observations motivated the restoration of this alga into Sydney's reefs, with the goal of re-establishing the habitat and achieving similar biodiversity to that in reference locations where *Phyllospora* still occurs. An area of ~20 m2 was restored at each of 2 locations in Sydney and the survival, condition and recruitment in restored patches was compared to those in reference locations. Abundances and diversity of benthic organisms, epifauna and fish were quantified and compared among restored, reference and control (non-restored) locations. Survival and recruitment of Phyllospora varied through time and between restored locations. After ~1 yr, only some components of biodiversity in restored patches, such as epifauna, became similar to those in reference populations. After ~1.5 yrs, recruits of the kelp *Ecklonia radiata* "swamped" restored patches, where the survival of *Phyllospora* was lower than in reference locations. It seems, therefore, that although the environment in Sydney is suitable for survival and reproduction of *Phyllospora*, other processes may prevent the establishment of self-sustained populations. Understanding these processes and their variability in time and space is necessary for successful restoration of this habitat.

Key words: Restoration, seaweeds, biodiversity, variability, kelp, scale.

Managing the risk of sea urchin barrens in eastern Tasmania.

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Overgrazing by the long-spined sea urchin *Centrostephanus rodgersii* presents the single largest threat to the integrity of seaweed based systems on shallow reefs in eastern Tasmania and the important fisheries they support. The situation reflects an interaction between ocean environmental change facilitating southward incursion of the urchin into eastern Tasmanian waters, and ecological overfishing of large rock lobsters (*Jasus edwardsii*) as the urchins' key predator in Tasmania. We examined several options to manage the threat of *C. rodgersii* barrens in the interests of mitigating risk to ecosystem functioning, local biodiversity and fishery performance. Experiments and modelling based on empirically derived parameters show strong hysteresis in the system so that rehabilitating extensive urchin barrens is much more difficult than preventing destructive grazing in the first place.

The work indicates that while a multifaceted management response to (1) cull and harvest urchins, and (2) rebuild biomass of large rock lobsters will be most effective in rebuilding resilience and reducing risk of ongoing barrens formation, controlling the extent of barrens depends fundamentally on rebuilding biomass of large predatory capable lobsters. Local-scale models indicates that it is possible to achieve the dual goals of ensuring a viable lobster fishery while greatly reducing risk of forming extensive barrens, but that this will require a shift in management of the fishery so that stocks are rebuilt. Introduction of spatial management in eastern Tasmania, and setting reduced total catch in the affected area in 2013 with the aim of rebuilding lobster stocks should reduce risk of ongoing barrens formation.

A key challenge is to predict spatially explicit dynamics, i.e. the particular dynamics of local sections of coast, based on interacting local and regional processes. We present an initial regional model based on coupling an array of local models (representing particular sections of coastline) through larval transport. We assess the performance of the regional model using current knowledge of urchin population structure and the distribution of sea urchin barrens habitat, and use the model to compare management options at local and regional scales.

Key words: kelp bed, sea urchins, destructive grazing, 'barrens' habitat, lobster fishery, management.

The effects of contaminants on ecosystem functioning

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Ecosystem services rely on efficient functioning of natural systems. Studies have generally focused on effects of stressors on biodiversity, or on how biodiversity links to function. However, the effects of stressors directly on function have been largely overlooked. Hence, we are not well versed on how managers can deal with such stressors to protect and manage biodiversity and, consequently, protect ecosystem function and services. Therefore, we reviewed studies that investigate toxicant impacts on at least one measure of ecosystem function as well as the effects of contaminants on functional traits of habitat-forming organisms that could translate into ecosystem function. Contaminants caused a decrease in the majority of the ecosystem functional endpoints that were assessed, such as net and gross primary production (GPP). These effects were generally consistent regardless of the type of contaminant studied. Multi-ecosystem components studies were more likely to find no effect of contamination than studies with only a single component. Habitat-formers, such as kelps and mussels, are also negatively affected by contaminants. Most classes of contaminants caused a reduction in the GPP and net productivity of habitat-forming primary producers as well as in the clearance and growth-rates of invertebrates. We have observed a strong bias in the ecotoxicological literature towards the study of ecosystem function in pelagic systems and biodiversity in benthic systems. There is also a bias in the toxicant focus. Herbicides were the third most common contaminant assessed in toxicity tests of ecosystem functioning, however, they have not yet been used as model contaminant in any of the marine biodiversity studies. Because of the identified gaps in the current knowledge, it is not currently possible to make strong causal links between diversity and function and the role that contaminants may play in this relationship. This review provides important information, not only for managers to choose between management interventions and priority actions, but also for conservation of natural systems.

Key words: Habitat-forming organisms, pollution; chemical stressors

Benthic productivity on artificial structures: maximising the benefit of marine renewable energy.

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Organisms that grow on reefs influence water column dynamics through benthic-pelagic coupling, and play a fundamental role in regulating nutrient availability and thus productivity. The productivity resulting from reef organisms forms the basis of a food-chain that includes commercial groups such as lobsters, crabs and fish. Marine renewable energy is at the forefront of the UK's government's drive to produce sustainable power and will result in the deployment of numerous structures, of various designs. As secondary artificial reefs, marine renewable energy devices (MREDs) have the capacity to deliver ecological services similar to their natural counterparts. Understanding the performance of artificial reefs, in terms of productivity, has been identified as a pressing research need. Such an understanding will help to predict the environmental consequences of the scale-up of renewable technology for commercial electricity production.

Cuttings of the bioindicator bryozoan *Flustra foliacea* have been transplanted to the Loch Linnhe Artificial Reef, a structure that is functionally similar to hard substrara that is a feature of offshore wind farms and other structures. Variations in the growth of these clones were linked to variations in the food supply, as a function of flow interactions and sedimentation on, or within a single reef unit and between different reef units. By deploying clones in different locations it is possible to 'map' growth rates as a function of location (including depth into the reef interstices), current speed, exposure or particle flux. Understanding the processes which govern the productivity associated with artificial structures with enable us to both predict the consequences of MRED deployment and inform us about how to modify proposed or existing structures in order to maximize their benefit to coastal ecosystems. Such an approach could mitigate against the potential loss of access (e.g. to fishermen) that may occur around offshore renewable energy devices.

Key words: Artificial reefs, Growth, Ocean Energy,

Drawing lines at the sand: evidence for functional vs. visual reef boundaries in temperate Marine Protected Areas

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Lyme Bay, in south west UK is popular with divers for the biodiverse reefs, but also with fishermen for the scallops, crustaceans and fishes that can be harvested. The non-selective, fishing practices, such as dredging and trawling, were damaging the benthic habitat including the reef structure and the epifauna that are typically long lived and slow growing.

Following the exclusion of towed demersal fishing in a 206 m^2 Marine Protected Area MPA to protect the rocky reef feature, the observation was made that sessile Reef Associated Species RAS were colonising pebbly sand habitats, which occurred between the rocky reefs. The sessile RAS are considered part of the reef feature, and therefore indicate that the extent of the functional reef feature boundary was greater than the visual reef boundary. This became of critical importance as fishers were seeking permission to re-enter the MPA to dredge and trawl between the rocky reef feature.

An annual survey to monitor the recovery of the reefs from towed demersal fishing that involved flying a HD camera over the rocky reef habitats commenced when the MPA was instigated. The pebbly sand habitats were also recorded but not analysed as they were not considered part of the reef feature. Here we present reanalysed data from the archived footage that shows that if protected from fishing sessile RAS colonise habitats that may not visually appear to be reef, yet, must functionally be reef.

These results are of particular relevance for feature based management regimes, e.g. SAC EU Habitats Directive, and suggest that only sessile RAS can indicate where the reef feature boundary is. MPAs should therefore be protected from human disturbance at the site level, encompassing proposed features, before feature boundaries can be drawn.

Key words: Human impact, remote video, habitat management, benthos, ecosystem, recovery, fisheries, biodiversity

Environmental management of benthic macro-algal communities: is hypothesis testing an appropriate management tool?

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A common misconception among environmental managers is that by simply implementing a Beyond-Before-After-Control-Impact (Beyond-BACI) style design, adverse effects–should they occur–will be readily detectable. However, hypothesis testing may be of limited value as a management tool, if (1) the effect size required to detect an adverse change is unobtainable for a given level of sampling intensity, or (2) the level of replication required to detect an adverse change is logistically and financially impractical. To date, these two issues have largely been ignored when designing and implementing environmental monitoring programs. In this study, macro-algal community data from a temperate reef at Alkimos, north of Perth, were artificially manipulated to determine the 'effect size' required to achieve a significant impact result (BvA*IvC interaction term). Utilising a classical beyond-BACI design, multiple simulations were undertaken comparing manipulated impact data with reference data. The study concluded that even with the best intention to implement a beyond-BACI, and widely considered best-practice, monitoring program, the level of replication adopted in most environmental programs may not be sufficient to detect adverse change above and beyond natural variation. Practical solutions to this issue are discussed in the context of cost-benefit analyses, the relative trade-off between Type I and II statistical error and the benefits of moving away from traditional statistical paradigms.

Key words: cost-benefit analyses, power, treated wastewater,

A method for estimating the potential impact of desalination plant ocean intake on nearshore larval fish populations.

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Several desalination plants with ocean intakes are under construction or in various stages of permitting in California. We present a proposed approach for conducting a preliminary assessment of the potential for an intake to impact marine organisms due to entrainment. The modeling approach is based on the Empirical Transport Model (ETM), which has become the standard approach in California for assessing impacts due to ocean intakes. The modeling approach is a refinement that does not require the extensive biological sampling used in previous studies. By assuming that the concentration of organisms are the same in the intake and source waters the daily mortality estimate of proportional entrainment, which is the basis of ETM, is estimated as the volumetric ratio of the intake to source water. The source water for the modeling was estimated using backprojections based on CODAR data on ocean surface currents. Data on surface currents over the entire Monterey Bay and surrounding coastline from CODAR stations were adjusted to midwater column speeds using data from an ADCP current meter that is located just offshore from the proposed intake. Using the source water estimates derived from the CODAR back-projections and adjusted by a kernel density analysis to eliminate the 5% least frequently occurring cells, the estimated annual mortalities due to entrainment by the proposed DWD intake of a maximum of 94,640,000 l per day were approximately 0.20 percent or less for the four coastal fishes analyzed, reflecting the small intake volume relative to the estimated source water.

Classifying benthic biotopes and reef fish assemblages on continental shelf reefs in SE Queensland: how useful are abiotic surrogates?

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Biodiversity of marine areas beyond the reach of conventional diving technology (>30m) is poorly known, yet subjected to increasing stresses from expanding recreational and commercial fishing, minerals exploration and other anthropogenic influences. In part, this is because they are logistically complex and expensive to undertake. Most deep-water surveys to date have concentrated on tropical or cool-temperate regions, with a particular focus on seamounts. There is a conspicuous gap in our knowledge of warm-temperate continental shelf reefs, which is of particular concern given the initiatives to establish Australia's National Representative System of Marine Protected Areas (NRSMPA). In part, resource managers address this by using abiotic surrogates for patterns of biodiversity in planning marine protected areas or other management measures. However, the efficacy of these surrogates varies from place to place, and is often not quantified at the scale used by MPA designers and managers. This study has two parts: we surveyed and classified benthic assemblages of continental shelf rocky reefs across three depth ranges from 30 to 70m at four locations spanning c.120km of coastline, using a suspended HD camera array. We also sampled reef fish populations using BRUV methods at four depth ranges from 30 to 85m, at two locations. In both cases we related the patterns of assemblage structure to commonly used abiotic surrogates to assess their effectiveness in representing the observed biodiversity. We also assessed how well benthic assemblage structure predicted patterns in fish assemblages. Five distinct benthic biotopes were defined, characterised primarily by abundances of gorgonians, sponges, kelp, and urchins. These were relatively poorly predicted by conventional abiotic surrogates, but the addition of recreational fishing pressure improved the fit.

Key words: Mesophotic, habitat map, representation, subtropical

Can management of local anthropogenic stressors improve the resilience of threaten habitats to global climate change?

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Coastal systems are increasingly being threatened by multiple anthropogenic, biotic and climatic stressors which can result in abrupt shifts to alternative habitats. Management actions are often being undertaken without a clear understanding of whether alleviating one or more key local anthropogenic stressors can improve the resilience of these habitats to other stressors and prevent these shifts. We present the results from experiments aimed at understanding whether of management for local anthropogenic stressors (nutrient enrichment and sedimentation) can improve the resilience of canopy-forming algae to global climatic stressors (increasing sea surface temperature and wave exposure). We focus on Fucoids (*Cystoseira barbata*) along the North Adriatic coast in the Mediterranean Sea in light of their ecological relevance, sensitivity to a variety of human impacts, and their declared conservation priority. Our experiments demonstrated that management of current nutrients concentrations and sediment loads observed along the North Adriatic coast would significantly the increase the resilience of *Cystoseira* populations to projected future climate changes. Reduction of nutrient concentrations resulted in significant increases in the growth and survival of juveniles of *Cystoseira* to increased sea surface temperature relative to controls while reduction of current sediment loads resulted in significant increases the survival of *Cystoseira* recruits to high wave exposure relative to controls. These results suggest that in the face of global climate change the management of local anthropogenic stressors may be more important in increasing the resilience of coastal habitat to habitat shifts than current thinking allows.

Key words: Nutrients, sediment, SST, waves, canopy-forming algae

Experimental evidence for invasion impacts on temperate reefs.

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Invasive species are a threat to biodiversity because invaders can alter community structure and ecosystem functions. To limit this threat, it is necessary to have a strong mechanistic understanding of how invaders affect local species and communities. We analysed the peer-reviewed literature that described field-based impact experiments in aquatic systems, to examine if temperate reefs are more or less impacted by invasive species than other wet eco-systems. Our review revealed that impacts had been experimentally quantified for >100 aquatic invasive species, in all major aquatic habitats, on all continents except Antarctica and for most broad taxonomic groupings. However, despite this extensive research effort we also found important biases. For example, only one invader was a marine fish and only six represented herbivores. Furthermore, >50% of all studies were from the USA and c. 65% were from a narrow temperate latitudinal band. Furthermore, despite most studies being temperate, only few were conducted on wave-exposed reefs (most were conducted in estuaries/soft-sediment systems), and with a narrow taxonomic focus on a few high profile invaders (e.g., *Littorina littorea*, *Carcinus maenas*, *Sargassum muticum*, *Undaria pinnatifida*). A quantitative meta-analysis suggests that effects sizes on temperate reefs are relatively similar to effect sizes quantified from other aquatic habitats, and that both positive and negative effects occur, depending, for example, on the trophic position of both the invader and local species. We conclude that many more experimental studies are needed to understand on a wider geographic basis how temperate reefs have been modified by invasive species, and that these studies should include less conspicuous invaders and report impacts on different types of resident species (including different trophic levels).

Key words: Human impacts, Biodiversity, Biotic homogenization, Cross-habitat comparison, Review.

Environmental and biological drivers of ecological function

Functional roles and compensatory potential at regional scales: range shift in intertidal grazers and consequences for community composition

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Equivalence in species functional roles is considered critical for ecosystem functioning and ecological resilience. Functional redundancy could determine the compensatory potential among species with similar traits at local scales, but its importance across regional scales remains unexplored. Taxonomically related species with parapatric distributions across part of their range are of great interest, because geographic range shifts may affect functional relationships within the guild over large spatial scales. Through grazer-enclosure/exclusion experiments we examined the potential for functional compensation under potential range expansion/contraction of two phylogenetically related species of grazer i.e. *Scurria viridula* and *S. zebrina.* The two species have parapatric distributions but overlap narrowly in north-central Chile, hence experiments where deployed in two locations within the geographic range of each and a third where they overlap. We found that inside their respective geographic range, each grazer had similar effects on ephemeral algal abundance, bare rock production and species richness when compared with effects found in the range overlap. Grazer effects on sessile species composition were dependent on the different sites considered, but were similar at the functional group level. Effects found on monoculture-enclosures at all sites were comparatively similar to polyculture-enclosures, where both species were enclosed together simulating their small-scale spatial distribution found in the range overlap. Our surveys showed the presence of the northern species, *S. viridula,* about 120 km south the previously reported range limits but we found no evidence of *S. zebrina* range contraction. Experimental results and the field evidence of range expansion in one species suggest a high potential for functional compensation in effects between the study species. But population-level effects of both grazers seem to be additive in their range overlap with unpredicted consequences for community structure and coexistence potential.

Key words: Algae-herbivore interactions, Chile, Functional structure, Grazer guild, Range limit.

Strong impacts of small arthropods on algal epiphytes in subtidal coralline turf

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Small arthropods, particularly amphipod crustaceans, are highly abundant in subtidal coralline algal turf. Many of the arthropods are herbivores, but little is known about the impact of their feeding on their host seaweed. In the current study arthropod abundances within subtidal *Corallina officinalis* turf in northeastern New Zealand were experimentally reduced *in situ*. This was achieved using plaster blocks impregnated with the insecticide carbary which was slowly released as the blocks dissolved. Blocks were replaced ~weekly for 15 weeks. In the carbaryl treatment total arthropod abundances were reduced by 86.5% relative to the unmanipulated control treatment. This resulted in major changes in the abundance and composition of algae growing epiphytically on the coralline turf. At the end of the study, the combined cover of *Colpomenia*, *Ulva* and brown microalgal epiphytes was 84% in the reduced arthropod/carbaryl treatment in contrast to 14% in the control treatment. During feeding assays amphipods in the family Hyalidae consumed *Colpomenia* and *Ulva*, suggesting that they may be responsible for supressing these two algal taxa in the field. Our results support the emerging view that small mobile arthropods are capable of influencing the structure of their habitat, as opposed to simply being “hangers-on”.

Key word: Mesograzer

Environmental change and marine disease: Are disruptions to macro-micro interactions contributing to declines of habitat-forming macroalgae?

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Canopy-forming macroalgae are showing signs of decline on many temperate reefs worldwide. These crucial habitat-forming organisms live in a 'microbial soup', constant contact with ubiquitous and abundant marine microorganisms in the seawater and in biofilms on their surfaces. Diverse macro-micro interactions between seaweeds and their microbial associates are now being described and can often be fundamentally inked to seaweed survival, development and condition. We hypothesised that environmental changes disrupt these intimate relationships, leading to reduced seaweed condition, higher incidence and severity of disease and lowered resilience of macroalgal populations. We have been investigating this on a continental scale with the dominant kelp *Ecklonia radiata* and the large fucoid *Phyllospora comosa*. In both species, putative disease symptoms were common and widespread with some phenotypes increasing in frequency during summer and others appearing more severe or common at sites closer to urban centres. Microbial assemblages on the surfaces of 'sick-looking' algae were different from those on healthy specimens, a pattern that was consistent on a continental scale, over multiple sampling years and among different algal families. Initial experimental investigations into the microbial and chemical mechanisms of these putative diseases will also be discussed.

Inter-specific variation of monthly recruitment rates in two biological models of rocky shores: spatial consistency of the temporal trends

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Species-specific adaptions allow organisms to survive under unfavorable environmental conditions and to overcome competition and predation. For organisms with pelagic larvae, different time windows for reproduction and settlement among species may also play a fundamental role. In this study the spatial consistency of the temporal trends of monthly recruitment rates were assessed to investigate inter-specific variability. Two groups of rocky shore intertidal invertebrates were used as biological models, cirripeds and bivalves. Recruitment rates were measured at three sites in Castelhanos Bay, distant by 5 km and located at the north portion of South Brazilian Bight, from April/2012 to April/2013. Recruits were sampled using artificial substrata randomly fixed to the intertidal zone. Barnacles of the species Megabalanus coccopoma, Tetraclita stalactifera and Chthamalus bisinuatus recruited during the study period, as well as the bivalve species Perna perna, Brachidontes solisianus, Isognomon bicolor, and unidentified genera from Mitilidae family. Maximum recruitment periods varied according to taxa. Species which adults are abundant at the same intertidal strata showed coincident maximum recruitment windows, suggesting that either these species reproduce in synchrony, or their larvae may use similar mechanisms to return to the settlement sites. Spatial synchrony of recruitment also depended on the species, but barnacles tended to show higher levels of correlation compared to that of bivalves. Even during simultaneous recruitment peaks, average recruitment rates were highly variable among the three sites. We observed that during one period within recruitment season, all species showed recruitment rates close to zero, after a important changes in the wind field. Although local circulation patterns and shore topography cannot be overruled as significant forcing to the observed recruitment variation, our data indicates that oceanographic processes may blur inherent spatial and specie-specific variability. In addition, we show that close related intertidal species do not always have similar recruitment temporal windows, an that spatial differences in recruitment can happen at very small scales. Thus, both sources of variation should be take into account for explaining recruitment trends.

Key words: rocky shores, spatio-temporal synchrony, inter-specific variation, barnacles, mussels, South Brazilian Bight.

Influence of light on the interactions between *Ascophyllum nodossum and Littorina littorea* and *L. obtusata*.

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Resource availability mediates trade-offs between tolerance and resistance of plants against herbivory. Since there is no consensus in former theories on plant defences the novelty in the Limiting Resource Model (LRM) is the incorporation of different environmental contexts. The aim of this study was to apply this model in a macroalgae-grazer system using light as limiting resource. We used primary shoots and apical shoots of *Ascophyllum nodossum* and manipulated the densities of *Littorina littorea* and L. obtusata under different light conditions (intensity and photoperiod). In the outdoor experiments, primary shoots were less consumed during winter and this result was associated with an increase of organic matter content (%OM). In laboratory conditions, macroalgae under 18 h of photoperiod had highest %OM in the apical shoots but under 4h it was highest in the primary shoots. The highest consumption was observed under 4h of photoperiod mainly by *L. littorea*. There was a higher effect *L. littorea* density in the primary shoots under 4h than 18h. In 18h, photosynthesis potential increased in low light conditions while %OM decreased. During summer the effect of grazers and light was more evident than during winter. Consumption rate was highest under low grazer density and low light conditions. C:N was lowest without grazing under low light conditions. During winter, the loss of biomass by grazing was highest under high light and high density of *L. littorea*. These results showed a trade-off by *Ascophyllum* under different portions and conditions, showing the importance of grazer's identity. The consumption by both grazers induced the change of tissue content by increasing %OM and C:N in the macroalgae. Light was important to compensate tissue loss by algae growing giving support to the Model of Growth Rate.

Key words: Limiting Resource Model, Herbivory, Defense, Trade-offs, Resistance, Tolerance

Comparison of the ecological functioning of mussels between upwelling and non-upwelling areas.

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Mussels are important providers of habitat and filters of coastal waters. Previously, we found no influence of upwelling on the fauna associated with mussels, but there was an effect of upwelling on the size-structure of mussel beds. There were more large (> 7 cm) mussels in the upwelling areas. This suggests that mussels were responding directly to factors associated with the upwelling, such as changes to the availability of food and the reduction in temperature. In this study, the ecological functioning of mussels, in terms of their filtration, was compared between upwelling and non-upwelling areas. Field experiments were done by measuring the filtration rates of mussels in situ, from 2 upwelling centres and corresponding non-upwelling areas in the cool temperate biogeographic province of South Africa. The overall size-structure of particles present in the water-column differed between upwelling and non-upwelling areas. In non-upwelling areas there were more particles in the water-column, and mussels consumed more particles. This indicates that the availability of food and feeding-rates of mussels do not explain the larger size of mussels in upwelling areas. Our findings do, however, suggest that upwelling influences the ecological functioning of mussels in terms of their filtration rates but not their role as providers of habitat.

Key words: Bioengineers, Bivalves, Filter-feeding, Productivity.

Who and here: social interactions as an explanation for grouping in limpets

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There is still a major issue in animal ecology; why are animals in groups. Most of the research underpinning our understanding of grouping in marine molluscs has concentrated on ecological explanations such as food supply, predation risk and desiccation. For most these, especially desiccation, these explanations have been found wanting. The most recent developments in the discipline of understanding grouping behaviour have been by theoreticians and modellers. Moreover, many of the important empirical studies have been done on animals such as fish in aquaria; so there is a dichotomy where for most vertebrates, researchers have considered social and ecological factors to explain patterns of grouping yet for almost all invertebrates, ecological (predation, food supply and settlement for example) causes for aggregation are the only explanations tested, the social dimension is not known for many invertebrates. Grouping could actually arise from social interactions and then ecological benefits arise as an emergent property. The first step in investigating whether social interactions are involved in patterns of grouping is to measure where a social network existed. Here we present the results of a study testing whether *Patella vulgata* forms a social network. We show the model of a random set of interactions is not a powerful explanation but if we consider an interaction of homing and social processes we can generate realistic distributions of animals consistent with real observed limpet groups.

Key words: aggregation, mollusks, behaviour, grazing,

Implications of mechanisms of succession to rockweed communities of the northwest Atlantic Ocean.

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On sheltered rocky shores of the Northwest Atlantic Ocean, mid-intertidal zone communities are often dominated either by *Ascophyllum nodosum* or *Fucus vesiculosus*. The broad window of phenology of *F. vesiculosus* means that it has more frequent opportunities to become established after a disturbance compared to *A. nodosum*. The prevailing view is that the occurrence of *Fucus spp*. on sheltered shores is but a successional stage leading to an endpoint of *Ascophyllum* either by facilitation or tolerance, but the mechanism of succession has never been tested explicitly. We designed an experiment to test whether recruitment of *A. nodosum* is facilitated or inhibited by, or tolerant of, the prior establishment of *F. vesiculosus*. Tiles, set out either face-up (to collect *Fucus* recruits) or face-down (controls) in autumn 2011, were collected in April 2012 and seeded with experimentally generated zygotes of *A. nodosum*. All fucoids on tiles were censused, placed in cages and returned to a sheltered mid-intertidal zone habitat. Thereafter, tiles were censused following 4, 12 and 15 months. *Fucus* inhibited recruitment of *Ascophyllum*. Fewer germlings of *A. nodosum* recruited initially, fewer survived and growth of survivors was suppressed in the presence of *Fucus*. *Fucus* appears to not be a simple intermediate stage during succession to an *Ascophyllum* community on sheltered rocky shores. The inhibition of *A. nodosum* by *Fucus* suggests *Fucus* as a third alternative community state in sheltered bay ecosystems of the Northwest Atlantic.

Patterns of grazing, landscape structure and assemblage structure along a latitudinal gradient in ocean climate

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The coast of Portugal includes regions representing a transition between cold- and warm-water species. We took advantage of this gradient to explore latitudinal affinities in the assemblage structure of canopy-forming macroalgae (kelp) and associated fishes. These were examined at five rocky reefs at each of three regions: Viana do Castelo (41.5º N), Peniche (39.2º N) and Sines (37.8º N). We also examined whether herbivory affects the distribution and abundance of kelp (*Laminaria ochroleuca* and *Saccorhiza polyschides*) recruits. In particular, the abundance and survival of recruits, the intensity of grazing on recruits and the abundance of herbivores were compared between Viana do Castelo and Peniche. Patterns of abundance of kelp recruits and the intensity of grazing were examined at within-reef scale (open reef habitat *vs*. crevices) from northern to central Portugal. Macroalgal and fish assemblages differed between Viana do Castelo and Peniche and Sines, but not between Peniche and Sines. Viana do Castelo was the only region with conspicuous kelp forests, while Peniche and Sines were dominated by patches of turf-forming algae. The abundance of kelp recruits was 3.9 times larger at the 'cold-water' (northern) region, where recruits were predominantly (ca. 85 %) found on open reef areas. In contrast, recruits were majorly restricted to crevices (ca. 87 %) at the 'warm-water' (southern) region. The 'warm-water' region had larger abundances of herbivores (> 200 times for sea-urchins and ca. 2.7 times for fishes), ca. 4.1 times larger presence of grazing marks, ca. 50 times higher rates of kelp consumption, and null survivorship of kelp recruits compared to the 'cold-water' region. These findings suggest a macroecological change along the Portuguese coast and that differences in herbivory not only affect the abundance of kelp recruits at large spatial scales, but also their within-reef distribution.

Key words: *biogeographical systems,* macroalgae, fishes, sea-urchins, Atlantic Ocean, reef topography

Does who you are or where you are determine your orientation?

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Orientation is an understudied aspect of animal distribution. At the smallest scale, animals may be orientated in regard to particular environmental variables or habitat features. The majority of studies on orientation have focused on how environmental factors drive patterns of orientation. It is equally true that habitat properties, intraspecific interactions and individual variation may be as important. At the level of the population, the limpet *Cellana tramoserica* exhibits a downwards bias in orientation but orientation varies between individuals at a given point in time. This may be because certain limpets are "downwards facers" and others are "upwards facers". Alternatively, orientation may be determined by where an individual is located at a fine spatial scale and differences in orientation are a reflection of differences in microhabitat. To test these two models, resting sites (home scars) and individual limpets were monitored over time. When located in the same resting site, limpets orientated in the same direction as each other (within 10°). In resting sites which were reoccupied by the same limpet after three days, limpets were three times more likely to orientate in the same direction compared with those resting sites occupied by a new limpet. In contrast, over four months homing limpets (< 60% time in the same resting site) were no more likely than non-homing limpets in the same resting site to consistently orientate in the same direction. Resiting sites can be classified as "downwards facing" or otherwise but limpets did not select particular resting sites over other available known ones. Limpets can't be classified as "downwards-facing" as the number of limpets which consistently face downwards was no greater than would be predicted by chance alone. In conclusion, where a limpet is located during low tide is a major determining factor of their orientation but their identity has little influence.

Key words: behaviour, gastropod, grazer, spatial positioning

Sea otter recolonization and conflict with shellfish fisheries in southern Southeast Alaska.

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Sea otters, which are well known as a major driver of nearshore marine ecosystem change, were extirpated by the fur trade in Southeast Alaska by the late 1800s and then reintroduced in 1968. In the absence of sea otters, lucrative fisheries developed for shellfish, including abalone, sea urchins, geoduck clams, sea cucumbers and crabs. As the sea otter population has grown in number and distribution, they have reduced shellfish resources available for fishermen, resulting in significant conflict. The sea otter population in southern Southeast Alaska grew from 106 sea otters in two locations in 1968 to 12,873 (cv=0.18) otters in 2010 distributed over 4727 km^2. In this study we hypothesized that sea otters preferred commercially important shellfish over non-commercial species and that sea otters diversified their diet as sea otter density and time of occupation increased. To quantify the direct impact of sea otters on invertebrate species, we calculated sea otter density on small spatial scales in southern Southeast Alaska from 1968-2011 and studied sea otter foraging in 2010-2012 (n=699 bouts, 6,117 foraging dives). We found that diet diversity increased logarithmically as a function of sea otter occupation and that the fraction of commercially important invertebrates in the diet decreased with sea otter density and time of occupation. Several areas in the region showed evidence of sea otter sub-populations reaching or exceeding carrying capacity as preferred prey species were reduced and diets diversified; however in most regions, the sea otters populations were increasing without limitation. We expect that the sea otter population in Southeast Alaska will continue to expand until resources are depleted across the region, with increasing conflict for commercially important and subsistence fisheries.

Key words: colonization, keystone species, prey-switching, marine mammal, kelp forest, apex predator.

How far to feed? Central-place foraging of the sand-bubbler crab *Scopimera intermedia*

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On sandy shores, many deposit-feeding brachyurans are central-place foragers, often returning to their burrows during feeding excursions to avoid predation, defend their territories or meet their physiological needs. The sand-bubbler crab, *Scopimera intermedia* Balss, exhibits such a strategy and its feeding patterns were investigated using *in situ* video recordings and experimental manipulations at Starfish Bay, Hong Kong. Feeding patterns were influenced by local crab density, previous feeding track length and sediment food value (total organic content). Foraging range (i.e. the distance between the most distal food pellet and central burrow of the crab) decreased as crab density increased. Food pellet production (pellets produced cm^{-1}) was greater when the crab fed along long feeding tracks (≥ 12 cm) as compared to short feeding tracks (≤ 4 cm), suggesting the crab gained information from previous excursions to make subsequent foraging decisions. When food quality was manipulated, a feeding threshold was detected as the crab rejected feeding on sediments with organic content < 0.87%. This threshold is, however, likely to be dynamic and appears to vary with the satiation level of the crab, suggesting that foraging decisions of this crab are state-dependent. When offered sediments above this threshold value the crab fed indiscriminately, exhibiting similar foraging ranges and production of food pellets, irrespective of the food value of the sediments offered. This lack of discrimination may be a response to the temporal constraints imposed by the limited foraging time available between tides, and the risk of disturbance, which drive the crab to maximize energy intake. Overall, therefore, *S. intermedia* exhibits variation in feeding patterns in response to both environmental conditions and resource availability, and provides an ideal model to investigate the feeding ecology of central-place foraging deposit-feeders.

Key words: Dotillidae, energy maximizer, feeding costs, optimal foraging, sandy shore

Effects of anthropogenic pressures on the structure of *Cystoseira* assemblages in the northern Adriatic Sea

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Over the past few decades important changes have been noted in the settlements of canopy forming macroalgae in the northern Adriatic Sea. In the 1970s regression of fucoid brown algae was noted at several places in the Rovinj area, while at the end of the 1990s recolonisation of those settlements was recorded. In this study we integrate available information on past and current distribution of canopy-forming species with field data from algal forest under different environmental conditions. On a fine-scale within the extensive algal forest to the depth of 2 m the abundance and morphological features of *Cystoseira* spp., and the coverage of its associated assemblages were measured. The results of this research indicate that fucoid algae are widely distributed along the western Istrian coast, forming abundant monospecific and mixed stands. In the urban areas the highest values of biomass, numbers of individuals and thalli length were noted for monospecific stands of *C. compressa* with understorey assemblages comprised mostly of extensive cover of foliose algae and articulated corallines. In the non-urban area mixed forest of *C. barbata* and *C. crinita* dominated in terms of abundance and thalli length, and its understorey assemblages were composed of filamentous turf and articulated corallines. The results suggest that density and morphology of fucoid algae are sensitive to environmental stress affecting also associated assemblages. Reproductive conditions of algal forest will be discussed as important factor for successful recruitment of new individuals that enabled the population expansion. Canopy-forming macroalgae in the northern Adriatic represent a healthy and abundant forest system suitable for understanding patterns of human induced changes in the shallow rocky bottom assemblages.

Key words: Fucales, algal forests, historical data, morphology, abundance, assemblages

The first reproducing crab species in the Baltic Sea – the invasion and impacts of *Rhithropanopeus harrisii*.

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The North American mud crab *Rhithropanopeus harrisii* is rapidly expanding its distribution area in Europe and is the first crab species known to be reproducing throughout the entire Baltic Sea. Since 2011 the mud crab has been found in the bivalve-dominated eutrophic Pärnu Bay, northeastern Baltic Sea. Sampling of standardized artificial reefs suggested that elevated ice scouring, exposure to waves, water chlorophyll *a* content and reduced macrophyte cover favoured the dispersal of mud crab. Seasonal changes constituted less than 10% of total variability of their density. Considering the recent arrival and strong invasive potential of the species, however, the niche breadth of mud crab is likely much wider than observed in this study. Concurrent with this invasion the density of native bivalves have significantly declined with mudcrab accounting for more than 10 % of biomass reduction. Outdoor and field experiments suggest that the observed decline in the density of bivalves is due to crab predation. Specifically, in a short-term outdoor artificial community competition experiment mud crabs increased the mortality of bivalves and amphipods on soft sediment but not on mixed sediments. The experiment also demonstrated that crabs preferentially ate larger clam. Algae modulated the impact of crabs on amphipods with significant effects being observed only on unvegetated soft sediment. Thus, algae and rocks provide mobile amphipods a short-time refuge from crab predation. In a medium-term in situ enclosure experiment mud crabs significantly reduced the density of bivalve and gastropod species regardless of sediment and/or vegetation type. To conclude, mud crabs effectively reduce the density of dominating bivalves and on longer run also amphipods. Providing the fast expansion of crab distribution area, high crab density and the lack of such functional trait in the Baltic Sea range, this invasion is expected to cause significant repercussions on the structure and functioning of invertebrate communities in the Baltic Sea range in the near future.

Key words: invasive species, species interaction, predation, habitat selection, brackish water, Baltic Sea

Indirect facilitation of herbivores by suspension feeding mussel *Mytilus trossulus* in a brackish water benthic community.

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Benthic suspension feeders remove suspended matter from the water column and deposit it on the bottom, consequently increasing sedimentation and nutrient input to benthic systems. Facilitation of deposit feeders or benthic vegetation has been shown to be the result of fertilization by mussels in several cases. Blue mussels are the most important sublittoral suspension feeders in the brackish northeastern Baltic Sea. This is a species-poor, eutrophic environment, where the most tolerant brackish and freshwater species meet the limits of their ranges. The impact of small patches of blue mussels on the adjacent biota was studied by a factorial field experiment. After 79 days, the stock biomass of filamentous algae was not affected by the presence of mussels, but the abundance and biomass of herbivores were higher in the vicinity of mussels. Benthic deposit feeders remained indifferent to the presence of mussels. Small patches of benthic suspension feeders appear to influence the patterns of surrounding benthic biota, with the main visible effect probably on the distribution of the consumers of benthic vegetation in the study area.

Key words: benthic suspension feeders, macrofauna, grazers, filamentous algae, positive interactions, Baltic Sea

Organic matter supply in European kelp forests: temporal variations and consequences on community structures

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Kelp forests in European subtidal areas are commonly dominated by *Laminaria hyperborea*. This erected seaweed reaches up to four meters in length and can be considered as a stratified habitat on its own. Macroalgal epiphytes develop all along the entire thallus, and making up a high amount of biomass with different structural features. Reef, epilithic and epiphytic features form different microhabitats known to influence species abundance distributions, which are particularly diverse. While reef topography is relatively stable, seaweed abundance changes throughout the year according to growth and senescence processes and may affect both microhabitat structure and trophic resource availability. In the present study, we analysed seaweed biomass at four seasons in a pristine kelp forest near Roscoff (Brittany, France), in order to infer differential supplies of organic matter to the associated community (100 seaweed and 397 faunal species). At two periods of low availability of phytoplankton, additional stable isotopes analyses were conducted and interpreted from temporal changes in isotope values and mixing models. These analyses inferred that decaying kelp laminae were a major contributor to the particulate organic matter pool and the fragmentation of old lamina promoted their contribution to the diet of deposit- and suspension-feeders in March. Growth of red algae enhanced direct grazer consumption in March, while their senescence contributed significantly to primary consumer diets in November through indirect consumption. These results highlight a strong temporal plasticity in species-specific feeding behaviour, with change in direct versus indirect macroalgal consumption, and in phytoplankton versus indirect macroalgal consumption. Given the stratified modifications of macroalgal forming habitat and changes in community structures, the involvement of continuous food availability on biodiversity and ecosystem functioning is discussed.

Effects of isolation and habitat size are mediated by species dispersal ability.

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The structure of local communities has often been thought to be the result of local interactions between environmental and biotic factors, but recent theoretical advances have emphasized the role of dispersal in structuring communities. In this study we examined the effects of habitat isolation and habitat size in structuring macroinvertebrate benthic assemblages. We manipulated distance to a rocky reef (as a surrogate to isolation) and habitat size of experimental mimics of macroalgal turfs. Experimental habitats were deployed following a hierarchical structure in which experimental patches were grouped in small (3 patches) and large (6 patches) groups (referred to as metacommunities). Our results show that isolation influenced the richness of sessile organisms that was greater close to the reef at the scale of the metacommunity, but not at the scale of the patch. Motile richness did not respond to habitat isolation. In contrast, sessile richness was similar in small and large metacommunities, whereas motile richness was greater in large metacommunities, but only at the scale of the patch. Species composition in isolated habitats was similar (for sessile) or a subset (for motile) of that found closer to the reef suggesting that differences in richness were associated with the ability of species to disperse and not to different environmental conditions between isolated and non-isolated habitats. Numbers of sessile individuals was not influenced by either habitat isolation or size. The numbers of motile individuals varied with habitat size, but only at the scale of the patch. Despite spatial variability in assemblages, results were spatially consistent. Overall, our results indicate that species dispersal ability mediates the effects of isolation and habitat size and that results are scale-dependent.

Key words: Scale, Artificial habitats, Species movement, Macroinvertebrates, Richness.

Responses to habitat-loss: Complex, complicated or both.

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To predict species' responses to habitat-loss, ecologists need to develop a better understanding of how particular attributes of habitats contribute to such responses across different scales and different systems. Reconciling empirical studies done at different scales remains a challenge: most research conducted at larger scales is based on observational data, whilst, in contrast, results from small-scale experimental studies are often dismissed as too narrow to contribute to general understanding of processes operating at larger scales. In this presentation, I will argue that the lack of a comprehensive understanding of species' responses to habitat-loss is due to different conceptual underpinnings of ecological studies done at different scales. I will support my argument by combining the results of a series of field experiments that were devised to empirically test ecological models often proposed to explain large-scale patterns (e.g. species-area relationships; habitat-complexity; habitat-heterogeneity; surrounding matrices and ecological boundaries) using diverse assemblages of intertidal organisms colonizing artificial habitats. My results show that many small organisms, when studied at the appropriate ecological scale, respond in similar ways to organisms responding to similar attributes of habitats at larger scales (i.e. landscapes). By combining this baseline understanding of the system, I was able to predict and test the outcome of habitat-loss on the diversity of benthic assemblages. This research highlights the importance of carefully planned experiments to disentangle the effects of different attributes of habitats, and supported the argument that small-scale experimental systems can be extremely valuable in understanding mechanisms underlying species' distributions and, ultimately, species' responses to habitat-loss.

Key words: habitat-loss, diversity, species-area, heterogeneity, scaling, microgastropods

Bioengineering by oysters across climatic gradients

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Bioengineers are key determinants of community development and influence the distributions of associated species by altering the availability of resources and ameliorating physical stresses. Ecological theory predicts that the positive influence of bioengineers on biodiversity will increase with the physical stress of the environment. We tested the hypothesis that differences in communities of intertidal invertebrates between oyster-engineered and oyster-free habitat would be greater in warmer than cooler climates, the difference increasing with desiccation stress. We sampled adjacent habitat patches with and without oysters, on replicate rocky shores and mangrove forests within eight estuaries spanning an 800 km latitudinal gradient of NSW coastline. Within each habitat patch we quantified (1) invertebrate community structure and (2) temperature and humidity. Across all latitudes oyster-engineered habitat supported a much greater biodiversity and abundance of invertebrates than oyster-free habitat, with the greatest dissimilarity in northern rocky shore sites. Latitudinal gradients in abundance and richness were strongest in oyster-free habitats on rocky shores, while mangrove communities showed little influence of latitude at all. Furthermore, rocky shore oyster habitats provided a cooler refuge from temperature extremes than bare substrata, with the greatest significance in northern latitudes. In contrast the influence of oyster habitat in shaded mangrove forests was negligible. These findings suggest that oyster habitat weakens the relationship between temperature and invertebrate assemblage under stressful conditions, the relationship weakening with reducing stress. By buffering the effects of climate for associated invertebrates, oyster microhabitat could serve as a natural refuge from climatic extremes offering associated organisms more time to adapt to changing conditions. Knowledge of when and where bioengineers modulate climatic effects on biodiversity will assist in developing strategies for biodiversity conservation in a changing climate.

Key words: Ecosystem engineering, stress amelioration, latitudinal gradient, invertebrate assemblage, habitat complexity

Predation risk outweighs effects of climate change on grazer activity.

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Increased temperatures and CO_2 concentration in our oceans are predicted to have significant impacts on marine ecosystems. These factors influence the activity, distribution and survival of many species, and in turn the species they interact with. Temperature affects metabolic activity, food consumption and mortality. Increased CO_2 may negatively impact upon growth and development of marine animals, and has been documented to dampen and even reverse predator avoidance behaviour in fishes. On rocky reefs, algal species are grazed upon by herbivorous marine, which are in turn preyed upon by other species, including crabs. Because changing environmental variables will affect different organisms in different ways due to their physiological tolerances and needs, it is vital to investigate how these changes may impact the interactions of key functional groups comprised of such species. By exposing a grazer (*Turbo undulatus*) to crossed combinations of CO_2 (380 and 750 ppm) and temperature (16, 20, 22 and 24°C) in the presence and absence of predators (*Ozius truncatus*), we tested the hypothesis that increased CO_2 will reverse the opposing effect of temperature and predators on foraging activity (increased and decreased, respectively). As predicted, the presence of a predator countered the positive effect of increased temperature on foraging activity. However, elevated CO_2 did not cause a reversal of avoidance response to predators. Instead, predation risk resulted in more avoidance behaviour, and less time spent foraging. This could have consequences for the individual species and the ecosystem as a whole as increased energy demands due to increased temperature (and therefore increased metabolic activity) may not be met.

Wave-exposure rapidly induced changes in morphological seaweed traits that modify trophic interactions with grazers

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Seaweeds are known to change their phenotype in response to wave-exposure. Shifts in shape or texture due to phenotypic plasticity may affect subsequent interactions between seaweeds and other species. In two transplantation experiments, we tested the ability of the brown seaweed *Fucus vesiculosus* to acclimate to different levels of wave-exposure and whether this acclimation affected its consumption by different grazer species. In different years, a transplantation of *F. vesiculosus* between exposed and sheltered sites provoked a rapid shift of apical thallus toughness, measured as puncture strength, towards values found in conspecifics that remained throughout the experiment at the respective recipient site (= replants). The time needed to significantly change thallus toughness was 9 times shorter in *F. vesiculosus* that were transplanted from the sheltered to the exposed site (8 days) than in the opposite direction (i.e. 72 days). Prior to transplantation, both the North Sea isopod *Idotea baltica* and the amphipod *Echinogammarus marinus* consumed significantly more sheltered-site than exposed-site apical pieces of *F. vesiculosus*. This pattern was confirmed with *F. vesiculosus* and *I. baltica* from the Baltic Sea population. In contrast, no discrimination was apparent when the North Sea grazers could chose between reconstituted food made of either sheltered-site or exposed-site *F. vesiculosus*. At the end of the transplantation experiment, grazers consumed equal amounts of transplanted and replanted *F. vesiculosus*. Results indicate that (i) wave exposure altered morphological rather than non-morphological properties (ii), a toughening of tissue with an increase of exposure is faster than the relaxation of toughness with decreasing exposure and (iii) trait plasticity modified the suitability of *F. vesiculosus* as food for mandible-bearing grazer species. Thus, grazing impact was reduced when wave exposure increased; possibly offering seaweeds an opportunity to trade-off costs that may be associated with a live on high-energy shores.

Key words: stress ecology, herbivory, macroalgae

Population and harem dynamics of a marine isopod.

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Many species have developed alternative reproductive strategies where the competing sex shows different morphs or behaviours. In these systems dominant male morphs often establish territories to control resources and access to females. Dispersal strategies of marine species can play an important role in population and distribution dynamics. Therefore, in order to understand the evolutionary processes in alternative mating strategies, a first step is to address the interplay between dispersal strategies and harem formation. The isopod *Paracerceis sculpta* has three different male morphs with life history trade-offs. This species occurs in relatively shallow waters where alpha males establish harems. Through a series of field surveys and experiments in the northern Gulf of Mexico we are addressing how *P. sculpta* harems are formed, with three potential hypotheses. First, harems are established by alpha males seeking new habitats and attract females while holding the territory. Alternatively, females could perform the dispersing phase, and males cue on habitats with females. Finally, colonization to new habitats is random and after settlement, individuals will interact to decide harem structure. Once we understand how harem formation occurs, we can address the ultimate mechanisms behind dispersal and territoriality.

Key words: sexual selection, evolution, invasive species, range expansion.

The role of chemical defences of kelp in fighting disease

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Despite the long-standing recognition of disease as a key process driving declines of marine habitat-forming species in the tropics, comparatively little is known about disease in temperate systems. *Ecklonia radiata* is the major habitat-forming macroalga in Australia, providing key resources that underpin biodiversity and ecosystem functioning. In previous field surveys, we identified thallus bleaching as a potential disease phenotype in this kelp and showed marked differences in bacterial community structure associated with bleached and healthy kelp at several sites along eastern and western Australia. In other seaweed-pathogen systems, antibacterial compounds are critical in defending against infection. To test the hypothesis that potential pathogenic bacteria of *E. radiata* are inhibited by putative defence compounds of kelp, we screened the effect of algal secondary metabolites to stimulate or inhibit growth and impede attachment of selected bacterial isolates. Observed biological activities of purified HPLC fractions included the stimulation and inhibition of bacterial growth, and the inhibition of bacterial attachment. These results suggest that low-molecular weight algal secondary metabolites may affect epiphytic bacterial colonization and thus play a crucial role in the maintenance of a healthy algal holobiont.

Key words: *Ecklonia radiata*, bacteria, pathogens, secondary metabolites

Endophytic infection in a habitat-forming macroalga: a potential contributor to recent decline?

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There is evidence for recent global declines in canopy-forming macroalgae. One potential reason for this decline is that anthropogenic impacts are causing physiological stress, leading to increases in the frequency and severity of diseases, a relatively understudied area for macroalgae. We tested this idea with *Phyllospora comosa*, a key habitat-forming seaweed endemic to southeast Australia, which disappeared from reefs within Sydney's metropolitan region in the 1970s, potentially due to impacts of urbanisation. We surveyed populations of *P. comosa* along its eastern Australian distribution to obtain baseline data about its abundance and condition. We frequently observed a putative endophytic infection in the stipe of *P. comosa* and this phenotype was common in many populations sampled. To assess whether this condition had any demographic consequences for affected individuals, we tagged visibly 'healthy' and 'infected' *P. comosa* individuals from two populations in NSW and monitored them for 6 months. To investigate progression of this condition, we measured the thallus area affected over time and also assessed survivorship. Additionally, we quantified fecundity, photosynthetic efficiency and size of the tagged algae over time to assess potential sub-lethal effects of this condition on *P. comosa*. Preliminary results indicate a significant negative impact of 'stipe rot' infection on algal survival and also fecundity, suggesting that this putative disease both increases the risk of mortality and decreases reproductive potential while algae remain alive. Results from initial experiments involving the inoculation of putative pathogens into healthy thalli will also be described. Understanding patterns and mechanisms behind the decline of habitat-forming organisms, such as *P. comosa,* is important for the study and management of natural populations, particularly as environments undergo rapid change

Coastal processes, turbulence and behaviour: a preliminary bio-physical integration of larval distribution from a 24-hour survey

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Increasing evidence of behavioural control over larval dispersal, coupled with the effect of small scale hydrodynamic components on larval transport, is making fine scale onshore studies significantly relevant to determine mechanisms that govern cross-shore transport, alongshore transit and delivery of benthic larvae to adult sites. In March 2013, we examined over 24 hours the quasi-hourly distribution of larvae belonging to two phyla at two onshore shallow stations (12m) in Algoa Bay, South Africa, to determine any possible diurnal migration or behavioural control of the larval position within the water column. Continuous measurements of the environment were recorded to characterise the physical structure of the onshore waters during the day and night and to determine a potential link to larval distribution. Preliminary analysis on the physical data show high variability in current speed and direction. During the morning, the currents were primarily northward and surface intensified. While from noon and for the rest of the sampling, the currents were variable and bottom intensified. The variability in the currents was not correlated with the tidal cycle. Despite such variability, the bottom-intensified flow appears to be overall along-shore (from 9m and below) or slightly offshore (at 6m). These currents suggest that larvae above 6m would be advected towards the shoreline, larvae at 6m would be advected up to 1 km away from the shoreline, and larvae at 9m would be advected along the shoreline. The physical patterns match the distribution of balanid nauplii, with most larvae accumulating between 8-12m early in the day and disappearing eastward afterwards. Within these preliminary 24 hours, larvae would be retained within about 1 km of the shoreline or moved along the coast. If successive 24-hour surveys confirm these observed patterns of alongshore and cross shore transport, they could explain the often described hotspot retentive nature of bays.

Interactive effects of larval history, location and habitat on juvenile performance in a temperate reef fish

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It is well understood that juveniles of many marine organisms are closely associated with structured nearshore habitats as they provide resources (refuge and food sources) that are critical for juvenile growth and/or survival. However, individual performance may not only be indicative of conditions experienced in the benthic phase, but also an individual's prior history. Evidence suggests that variation in condition experienced during pelagic larval development can impact on subsequent ecological performance (e.g., feeding ability and/or predator avoidance) and therefore influence subsequent fitness (i.e. rates of growth and/or probabilities of survival).

We ran subtidal manipulation experiments to evaluate variation in the strength to which larval history can mediate juvenile performance (growth and survival) for a reef fish (*Forsterygion lapillum*) common to rocky reefs of New Zealand. We found overall that individuals that grew fast as larvae tended to experience proportional growth advantages as juveniles. Fine-scale variation in macroalgal composition had the ability to mediate the importance of larval quality to survival, however, the effect of habitat varied between local populations and settlement events through time. Specifically, a stronger growth advantage was found on some microhabitats (e.g. mixed stands of macroalgae) relative to others (e.g. monocultures of *Carpophyllum maschalocarpum*) for some cohorts and locations only. Similarly, the intensity of growth-based selective mortality varied among cohorts, locations and microhabitats: for the cohort and location where carry-over effects differed between microhabitats, we also observed difference in the intensity to which fish with rapid larval growth rates were favoured. Overall, our results highlight how this spatial and temporal patchiness in extrinsic factors can interact with intrinsic variation of recruiting individuals to have a major influence on the resulting distribution of juveniles and their phenotypic traits.

Key words: larval condition, post-settlement performance, macroalgae, nursery habitat.

Different host, different guests? : Effects of the presence of the invasive seaweed *Undaria pinnatifida* on native epifaunal communities

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Small mobile invertebrates (e.g. amphipods, isopods) are the dominant secondary producers on in temperate reefs and provide an important trophic link between primary producers, such as their host seaweeds, and higher level consumers. Changes in seaweed community composition, like those that can be caused by invasive seaweeds, may affect the epifaunal community and thus potentially also affect higher trophic levels. The Asian kelp *Undaria pinnatifida* (Harvey) Suringar, is one of the world's most invasive species and has spread thoughtout New Zealand. We collected information on the abundance of *U. pinnatifida* relative to native seaweed species on reefs in the subtidal and found it can comprise up to 46 % of total seaweed individuals per m^2 and up to 70 % of seaweed canopy cover. We then hypothesised that *U. pinnatifida* hosts a less dense and diverse epifaunal community relative to some native seaweed due to its simpler morphology. In accordance to this hypothesis, we found that despite its abundance, *U. pinnatifida* does not provide a comparable habitat to some native seaweeds (*Carpophyllum flexulosum*, *Cystophora scalaris* and *Sargassum sinclairii*), hosting only 25% of the density of epifauna and, in some cases, less than 50% of the diversity that these native seaweeds can support. These findings suggest changes to a seaweed community due to introduction of invasive seaweeds may affect the population of secondary producers of an invaded environment.

Key words: invasive seaweed, epifauna, seaweed morphology

Realizing connectivity- the influence of early life history on the dynamics of marine metapopulations.

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The replenishment of benthic marine populations is the culmination of many processes that influence the production, dispersal, settlement and survival of larvae to maturity. Although there have been recent advances in our understanding of dispersal and its importance to population connectivity, to date no study has attempted to evaluate all early life-history processes to assess their relevance to the maintenance of marine metapopulations. Using a model temperate reef fish species, the southern hulafish (*Trachinops caudimaculatus*), we present data on larval vertical distributions, larval settlement behaviour from choice experiments, and spatial population structure and integrate these empirical results into a coupled biophysical connectivity framework. We then compare modelled estimates of connectivity to larval dispersal patterns from otolith microchemistry. Our findings reveal that realistic estimates of connectivity depend on a high degree of biological complexity, highlighting the importance of empirical validation of biophysical models of larval dispersal.

Key words: Natural tags, olfactory cues, Port Phillip Bay, recruitment, larval retention, self-recruitment

Mechanisms enhancing ecosystem function in diverse macroalgal assemblages

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Light fundamentally underpins primary productivity in all ecosystems, yet our understanding of how structurally complex macroalgal assemblages use and distribute light is limited. For light to be efficiently used, all photons within the PAR range must be captured by photosynthetic pigments, with more diverse assemblages potentially able to capture a greater proportion of light through two processes: 1) through greater diversity of thallus structure, thereby capturing a higher proportion of the incoming irradiance, and 2) through efficient conversion of light into carbon fixation throughout the entire PAR spectrum. Considering the diversity of photosynthetic pigments present in red, green and brown macroalgae, more efficient use of the PAR spectrum may be possible in diverse assemblages. Here we test the ability of assemblages composed of multiple functional and taxonomic groups to use different light wavelengths compared to the contributing components alone. Furthermore, we examine the role of sub-canopy macroalgal diversity on NPP at different canopy densities to understand how variation in morphology and pigment composition may enhance NPP of diverse communities. We show that under typical canopy densities, sub-canopy species diversity enhances rates of NPP, but at lower canopy densities, the diversity of the sub-canopy assemblages has a minimal impact on NPP. Although it has long been understood that diversity of photosynthetic pigments has led to differences in wavelength use between algal species, there has been little work to understand how these differences relate to *in situ* light conditions and the potential for resource complementarity within diverse communities. We hope to explore these mechanisms and encourage further research to get a better understanding of how light quantity and quality impact macroalgal assemblages in coastal waters, which are increasingly threatened by diminishing light quantity through processes such as sedimentation and eutrophication.

Key words: Irradiance, net primary productivity, canopy

Effect of light, zoospore density and understory algae on *Ecklonia radiata* recruitment

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Kelp ecosystems are threatened by several anthropogenic stressors. In eastern Tasmania, cool-water temperate ecosystems are increasingly being exposed to the warm water of the East Australian Current (EAC). *Ecklonia radiata*, is one of the most important subtidal habitat-forming species in southern Australia supporting diverse and economically important food webs. An increasing concern for *E. radiata* is how anthropogenic stressors will impact the recruitment of its early life-cycles stages via changes to temperature, nutrients, light regimes and reduced propagule supply. In this study we determined: 1) how light and zoospore density interact to influence the recruitment of *E. radiata* gametophytes and sporophytes, and 2) the effects of low, medium and high understory algal abundance on the recruitment of microscopic and macroscopic of *E. radiata* sporophytes. In the lab, more gametophytes (both male and female) recruited at low light and with high initial zoospore destiny. Importantly and in contrast to gametophytes, no sporophytes recruited at low light whereas high numbers of sporophytes recruited when there were both high light and high initial zoospore densities. The lack of sporophyte recruitment at low light appears to be due to poor growth and development of gametophytes under those conditions. When understory algae was manipulated in the field, out-planted microscopic recruits and naturally recruiting macroscopic recruits were at significantly higher densities when there was low and medium understory algal cover. No *E. radiata* recruits occurred when there was a high cover of understory algae. This study suggests reduced recruitment of *E. radiata* sporophytes will occur when understory algal cover is high and light is low and moreover, there is the potential for adult *E. radiata* canopies to create conditions conducive to its recruitment.

Deconstructing marine metapopulation persistence: dynamic modelling reveals key biological and physical drivers.

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The persistence of marine metapopulations is dependent on many factors, including life-history characteristics, demographic processes, connectivity through larval dispersal, and the disturbance regime. Although we have made significant advances in our understanding of these individual processes, developing an integrated approach to studying this entire cycle from reproduction, through dispersal, and to the recruitment of individuals has been difficult. Using the southern hulafish (*Trachinops caudimaculatus*) population in Port Phillip Bay, we present an empirically-based biophysical and stage-structured metapopulation model for this system. We present data on population demographic and vital rates, describe the modelling approach, and show how a sensitivity analysis was used to quantify the impact of i) life histories, ii) demographics, iii) larval dispersal, and iv) the physical seascape, on the spatial structure of metapopulation dynamics and persistence. We show how system-wide emergent properties and sub-population characteristics can be used in setting conservation priorities in this and similar systems.

Key words: network analysis, reproductive output, spatial prioritisation, local retention, model validation.

Herbivory by *Parma mccullochi* (Pomacentridae): its diet and impact on temperate algal-dominate reef.

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Pomacentridae is one of the most representative families of herbivorous fishes inhabiting both tropical and temperate reefs. Despite the high abundances of the pomacentrid *Parma mccullochi* in temperate waters of Western Australia, and their likely importance as ecosystem engineers in the region, there is a lack of information on their diet and their impact on the reef algal community. This study aims to determine the ecological role of *Parma mccullochi* in temperate algal-dominated reefs in the metropolitan waters of Perth, Western Australia. To achieve this, the diet of *P. mccullochi* and any ontogenetic differences, and its impact on the reef in terms of algal composition and algal recruitment were determined. *P. mccullochi* in the temperate reefs of Western Australia was found to be a strict herbivore, with its diet comprising almost entirely red foliose and filamentous algae such as *Hypnea* spp., *Ceramium* sp. and *Brongniatrella* sp., and showing no ontogenetic shift. Based on electivity indices, *P. mccullochi* showed a positive selection for specific algal taxa such as *Brongniartella* sp., *Dasyclonium* sp., *Hypnea* spp. and *Dictyopteris* spp. The species composition of macroalgae differed significantly between inside and outside *P. mccullochi* territories ($P = 0.010$), and a caging experiment in *P. mccullochi* territories didn't show an effect on the composition of recruiting algae ($P = 0.067$). Total algal biomass was significantly lower ($P = 0.0126$) while species richness was higher ($P = 0.0114$) inside compared to outside territories. *P. mccullochi* has the capacity to structure the benthic composition of reefs and maintain high biodiversity patches within kelp canopies. This effect is amplified by the high abundances of the species observed in Perth metropolitan waters, and can therefore be considered an ecosystem engineer/landscaper of temperate algal dominated reefs, highlighting its importance in ecosystem processes of temperate reefs in the region.

Effects of predator and competitor presence on larval settlement preference behaviour in intertidal mussels.

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Predation and competition are well established distribution setting variables on rocky shores, however, less is known about how these factors influence behaviour in early life stages. The ecological importance of pre-emptive behaviours and traits that enable organisms to avoid predation and competition, particularly during the larval and settlement stages, may be as important as direct effects on recruit and adult populations. We tested whether the threat of predation, or of competition, induces preferential settlement behaviour in the intertidal mussel *Perna perna*. To identify behavioural preference, field experiments at two sites examined settlement rates on manipulated artificial units of habitat (AUH) deployed in rosettes so as to present situations where a choice of treatment was available and where no choice was available. Treatments comprised predator-inhabited, competitor-inhabited, biofilm conditioned and untreated AUH. Preliminary results differed between sites, however, settlement rates were lowest on the untreated AUH when no-choice was given. Comparison of observed and expected proportions derived from choice and no-choice rosettes showed preferential behaviour at one of the two sites, with a higher proportion of settlement on the predator-inhabited treatment. This may be evidence of 'swamping' behaviour by the settlers.

Long time series and broad spatial scales

Continental-scale patterns and environmental drivers of population ecology of a ubiquitous habitat-forming kelp (*Ecklonia radiata*)

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The kelp *Eckonia radiata* is a prominent habitat-forming species on coastal reefs throughout the three temperate biogeographical provinces of southern Australia, where it has been dubbed the ecologically most important species. In order to better understand what drives the ecological functions associated with this ubiquitous species, we assessed the density, growth, erosion and fecundity of kelps in 36 kelp populations across a hierarchy of spatial scales in Western Australia, South Australia, Tasmania and New South Wales (>5,000 km coastline). We explore links between environmental conditions, productivity, erosion, reproduction and recruitment, and discuss the results in light of the broad ecological importance of kelp beds and their sensitivity to environmental change.

Key words: Productivity, erosion, fecundity, timing, phenology, Australia

Spicule armament and defense in temperate zone sponges: a transcontinental comparison.

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We tested the hypothesis that siliceous spicules from temperate zone sponges were an effective defense against common rocky-reef sea-urchins. We added spicules to palatable agar discs and determined the amount consumed by *Strongylocentrotus droebachiensis* in the northern Gulf of St. Lawrence and *Centrostephanus rodgersii* in southeastern Australia. The energy and protein values of the agar discs were matched to that of the sponges tested. Of the four sponge species examined in Australia, three deterred local urchins from feeding while spicules were an effective defense for two of the three sponge species examined in Canada. For several sponge species the effectiveness of spicules as a defense was dramatic, despite modest sample sizes. Generally megascleres were an effective defence, but surprisingly microscleres defended *Chondrilla australiensis*. Although 'local' sponge spicules fed to 'local' urchins were generally effective deterrents, spicules from Canada were highly effective against the Australian urchin while spicules from Australian sponges proved ineffective against *Strongylocentrotus.* Our findings confirm that spicules play more than a role in skeletal support, but may underestimate the defensive capabilities of sponges as we have not considered chemical defense. We are aware that some of the sponges we have examined exhibit chemical defense against urchin feeding. Importantly, our data indicate that physical defense in sponges may be tightly co-evolved within a continent.

Key words: Porifera, Echinoid

How has a changing coastal climate affected the long-term dynamics of habitat-forming algae and their associated communities?

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Changes in coastal wind direction, maximum wave height and sea surface temperature can greatly affect the distribution and abundance of key intertidal algae and modify their associated communities. Long-lasting impacts on intertidal communities after even minor reductions in the abundance of habitat-formers are often associated with changes in storm intensity, frequency, timing or direction. Here, we relate temporal changes in physical data from coastal New Zealand (discussed in a companion talk by *Schiel et al.*) and changes to the long-term dynamics of habitat-forming algae and their associated communities over twenty years and across multiple sites. The ecological implications of altered community structure together with seasonal disturbances, El Niño and La Niña cycles, and long-term wave height trends are all discussed in the context of a changing coastal climate.

Using Niche Modelling and different paleo-scenarios to explain the antitropical distribution of *Sargassum* subgenus *Bactrophycus*

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Sargassum is an ecologically and economically important genus of brown macroalgae widely distributed in the world's oceans. Although the *Sargassum* subgenus *Sargassum* is abundantly represented in tropical to subtropical regions, the subgenus *Bactrophycus* is more diverse in temperate regions. Most species of *Bactrophycus* are distributed in East Asia while members of the section *Halochloa* are also found in Australia/New-Zealand and the South West Indian Ocean (South Africa, southeast Madagascar and southern Mozambique). Molecular data have recently lent support to the hypothesis that the southern species of section *Halochloa* originated in South East Asia and crossed the tropical region only once, resulting in this intriguing antitropical distribution, with a disjunction in the southern hemisphere. We present different paleo-scenarios to explain the observed present distribution using a multidisciplinary approach. Firstly, the age of the northern hemisphere ancestor of the section *Halochloa* was estimated using a new molecular clock for the genus *Sargassum*. A niche model was then trained using maximum entropy modelling (in Maxent) on known distributions and present-day climate layers and projected in warm (Pliocene) and cool (LGM) climates. Paleo-climate layers (various environmental parameters) were obtained from the coupled Ocean Atmosphere general circulation model IPSL-CM5A. From our results we discuss the hypothesis that the ancestor of the southern hemisphere section *Halochloa* species crossed the equator and then the Indian Ocean via floating rafts at the Pliocene-Pleistocene transition period (around 3 to 3.5 Ma).

Key words: Biogeography, Indo-Pacific, Phaeophyceae, Phylogeny, Seaweed.

The effects of the environment on the reproduction and early performance of the habitat-forming kelp *Ecklonia radiata*

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Around the world patterns in reproductive synchrony, seasonality and juvenile growth vary with time and biogeography. *Ecklonia radiata* is the major marine habitat-forming algae in temperate Australia, and provides shelter and habitat for many species including some economically important species. The aim of this study was to examine patterns of reproductive synchrony, seasonality and the growth and survival of early life phases of *E. radiata* to examine the influence of environmental conditions on these patterns. Spore concentrations were quantified at different spatial and temporal scales, using a unique method specially devised for this research. Spores were collected from a number of different locations around Australia and grown at a range of temperatures, to examine biogeographic patterns in survival and growth of gametophytes. The results show that *E. radiata* in South Western Australia is fertile and reproduces from mid-summer to the end of autumn. The timing of spore production and release was linked to changes in sea temperature, and differs dramatically between populations, with significantly reduced reproductive periods where individuals exist near the temperature limits of this species. There were also dramatic differences in the survival and growth of gametophytes collected from around Australia, with extreme differences in size of individuals grown from the southern-most populations. Temperature influenced geographically remote populations in different ways; warmer climate gametophytes, from Western Australia, appeared better adapted to extreme temperatures than those from cool populations, such as Tasmania.

The role of food limitation on reproductive capacity and larval recruitment in purple sea urchins

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Purple sea urchins (*Strongylocentrotus purpuratus*) serve as a model system to evaluate how food availability may influence recruitment dynamics through both adult reproduction and larval survival. To quantitatively estimate how food supply impacts female fecundity, we exhaustively spawned urchins from multiple healthy kelp forests, where food was abundant, and from deforested areas where food was scarce. Size specific fecundity of females from kelp forests (measured as the number of eggs produced) was an order of magnitude greater than that of females from deforested areas. Lab experiments showed that similar changes in gonad size for well fed urchins can occur over seasonal time scales (six weeks to three months) when urchins are deprived of macroalgae, their primary food source. Similarly, the gonad size of emaciated urchins increased to that of well-fed urchins within several months when consistently provided modest rations. These results mean that large scale, regional reductions in food supply prior to the spawning period have the potential to substantially impact larval production and thereby recruitment. We search for evidence of this phenomenon over a twenty-two year period using time series data of: (1) biweekly sea urchin settlement (2) seasonal kelp canopy biomass (adult food availability) (3) bimonthly sea surface chlorophyll (larval food availability) and (4) physical process that might influence sea urching settlement (namely wind stress and sea surface temperature). Results have implications for understanding limitations to recruitment in species that are susceptible to food limitation in both the adult and larval stage.

Key words: Time Series, Giant Kelp, Subtidal,

Long term patterns in assemblage structure on intertidal rock platforms at Rottnest Island, Western Australia.

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At 32°S, Rottnest Island lies in temperate waters, but receives larvae of tropical marine invertebrates via the southward flowing Leeuwin Current. The marine invertebrates of Rottnest Island have been well documented as a unique mix of tropical and temperate species not seen on the adjacent mainland, including the tropical species such as the sea urchin *Echinometra mathaei*, the purple *Morula uva*, and the serpent's head cowry, *Cypraea caputserpentis* co-occurring with temperate species such as the turban snail *Turbo intercostalis*, the whelk *Thais orbita* and the limpet *Patelloida alticostata*. Censuses of the assemblages on 24 intertidal platforms fringing the island over the last 20 years has seen changes in the occurrence and relative abundance of both temperate and tropical species. This paper explores those changes, comparing them with concurrent studies on individual species to see if those changes fit a pattern consistent with changes in oceanographic parameters over the same time period, including the recent marine heatwave that caused an increase of 3°C in sea surface temperatures.

Key words: intertidal invertebrates, *Echinometra mathaei*, Leeuwin Current, marine heatwave

Spatial variation of the dietary regime of two filter feeders along the South African rocky coast: fatty acid and stable isotope approaches

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Benthic filter feeders have a key functional role in food web dynamics in coastal areas. These ecosystems are influenced by several factors (e.g. hydrographic regime) that can affect the composition of the water column and thus the availability of food and nutrients for benthic populations. Food availability for benthic filter feeders can affect growth, reproductive rates, biomass and survival of benthic organisms, and consequently, can influence the functioning of the entire ecosystem. The aim of this study is to evaluate if intertidal filter feeders living under different conditions along the South African coast have different diets. Specifically, the effects of upwelling and biogeographic region on the diets of two mussel species (*Mytilus galloprovincialis*, *Perna perna*) and three barnacle species (*Octomeris angulosa*, *Chthamalus dentatus*, *Tetraclita serrata*) were investigated using fatty acid and stable isotope analyses across 13 sites (separated by 100s km) with 2 locations (separated by km) in each site. These techniques have been recognized as important tools for understanding the relationship between dietary sources and consumers, and for answering ecological questions about ecosystem functioning and trophic relationships. Both stable isotope ratios showed the same pattern for all species. $\delta^{15}N$ signatures increased from the east to the west coast, with no upwelling effect, while $\delta^{13}C$ was significantly decreased in upwelling sites relative to non-upwelling areas. The decrease in $\delta^{13}C$ suggests that upwelling plays an important role in carbon availability along the coast, and it's indicative of a different food source for organisms under upwelling conditions. In addition, within-site differences were found for all species, suggesting high microscale variability in isotopic signatures. These preliminary results highlight the profound effect hydrographic regime and biogeographic location can have on benthic ecosystems, and the need for microscale experiments to understand better the factors driving dietary regime.

Key words: Trophic ecology, Biogeography, Multiple spatial scale, Intertidal ecology, Rocky shore, Oceanography

Do the marine bioregions predict patterns of biodiversity? A test of the marine bioregional boundaries of Australia using gastropod assemblages as a model fauna.

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The management of biodiversity for conservation matters often involves dividing the land/seascape into regions according to their abiotic and biotic affinities. For marine systems, the boundaries of such bioregions are often determined using proxies such as presence of seagrass or types of substratum. In the case of the designation of the Australian marine bioregions it is not known whether these boundaries accurately predict real discontinuities in ecological assemblages. This research will address the issue by relating patterns in diversity of gastropods with the location of bioregional boundaries. At fine scale a number of artificial units of habitat (AUHs) were deployed as samplers in four of the five bioregions given for NSW, Australia; in the northern and centre areas of each bioregion, at different spatial scale (location separated by 10 to 100 km, patches from 10 to 100 m and quadrats from 1 to 10 m). This is the first study incorporating AUHs to measure biodiversity at large scale. The test of the hypotheses that bioregions differ was implemented using PERMANOVA. The results showed that the Hawkesbury and Batemans shelf bioregions actually do not support different assemblages therefore, should be considered as one bioregion, and the discontinuities between assemblages were not consistent at the level of bioregional boundaries which means that these boundaries are not clear. It is discussed that the difference in gastropod assemblages along the marine bioregions might be driven by oceanographic factors.

Key words: Marine Bioregions, surrogate, gastropods, pattern of distribution, artificial units of habitats

The abiotic context for ecological change in coastal waters of New Zealand: a changing coastal climate over the past several decades

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Production and standing stock of benthic algal assemblages are often mediated by abiotic factors such as seawater temperature and wave disturbance. Where large impacts occur, community structure and productivity can be compromised for years, and changing oceanographic conditions have a significant effect on the resilience of coastal ecosystems. These changes are nested within large scale phenomena such as El Niño and La Niña events. New Zealand collects a wealth of relevant physical data (e.g., sea surface temperature, wave forces, upwelling metrics, riverine output, sedimentation, currents and coastal topography), but this is only partially analysed and barely synthesised. Here we show that SST has increased around coastal water of NZ, particularly in the north, and significant wave height has increased in the south. Extreme wave events have also increased in some sectors of the coastline. In this and a companion talk (*Lilley et al.*) we discuss these changes with respect to long-term impacts on benthic assemblage.

Latitudinal patterns in temperature, aren't.

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Temperature has long been recognized as a major driver of many ecological processes in the intertidal environment. In recent years there has been an increasing number of studies showing the relevance of thermal variability at the scale of organisms. Nevertheless, given that few longstanding, broad scale networks of sensors exist at the moment, the availability of temperature data at the microhabitat level remains very limited. In an effort to overcome this problem, researchers often assume that microhabitat temperatures vary latitudinally, just as broad scale patterns often do. In the present study we make use of a network of biomimetic temperature loggers spanning more than 15 degrees of latitude, along Europe's Atlantic coast. Three years worth of daily data were analysed in order to find how microhabitat temperature correlates with latitude. While some ecologically relevant temperature metrics do vary latitudinally (e.g. overall frequency distribution, mean), there are notable exceptions. Our results revealed that unless in situ data is obtained, and the appropriate temperature metrics are analysed, any assumption that a microhabitat temperature metric varies latitudinally is unwarranted. In turn, this work also shows that an improved knowledge of the patterns of temperature variability will confer researchers greater confidence when studying the link between physiology, phenology and temperature.

Key words: NE Atlantic, robolimpet, latitude.

Longitudinal variation and effects of habitat on biodiversity of Australasian temperate reef fishes.

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Patterns of change in the biodiversity of marine fishes along latitudinal gradients are well documented, but very little is known regarding patterns of change with longitude. We will describe the results of a quantitative study of temperate rocky reef fish assemblages in two habitats (kelp forests and open reefs), spanning a very large geographical extent in longitude, from New Zealand to Western Australia (117.91°E - 174.81°E), but within a reasonably restricted latitudinal band (33.64°S - 37.08°S). The structured hierarchical sampling design allowed variation to be quantified at a range of spatial scales - from tens of metres to thousands of kilometres. Five univariate measures of biodiversity were examined: total (log) abundance, richness, evenness, average taxonomic distinctness and variation in taxonomic distinctness. Multivariate compositional changes in fish communities were also examined at species and at family levels. Our results highlighted how different diversity measures capture different and complementary aspects of biodiversity. In addition, unlike many previous marine ecological studies, family-level variation did not mirror patterns seen at the species level. Possible explanations include oceanographic, functional and/or historical processes. We also propose here a “village” hypothesis of community assembly which can be tested in other systems and for other faunal groups across large spatial scales.

Key words: Community structure, multivariate analysis, spatial distributions, taxonomic resolution.

Causes of change in intertidal assemblages: analyses of 30 years of observation and experiments

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It is an important goal to understand the causes and processes creating change in natural assemblages. Models have been proposed about the relative importance of disturbances due to weather, competition and predation or recruitment of component species. There have, however, been few long-term observations on natural assemblages to document the types and rates of change of assemblages. There have been even fewer long-term studies that have integrated results of intensive short-term experimentation to be sure about the processes that actually caused change. Here, the changes in assemblages in 88 sites (each approximately 25 m^2 in area) on rocky shores in New South Wales are identified. Sites were sampled every 5 years from 1974 to 2004 and the 9 major species counted. Criteria for discriminating 6 different assemblages were established so that each site could be categorized at each time. The cause(s) of change from one type of assemblage to another were identified from experimental analyses over these areas during the entire period. Such experiments considered effects of storms, major episodes of extreme low-tidal high temperature, competition amongst grazers and users of space, predation and effects of large or no recruitment. Nearly all changes could be explained using experimental results. In this talk, the nature and amounts of change will be described, including the very surprizing fact that most changes were caused by very short-term (lasting one day) processes which had very long-lasting effects. The results indicate how much the ecological history of a site must be understood to ensure that the current nature of an assemblage makes much sense. They also show the huge benefits of coupling detailed, multifaceted experimentation with long-term observations to achieve greater understanding of the relative importance of ecological interactions and responses to environmental changes.

Key words: alternative state, ecological history, long-term, natural change,

Ecology in the 21st century

Growing blue-green cyanobacteria-based biofilms on experimental sandstone units

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On most intertidal reefs in the world, marine filamentous cyanobacteria Oscillatoriales are important components of natural biofilms. Some studies have already suggested the nutritional importance of benthic cyanobacteria for intertidal grazers; however, due to the complex nature and technical difficulties at attempting biofilm manipulation *in situ*, questions related to the relationship between what is available and what is actually consumed and assimilated by intertidal grazers still remain. An alternative approach could be to use an isolated benthic cyanobacterial strain and grow it on surfaces resembling natural rocky shores under controlled laboratory conditions. Researchers can then test hypotheses about feeding behaviours and nutritional implications of grazers feeding on monospecific biofilm. In this study, we grew a monospecific cyanobacteria-based biofilm on experimental sandstone cores. Evidence of their growth is demonstrated using two established techniques in the analysis of chlorophyll *a* as a proxy for biomass. Destructive (spectrophotometric) and non-invasive (spectrometric) methods were used to measure photosynthetic pigments in the benthic filamentous blue-green cyanobacteria *Geitlerinema* sp. strain CS-897 in a 26-day experiment. Amounts of chlorophyll *a* were assessed every two days and a continuous and significant growth of a monospecific biofim was observed through time (values ranging from 0.19 µg cm^{-2} on day 0 to a maximum of 1.08 µg cm^{-2} on day 22). To fully differentiate this genus from others and then obtain a spectral signature for *Geitlerinema* sp., absorbance and reflectance spectral curves were also analyzed and photosynthetic pigments identified. Taken together, the results obtained in the present study provide a platform for further studies essentially focusing on intertidal grazer's nutritional ecology, feeding behaviour and/or food choice.

Key words: *Geitlerinema* sp., growth rate, pigments, spectra, field spectrometry

The big picture: imaging and mapping intertidal rocky shores with a remotely piloted aircraft

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The basic methods for sampling rocky shore communities have not changed for many decades. Most surveys are variations on transect-based and/or stratified random sampling of quadrats whose scales and spatial arrangement are determined by the capabilities of the observer. The primary goal is to provide estimates of abundance of assessed species that are representative of the whole shore, based on statistical assumptions. Here I present the results of an alternative approach using multiple images taken by a camera mounted on a low-flying remotely piloted aircraft, flying a pre-programmed flight path. Three locations in the Outer Hebrides were surveyed in June 2013 as part of the pre-deployment phase of a study to assess the effects of an array of nearshore wave-energy extraction devices. Ground-based low-tide surveys were made using categorical abundance and quadrat-based estimation of abundance of conspicuous cover-forming species. Overflights were made at the same time using a 1.5m-wingspan Quest 200 UAV at 30m altitude, equipped with a Panasonic LX5 camera taking images every 2s. Flights lasted up to 25 minutes and returned 150-200 overlapping GPS-located images of the target area. Photogrammetry software allowed the production of ortho-photographs and digital elevation models (DEMs) of areas extending 400-700m along the coast and 70-100m from low to high shore. The orthophotos and DEMs had resolution of 1.5cm and 5cm respectively. This resolution showed individual fucoid plants and other macroalgae, notably *Enteromorpha intestinalis*, and the quality of the images permitted the distinction between areas dominated by newly settled and older barnacles (mostly *Semibalanus balanoides*). Supervised pixel classification on downscaled (5-cm) images gave moderately successful recognition of six types of substratum cover. The results of the aerial and ground-based surveys were compared, and the relative merits of each were assessed. Aerial methods are not likely to replace ground surveys soon, but they allow scaling up from quadrat-based estimates with an unprecedented level of confidence, and are likely to play an increasingly important role in the development of rocky shore ecology in the 21st century.

Key words: aerial photography, mapping, rocky shores, wave energy

Timing your run: Exposure to fishing of Snapper (*Pagrus auratus*) migrating to and from an annual spawning aggregation site

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Many fish species that aggregate to spawn have been subjected to heavy fishing pressure, sometimes sufficient to threaten their reproductive success. On the lower west coast of Australia, a large demersal sparid, *Pagrus auratus,* migrates annually to and from three adjacent marine embayments close to Perth, to aggregate and spawn. The importance of these aggregations, particularly in Cockburn Sound, to the broader stock of *P. auratus* on the lower west coast led to the implementation of an annual closure to fishing in the three embayments during the spawning period. This now extends over four months and includes the peak of spawning. However, significant recreational fishing of migrating and aggregating fish occurs prior to the commencement of the annual closure. Following spawning, these fish disperse widely across the adjacent continental shelf. Using acoustic telemetry, the movement of 40 *P. auratus* was tracked through a gate array surrounding Cockburn Sound over a period of three years. The aim in part was to gain a better understanding of the exposure of aggregating snapper to fishing in this region. The resultant telemetry data were examined in terms of (1) the numbers and location of entrances used to immigrate into and emigrate from Cockburn Sound in relation to where fishing occurs, (2) the fidelity of individuals to Cockburn Sound and a particular aggregation location within it (3) the timing of entry and exit from the Sound in relation to the annual closure. Approximately 95 % of immigrations and emigrations occurred through one out of three entrances, where recreational fishing vessels are regularly observed. Around a third of the individuals returned to Cockburn Sound annually, while the majority returned at least once. Returning fish were always recorded at a particular aggregation location in Cockburn Sound each year, where large numbers of recreational vessels target *P. auratus* prior to the start of the closure.

Key words: Vemco, Kernel Density, spawning closure, fishing closure

How to mobilise gen-millennium: engaging educators in marine citizen science

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Tracking impacts and changes to marine systems on national or global scales requires large-scale, long-term monitoring programs which is often beyond the reach of single research organisations. The citizen science model is one method which has been successful in overcoming the logistical requirements of compiling such datasets, particularly for temperate reefs (e.g. Reef Life Survey, Red Map, Big Sea Survey) and beach environments (e.g. Tangaroa Blue). Here we present the experiences of two citizen science programs, ClimateWatch marine and TeachWild, which primarily engage secondary and university students as data collectors for intertidal invertebrate and marine debris surveys. Both programs have an average participant age of below 25 and have been able to mobilised thousands of students in cities and remote regions across Australia. Our experiences suggest researchers should give more thought to mobilising student assistance over large scales as they represent both a diffuse and 'hub' network of potential data collectors. We discuss the requirements for resources, models of engagement, links to the National Science Curriculum and training which must be overcome before engaging the education sector in citizen science but advocate the merits of doing so far out way the costs, both in terms of research outcomes and educating youth through participatory science learning.

Key words: education, public, beach, volunteers, online

Breathing life into fisheries stock assessments through citizen science

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Citizen science provides the opportunity to collect large data sets over wide spatial scales with limited funding and has frequently been used in a variety of ecological studies. However, it is not used widely to support fisheries stock assessments. Recently, significant changes to management were introduced to recover stocks of west Australian demersal fishes from overfishing along 1000 km of coast. The resultant lower catches and negative sentiment in this socially- and politically-important fishery reduced the opportunity for scientists to collect the quantities of biological samples essential for assessment from their traditional stratified sampling of the recreational fishing sector. Thus, the contributory citizen science program *Send us your skeletons* (*SUYS*) was developed. *SUYS* asks recreational fishers to voluntarily donate biological samples of fish frames (skeletons) to help monitor the stocks of demersal species. During three years of the *SUYS* program, dramatic improvement has occurred in recreational fisher involvement, sample sizes and spatial and temporal representativeness. Statistical error around stock status estimates was also reduced. In addition, as sampling the entire coast effectively with traditional methods was not economically feasible, this program has allowed scientists to more efficiently monitor whether demersal fish stocks are recovering. This has led to better information for management of the demersal resource and importantly, has improved knowledge among the fishing community as well as a sense of stewardship of the local resource.

Keywords: voluntary, public participation in scientific research, long-term monitoring, fish

Modeling an inscrutable species: A case study of the Western Rock Lobster

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Lobsters are in decline globally, yet their spatial ecology is not well defined. For the western rock lobster, little is known about the key factors that influence their distribution, beyond reef and kelp. We developed distribution models of seafloor substrates and benthic biota using underwater towed video cameras and full coverage bathymetry. These were then used for predicting lobster distributions. Substrate models explained 53-87% of the total deviance, with strong associations to geophysical variables. Biota showed a strong association with depth and hard substrate types. The final lobster model explained 64% of total deviance with an 80% correct classification. Kelp and reef were not selected as predictors, but the model selected geophysical and geomorphic scalar variables, emphasising a mix of fine scale terrain.

Following this study, we did a case study on the potential for investigating the western rock lobster, and their habitat use in offshore marine environments using the AUV, '*Sirius'*. We found that the results from the survey support previous laboratory and field studies documenting greater lobster activity in darkness and the preference for fine scale complexity in terrain, with reef and kelp-dominated mixed-algae assemblages being a key feature at a broad scale. However, the unique outcome from the AUV survey is that, in the absence of diver interference or luring lobsters to baited pots, the AUV captured adult lobsters in natural foraging and sheltering habitats. This non-invasive survey technique enabled a pilot level assessment of the locomotive behaviour and habitat use of adult lobsters.

Remotely studying shifts in dominant marine species through the eyes of robots (AUVs)

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Management of natural resources calls for an accurate description of the location of hotspots of biodiversity, spatially aggregated populations and preferred habitats for commercially important species. Monitoring the status and health of marine benthic habitats now forms a major component of the more holistic ecosystem-based management approach, which shifts the focus from a single species to the dynamics of the whole ecosystem. Autonomous Underwater Vehicle (AUV) technology was used to conduct routine, high precision monitoring of benthic habitats at 3 key locations in temperate WA; Houtman Abrolhos Islands, Jurien Bay and Rottnest Island, as part of a national Integrated Marine Observing System (IMOS). Surveys of benthic assemblages on submerged reefs have been repeated over the last four years (2010 to 2013) with the AUV '*Sirius*', capturing over one million overlapping, geo-referenced high-resolution images of the seabed. Surveys were designed to obtain 100% coverage of 25 x 25 m patches of seabed; at sites at three depths between 15 and 45 m. Captured within this monitoring period was a marine heat event where warming anomalies of 2–4 C persisted for more than ten weeks along >2,000 km of coastline. Here we describe the changes in reef structure associated with the marine heat wave.

Building open source software tools for cost effective habitat mapping of temperate shallow subtidal reefs.

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Habitat maps are vital to resource management efforts as well as for many ecological studies. Automated classification of satellite imagery can be a valuable method of generating habitat maps for shallow subtidal habitats, including reefs, in temperate regions. However, current methods require expensive proprietary software and/or specialised knowledge and skills to implement and are difficult to integrate with field based reference data for the production of quantitative accuracy assessment. A set of free open source software tools will be described that will make these methods more accessible and efficient and integrate low-cost field data for classifier training and accuracy assessment. Two of these tools, Benthic Photo Survey (BPS) and the Accuracy Assessment QGIS plugin, are currently available for use. BPS has been used with an inexpensive camera, GPS, and depth logger to map the extent of an *Ecklonia radiata* die-back. In conjunction with the Accuracy Assessment plugin, BPS has been used to gather reference data from the field for classifier training and accuracy assessment in the production of preliminary habitat maps from 8-band WorldView-2 satellite imagery. Increased accessibility and availability of cost-effective tools for mapping subtidal habitats, such as those presented here, will be of value to marine spatial planning initiatives and ecological studies in coastal regions worldwide.

Key words: GIS, Remote Sensing, Photo Transects

Spectral or spatial variability in remote sensing signal – which is the best indicator of benthic species richness?

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We have tested different airborne hyperspectral sensors to map benthic habitat in shallow waters of the Baltic Sea. Our results show that recognising of broad groups of benthic algae (e.g. red, green and brown macroalgae) by means of remote sensing is feasible even in such optically complex waters like the Baltic Sea. However, recognising benthic vegetation at species level is very challenging. Nevertheless, we made an attempt to characterise species richness in shallow coastal waters by means of remote sensing. Both spectral signatures of different benthic habitats and spatial variability of the measured signal were analysed. Locally, remote sensing was insensitive to changes in benthic substrate and macrophyte species richness. At larger spatial scales, however, spatial variability in remote sensing signal is a better indicator of benthic substrate and species richness in coastal waters.

Key words: remote sensing, seabed geology, species richness, brackish water, Baltic Sea

A unique opportunity to study the recruitment, growth and ecology of juvenile WA dhufish *in situ*, utilising 21st century techniques.

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Fishes have often been documented using man-made structures during both juvenile and adult life-cycle stages. The unexpected appearance of large numbers of juvenile West Australian dhufish (*Glaucosoma hebraicum*) at newly-established artificial abalone aquaculture habitat, provided a unique opportunity to study the recruitment, growth and ecology of juvenile dhufish *in situ*. WA dhufish is a demersal reef species endemic to temperate marine waters of Western Australia and is highly sought after by both commercial and recreational fishers. Previous information on juvenile dhufish habitat preferences, recruitment and growth was only available from a study based on limited samples collected from scallop trawlers. To capitalise on this opportunity we utilised the 21st century techniques of stereo diver operated video (DOV) to survey the artificial habitats for 16 months and next generation genetic sequencing (NextGen) of gut contents to examine the diet of the juveniles. This presentation will provide results from the utilisation of these 21st century methods to elucidate the ecology of juvenile dhufish at this aquaculture site. The continuation of monitoring annual dhufish recruitment through stereo DOV surveys at this site along with extension to similar artificial habitat and representative natural habitat sites elsewhere along the coast of WA would develop an understanding of annual recruitment variability for this species which would be an invaluable dataset for fisheries managers.

Key words: WA dhufish, juvenile, growth, recruitment, ecology, NextGen sequencing.

Running too hot: satellite-derived high resolution sea surface temperatures (HRSST) largely miss near-shore upwelling

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Coastal systems have been used as models of how temperature shapes the distributional patterns of species, and as a warning system for the biogeographic effects of climate change. Most studies addressing thermal stress on coastal communities have relied on remote-sensed sea surface temperature (SST) measurements. Still, advances in this area have been hindered by the lack of reliable, high-resolution observations. Traditionally, satellite-derived SSTs either lack data for near-land areas, or more commonly, SST providers report low confidence for coastal data. Recently-available global high-resolution (<10 km) SST products (HRSST) promise to resolve much of the near-shore SST uncertainties. In this study we compared 10 HRSST data sets from US, European, and Australian providers (NOAA NCDC, NASA JPL, Naval Oceanographic Office, Remote Sensing Systems Inc, Medspiration Project, UK Meteorological Office, MyOcean, and Australian Bureau of Meteorology) with in-situ daily sea temperatures, collected during 2010/2011 at 17 locations along the European coast and during 2009/2011 at 10 locations along the Chilean coast. All HRSST products showed similar accuracies, with GMPE performing slightly better. Strikingly, however, tested remote-sensed products were largely blind to the near-shore upwelling, running hotter than in situ temperatures. This was true for all HRSST products and independent of geographic region. Our results are relevant because they show that on upwelling regions - which are important for productivity, fisheries and thermal refugia - remote-sensed SST data may be less accurate than most researchers assume.

A short crepuscular changeover period in a temperate reef fish assemblage in Western Australia.

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Diel cycles commonly influence the distribution, abundance and composition of marine fishes. The majority of diel studies have demonstrated that there is a greater abundance and species richness of fish during diurnal hours in comparison to nocturnal hours, and that fish species composition varies with time of day or night. I investigated fine scale (hourly) diel cycles in the composition and relative abundance of a temperate reef fish assemblage in Western Australia. Surveys were conducted using unbaited remote underwater stereo-video systems. At night the field of view of the cameras was illuminated with a blue light. Diurnal surveys recorded a greater number of individuals (16, 990) than nocturnal surveys (1053). The crepuscular hours of dawn and dusk showed the greatest variation in assemblage composition, reflecting the changeover of diurnally and nocturnally active species at dawn and dusk. Within the diurnal period the temporal variation was relatively homogenous, indicating that diurnal sampling need not necessarily be standardised for one particular time of day. This study highlights the influence that changes in the activity rhythms of fish can have on their assemblage structure through a diel cycle. The clear difference between day and night emphasises the importance of sampling during both diurnal and nocturnal periods in order to fully assess the variability of temperate marine environments.

Key words: Stereo-RUVs, circadian, artificial light.

The Big Sea Survey: Involving the community in monitoring change in coastal environments

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A tractable database of marine species records is crucial to the effective monitoring of the impacts of environmental change, and to distinguish these from other anthropogenic and natural changes. Accurate and detailed knowledge of abundances and geographic ranges of even our common species is lacking for many parts of the coastline. The constraints of manpower in collating such information can prove prohibitively burdensome. Citizen Science offers a way of overcoming this shortfall in manpower and resources and can help to fill in the gaps of species records necessary to build-up long term databases. At Newcastle University, a cohort of 240 volunteers have been trained in species identification and intertidal survey techniques, and are routinely collating information over a 150 mile stretch of coastline in the north-east of England. The resulting database will be accessible to scientists and organisations with biodiversity remits, and will feed into national networks of species records. The ramifications of such volunteer participation should not be underestimated. Compared to other habitats, marine environments are perceived as being inaccessible. At a time when threats such as sea level rise, coastal squeeze, ocean acidification and pollution pose real and imminent threats, changes to these perceptions are crucial. 'Big Sea' participants report renewed enthusiasm for supporting the environmental agenda, an increased awareness of marine issues, and a sense of empowerment in being able to contribute to effective action. Previous UK governments have recognised the importance of engaging members of the public if long term sustainable management of marine resources is to be achieved, this reflects the philosophy behind the project, that conservation and stewardship of the environment is the responsibility of all.

Key words: Citizen Science, biodiversity, long-term databases

Poster Presentations

Reproductive seasonality and early life temperature sensitivity reflect vulnerability of a seaweed undergoing range reduction.

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Temperature is a major determinant of the performance and geographical ranges of marine species. Changes in temperature can therefore result in localised mortality and shifts in species distributions. Despite this, the phenology and temperature sensitivity of many important habitat-forming seaweed species are poorly understood. Through field observations and culture growth experiments, the present study investigated the temperature sensitivity of reproductive timing, early post-settlement growth and survival, and recruitment success of the widespread foundation seaweed *Scytothalia dorycarpa* in Australia. In culture, the highest settlement densities and lowest mortality rates were achieved at 15°C, and optimal temperatures for germling fertilisation occurred at 18°C, whereas temperatures greater than 20°C delayed germling settlement and significantly increased mortality rates, with no germlings surviving at temperatures greater than 23°C. Experimental findings were consistent with field observations that found adult reproductive development and gamete release to occur in synchronous pulses throughout the winter months, when seawater temperatures were ~18°C. Surveys of the latitudinal distribution of *S. dorycarpa* recruits showed significantly lower recruit densities in warmer, low-latitude reefs where summer maximum temperatures often exceed 23°C compared to much higher recruit densities in cooler pole-ward reefs where average summer maximum temperatures are 21 to 22°C. The timing of reproduction, latitudinal distribution of recruits and culture temperature optima all indicate high temperature sensitivity among the early life stages of *S. dorycarpa.* These findings help to explain the rapid range contraction of this species following a 2011 marine heatwave off the southwest coast of Australia.

Key Words: Thermal tolerance · Macroalgae · Reproduction · Recruitment · Germling Distribution · Range contraction · Extreme event · Heat wave · Western Australia

Effects of subsidence caused by the 2011 Tohoku Pacific Earthquake on an *Eisenia bicyclis* kelp bed off Oshika Peninsula, northeastern Japan

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The 2011 Tohoku Earthquake and Tsunami resulted in large-scale subsidence along the Pacific coast of northeastern Japan. On the west coast of Oshika Peninsula where the rocky reef sank 0.9 m, monthly monitoring surveys of the *Eisenia bicyclis* kelp bed have been conducted since three months after the earthquake. All kelp individuals in the permanent study area (4 m wide x 30 m offshore) were tagged, located, and their survival and growth have been recorded. While the nearshore 24 m^2 area, formerly in the upper-intertidal zone, sank to become subtidal, the offshore 36 m^2 area sank beneath the pre-earthquake lower limit of *E. bicyclis* distribution. Abundant settlement of young plants started to occur at both the nearshore and intermediate areas six months after the earthquake. First-year survival rate of young plants was about 40%. At the offshore area, weakening or death of plants started to occur and young settlers were few. These offshore events can be attributed to offshore mud deposition probably caused by the retreat of the tsunami. The sedimentation is considered to cause both settlement inhibition of young plants and low light conditions by increasing the water turbidity. We predict that the size of this kelp population will expand as a result of the earthquake-related subsidence.

Key words: Population dynamics, tagging study, long-term monitoring, rare disturbance events, hardbottom habitat

Corals in a tropical-temperate transition zone

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Scleractinian corals are usually excluded from temperate reefs because of low temperature and/or competition with seaweeds. The mid-west region of Western Australia constitutes a temperate-tropical transition zone where corals can be found in large numbers among canopy forming seaweeds. Because this region is highly dynamic and could shift into a more tropical dominated habitat with future increase in seawater temperature, it becomes crucial to collect baseline data on existing coral communities (diversity, population and habitat preference) to enable the detection of potential tropicalisation in the future. A recent study (see poster by Tuckett et al.) indicated a recent change in coral communities following a significant increase of the ubiquitous coral species, Plesiastrea versipora since 2005. Here we provide data on high-latitude coral communities, with an emphasis on community and population structure on reef flats (mores seaweed dominated) and reef edges (no seaweed). We found similar coral communities on reef-flats and reef-edges. In contrast, the size structure of coral populations was significantly different between the two habitats with reef flats being dominated by medium sized corals and reef edges lacking the smallest size classes and being more dominated by large corals. Surprisingly these findings suggest that some corals recruit and establish better in seaweed dominated habitats while survival is promoted on the vertical sections of the reef, where there is no direct competition with large seaweeds.

Key words: coral population and community, high-latitude corals, temperate reefs, coral-algal competition, habitat preference

Phenological decoupling of mortality from wave forcing promotes population equilibrium in kelp beds

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Kelps live in a harsh hydrodynamic environment where wave-driven dislodgement of individuals is an important ecological process which can alter the biodiversity and functioning of reef systems, and increase production in coastal ecosystems adjacent to reefs. The current paradigm is that winter storms tear kelps from reefs once hydrodynamic forces exceed attachment or tissue strength - a threshold response which implies a pulsed relationship between wave forces and dislodgement, increasing in times of peak storm activity. Here, we challenge this understanding by showing how kelp phenology can decouple susceptibility to dislodgement from seasonal patterns in wave forces. We measured kelp dislodgement rates and hydrodynamic forces at 9 subtidal reefs over 2 years. Contrary to expectation, we found relatively low and constant dislodgement rates for all reefs (mean per season ± SD, 13% ± 6) in spite of a strong temporal pattern in wave-action and extreme water velocities (winter peaks up to 3 - 4 m s^{-1}). A biomechanical model, based on the balance between kelp attachment strength and hydrodynamic drag forces, demonstrated that severe reduction in individual kelp size towards winter (> 50% decrease in biomass for all sites) minimized drag forces and made the kelps less susceptible to peak flow during winter storms, allowing individuals to survive storm velocities over 3 - 4 m s^{-1}. We conclude that the timing of reduced susceptibility to disturbance, through the seasonal reduction of individual kelp biomass that coincides with times of peak flows is critical to the dynamics of kelp dislodgement and survival. We propose that phenological processes maintain many kelp beds in a higher degree of population stability and equilibrium with hydrodynamic forces than previously believed.

Key words: Physical disturbance, stress, survival, foundation species, biomechanical model

Seasonal variations of primary production and respiration of two rocky-shore communities dominated by canopy-forming algae, *Fucus vesiculosus* and *Fucus serratus*

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Canopy-forming algae are considered as ecosystem-engineer species as they structure their community and modify the abiotic conditions. *Fucus vesiculosus* (Linnaeus, 1753) and *Fucus serratus* (Linnaeus, 1753) characterize respectively the mid-intertidal and the lower mid-intertidal zones of the Atlantic rocky coasts and are among harvested species. The productivity of such algae has long ago been shown to be important but still needs to be specified at the community scale all over a year. Using a benthic chamber coupled to a CO_2 infrared gas analyser, in situ measurements of net community primary production and community respiration (CR) were carried out monthly under emersion periods on the two communities dominated by these canopy-forming algae. Measurements were first performed on the whole community and then after the removal of the canopy. This survey showed high gross primary production (*F. vesiculosus*: from 206 ± 18 to 1001 ± 208 mgC m^{-2} h^{-1} ; *F. serratus*: from 182 ± 36 to 1173 ± 111 mgC m^{-2} h^{-1}) and respiration (*F. vesiculosus*: from 102 ± 14 to 589 ± 128 mgC m^{-2} h^{-1}; *F. serratus*: from 60 ± 5 to 491 ± 68 mgC m^{-2} h^{-1}) values for the whole communities. Both canopies largely dominated the benthic metabolism of each zone confirming that these macroalgae act as major supplier of organic carbon to marine food webs. A seasonal pattern was also demonstrated, confirming the control of metabolism by light and temperature. No CR differences were found between the two communities whereas gross community production (mgC m^{-2} h^{-1}) and productivity (mgC g_{DW}^{-1} h^{-1}) were higher for the *F. serratus* community. This probably indicates better photosynthesis efficiency under emersion periods for the lower shore community.

Key words: Phaeophyceae, carbon fluxes, Brittany shore

How increased suspended sediment impacts on benthic suspension-feeders: a structural and functional approach.

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Increased suspended sediment in the water column has the potential to significantly impact marine environments through increases in turbidity, light attenuation, smothering of the benthos and changes in food resources. Due to their relative immobility, suspension-feeders are likely to be negatively impacted by increased sedimentation through coastal development such as land use, road building, logging, mining and dredging… For the same reason they are assumed to be good candidates to indicate changes in ecosystem functioning. This project aims to understand the mechanisms through which increased suspended sediment can impact suspension-feeder assemblages and their key functions in the ecosystem. The poster will outline the structural and functional diversity of the suspension-feeder assemblages along a gradient of suspended sediment concentration. In addition, impact of increased suspended sediment on the feeding activity and plasticity of the suspension-feeders will be examined in order to evaluate the functional consequences for the ecosystem trophic web. For this project, I am using stable isotopes and flow cytometry analysis to understand feeding ecology of suspension-feeders. Stable isotopes analysis are not only used to trace C and N pathways or determine contributions of food sources. But I am also trying to develop new approaches coupling these results with flow cytometry analysis to better understand how co-occurring suspension-feeders species can share or not their food and if suspended sediments could affect these processes. The poster summarises the mechanisms of impact, clarifies the pressure/response relationships between suspended sediments and suspension-feeders and outlines the approaches being used to understand how shallow marine ecosystems could be affected.

Key words: Stable isotopes, Flow cytometry, Trophic plasticity, Suspension-feeders, Suspended sediments.

The big picture: imaging and mapping intertidal rocky shores with a remotely piloted aircraft *

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The basic methods for sampling rocky shore communities have not changed for many decades. Most surveys are variations on transect-based and/or stratified random sampling of quadrats whose scales and spatial arrangement are determined by the capabilities of the observer. The primary goal is to provide estimates of abundance of assessed species that are representative of the whole shore, based on statistical assumptions. Here I present the results of an alternative approach using multiple images taken by a camera mounted on a low-flying remotely piloted aircraft, flying a pre-programmed flight path. Three locations in the Outer Hebrides were surveyed in June 2013 as part of the pre-deployment phase of a study to assess the effects of an array of nearshore wave-energy extraction devices. Ground-based low-tide surveys were made using categorical abundance and quadrat-based estimation of abundance of conspicuous cover-forming species. Overflights were made at the same time using a 1.5m-wingspan Quest 200 UAV at 30m altitude, equipped with a Panasonic LX5 camera taking images every 2s. Flights lasted up to 25 minutes and returned 150-200 overlapping GPS-located images of the target area. Photogrammetry software allowed the production of ortho-photographs and digital elevation models (DEMs) of areas extending 400-700m along the coast and 70-100m from low to high shore. The orthophotos and DEMs had resolution of 1.5cm and 5cm respectively. This resolution showed individual fucoid plants and other macroalgae, notably *Enteromorpha intestinalis*, and the quality of the images permitted the distinction between areas dominated by newly settled and older barnacles (mostly *Semibalanus balanoides*). Supervised pixel classification on downscaled (5-cm) images gave moderately successful recognition of six types of substratum cover. The results of the aerial and ground-based surveys were compared, and the relative merits of each were assessed. Aerial methods are not likely to replace ground surveys soon, but they allow scaling up from quadrat-based estimates with an unprecedented level of confidence, and are likely to play an increasingly important role in the development of rocky shore ecology in the 21st century.

Key words: aerial photography, mapping, rocky shores, wave energy

Harnessing the power of online citizen science to assess 30 years of satellite derived giant kelp abundance at a global scale

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Citizen science is fast becoming a way to acquire large amounts of data from imagery datasets that confound computer processing. We demonstrate its application to a novel 30-year dataset of giant kelp canopy cover around the globe. Information about global patterns of change in abundance of kelps in nearshore ecosystems is limited due to the logistical difficulties of large-scale subtidal scuba sampling. While aerial and satellite methods provide one solution, the resulting images typically defy easy classification by computers, and require detailed evaluation by people. While this is practical for observing areas at the sub-regional scales for a handful of years, it does not scale to global datasets over longer time periods. Here we present collaboration between our group and the citizen science organization Zooniverse. Zooniverse (http://zooniverse.org) is a public science group based out of the Adler planetarium that specializes in crowdsourcing the extraction of data from large sets of images (e.g. galaxy images from the Sloan Digital Sky Survey, historic handwritten ship logs, or benthic photos from deep-sea submersibles). We are developing a project to involve citizen scientists in the gathering of canopy cover of giant kelp (*Macrocystis pyrifera*) around the globe from Landsat satellite imagery collected from 1984-2014. We show both the practical data gathering interface – going from geotiffs of satellite imagery to data for analysis - as well as our extensive outreach program to engage and involve interested citizen scientists.

Key words: crowdsourcing, remote sensing

Influence of natural habitat fragmentation on barnacles and gastropods populations from subtropical rocky shores

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We investigated the influence of natural habitat fragmentation on the structure of animal macrobenthic community on intertidal rocky shores from south-eastern Brazil, focusing on abundance and body size patterns of barnacles and gastropods populations. These parameters were compared between boulders with different geomorphologies (WSL, boulders connected to land and with supralittoral level; and NSL, boulders isolated and with no suprallitoral level) on two rocky shores (Enseada and Lamberto). In addition, we described the vertical distribution patterns in these different boulders and shores. The abundance of animals varied significantly according to the spatial small-scale heterogeneity. We identified a trend of habitat fragmentation influence upon abundance of the limpet *Collisella subrugosa* and barnacle *Chthamalus bisinuatus*. Except the *C. bisinuatus* at the rocky shore from Enseada, all other species had larger body size in isolated boulders (NSL). Habitat fragmentation has emerged as an important factor influencing ecological patterns of barnacles and gastropods populations on subtropical sheltered rocky shores.

Keywords**:** Ecological patterns, landscape ecology, population ecology

Epifaunal colonisation under the Busselton Jetty: Influence of substrate and light on epifaunal community structure

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As large scale developments become more common in our coastal waters it becomes imperative to understand the effect these structures may have on the surrounding marine life.

These urban structures have the potential to work favourably in our coastal waters by behaving as artificial habitats for local marine life. Retired jetties and piers often become local attractions due to the diverse array of marine life that thrive in the protected and complex environment they provide; the Busselton Jetty is no exception. In 2011, six years after a fire destroyed part of the wood piled jetty, reconstruction was completed with the addition of the first steel piles ever to be driven at the Jetty.

With these new steel piles an opportunity arose to determine if colonisation and community structure differed depending on substrate and light availability. Sample groups were dependant on substrate type and location – either underneath the jetty where shading occurred or on the east side of the jetty where light availability was higher. An experiment was carried out over the course of twelve months utilising scrape samples of invertebrates and monthly photo monitoring to determine any differences in the stages of succession or community structure.

In both steel and wood sample groups analysis revealed no differences between high light and lower light conditions (Wood: ANOSIM, R= 0.027, P= 1.9, Steel: ANOSIM, R = 0.048, P = 0.98). This trend carries on when comparing overall Wood and Steel sample groups. Both substrate types were dominated by turf algae and the Blue Ascidian *Clavelina moluccensis.* Slightly higher amounts of *Clavelina moluccensis* and the purple bryozoan (*Celleporaria fusca)* were found on the wood sample groups.

Invertebrate scrape samples were dominated by Tanaidacea, Amphipods and Polycheates with these three groups making up over 60% of the individual abundance. Tanaidacea and Ophelid Polycheates were found in slightly higher numbers on steel piles however ANOSIM analysis revealed similar species composition for both wood and steel piles (ANOSIM, R=0.198, P=.01). Similarly, the effect of light appeared to have minimal effect on species composition (ANOSIM, R=0.064, P=0.02).

Key words: Fouling, Biofouling, Colonisation, Artificial habitat

Marine urban sprawl: how can ecology inform the design of multifunctional artificial structures.

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Underwater cities have long been the subject of science fiction novels, but the 'urban sprawl' of artificial structures from terrestrial to marine environments is becoming a reality. Development is accelerating as a result of expansion of coastal cities, greater threats from climate change, storm surges and sea level rise, and renewable energy production, which is one of the fastest growing industries on the seafloor. The notion of combining ecological principles with the planning, design and operation of marine urban infrastructure is rather new, yet examples of successful engineering applications are increasing. Here we review the emerging research on ecological engineering to explore whether and how it builds on ecological principles and knowledge. We select two case studies to discuss marine infrastructure planning in practice. We also provide a conceptual framework for the design of multifunctional coastal infrastructures to reduce their ecological footprint and maintain vital ecosystem services.

Key words: artificial structures, rocky reef, marina, offshore energy platforms.

Combined effects of temperature, light, and nutrient conditions on phlorotannin production of juvenile kelp, *Eisenia bicyclis*

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Although global warming is predicted to affect plant-herbivore interactions, little is known about the effect of temperature on marine plant secondary chemistry and how these effects may impact plant-herbivore interactions. In the present study, culture experiments were conducted with juveniles of the brown alga *Eisenia bicyclis* to test the combined effects of temperatures (23 and 26ºC: summer temperature at the northern and southern limits of the distributional range in this species), light conditions (180 and 20 μE/m^2/s: light levels at the upper and lower depth limits), and nutrient conditions (seawater enriched with 25 % PESI medium and non-enriched seawater) on the concentration and production rate of phlorotannins (defensive compounds of brown algae). There were no significant effects of temperature, light condition, or nutrient condition on phlorotannin concentration of the cultured thalli. However, phlorotannin production rates calculated as % changes of phlorotannin contents between initial and cultured thalli were affected significantly by temperature and light condition, although nutrient condition had no significant effect. The phlorotannin production rates decreased with increased temperature and decreased light level. These results suggest that the juveniles recruited at the lower depth limit might be more susceptible to herbivory than those at the upper depth limit, and recent warming trends may weaken the anti-herbivore defense in this species.

Key words: Climate change, Plant-animal interaction, Anti-herbivore defense, Secondary metabolite, Habitat-forming macroalgae.

Susceptibility and resilience of coral genera on high latitudinal coral reef systems to marine heatwave events.

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The Houtman Abrolhos Islands (Abrolhos) are the southernmost true coral reef system in the Indian Ocean and one of the highest latitude reefs in the world. The Abrolhos is both ecological and economically important, supporting a unique and diverse blend of tropical and temperate marine species as well as commercial fisheries (i.e. western rock lobster) and eco-tourism. The benthic composition of the Abrolhos reef systems, based on data collected from ten long-term monitoring sites, shows the dominant benthic habitats are highly variable, with hard coral cover varying between 20–60% and macro algae varying between 0.5– 50%, demonstrating the unique balancing act of this reef in the temperate / tropical transitional zone. The corals of the Abrolhos are also diverse for its high latitudinal location, with a total of 184 species recorded, only 13 species less than recorded for Ningaloo In 2011 a significant la Niña event produced anomalous conditions along the whole Western Australian coastline, producing the first-ever widespread bleaching event at the Abrolhos. Using the in-situ temperature data and the results of coral cover surveys at the long term monitoring sites at the Abrolhos in 2010 and 2012 we examine the susceptibility and resilience of coral genera at the Abrolhos to influences of increased water temperature. The results are critically important for effective management of this high latitude coral reef at the edge of its distribution.

Key words: bleaching, susceptibility, resilience

Conservation of limpet populations: a heavily exploited resource in Azores, NE-Atlantic

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Limpet harvesting in Azores (NE Atlantic) has been taking place probably since the islands were first colonized in the XV century. Limpet species are highly exploited and populations from most islands have declined steadily bringing about catastrophic effects on coastal communities. Despite their economic importance limpets are also ecologically key species and require prioritizing conservation strategies. Patellid limpets are broadcast spawners which go through a planktonic larval stage in their life cycle. They are benthic as adults and the larva is the only phase during their life-cycle which has the ability to disperse over assumed large spatial distances. However, there is now mounting evidence that gene flow between islands and mainlands can be low, even for species with a relatively long planktonic larval stage. Low levels of larval exchange may thus limit the success of conservation objectives expected upon migration and recruitment. In dispersive isolated oceanic islands such as the Macaronesian Islands, the Azores Archipelago in particular, is not clear whether limpet populations from different islands form a single meta-population or, in contrast, populations on each island are isolated from the rest. Knowledge on this scenario is crucial for the management and conservation of exploited populations of limpets. Here we have developed and described species-specific multiplexed microsatellite markers for the limpets *Patella candei* and *Patella aspera* using whole genome shotgun 454 sequencing. These genetic tools have allowed the study of the population genetic structure and evolutionary history of patellid species in the archipelago of Azores. Genetic studies, alongside with biological, ecological and oceanographic information, represent an important contribution for the understanding of population dynamics by allowing testing hypothesis about larval dispersal patterns, recruitment and life history traits, population connectivity, genetic diversity, and population equilibrium.

Key words: Gene flow, fisheries overexploitation, insular genetic disruption, marine ecosystems

EuroNads: the effect of recent warming and extreme weather events on limpet reproductive phenology across Atlantic Europe

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The climate-warming trend in northwest Europe has been punctuated by periods of extreme warming and cooling. Patellid limpets are key species on rocky shores controlling the distribution of macroalgae by their grazing activity. Recently, Moore et al. (2010, GCB) documented changes in the reproductive phenology of *Patella vulgata* and *Patella depressa* in relation to recent warming in response to global climate change. Little is known about how phenology will change in response to extreme weather events, or how phenology varies throughout the geographic range. Using a combination of historic and contemporary data, collected from 15 locations across Atlantic Europe (Norway to Portugal), the EuroNads team investigated the effect of recent climate warming and extreme weather events on the reproductive phenology of four con-specific intertidal limpet grazers, with cool/boreal and warm/lusitanian centres of distribution. We present the preliminary data from a subset of the locations.

Key words: biogeography, cold wave, broad-scale, long-term

Facing the heat: does body orientation reduce desiccation and thermal stress in limpets?

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The abundance, distribution and behaviour of intertidal organisms have traditionally been attributed as a response to physical conditions such as wave forces and thermal stresses and these stressors are predicted to increase with climate change. More recent work has shown that interactions between organisms and settlement and recruitment processes are equally important in determining distribution patterns. Patterns of orientation of intertidal animals are relatively understudied compared to patterns of distribution and abundance at a larger spatial scale but explanatory models based on organism responses to physical forces still predominate in the literature. Small-scale behaviours have the potential to ameliorate desiccation and thermal stress and reduce the impact of climate change. In order to make accurate predictions about the future, we need to examine links between fundamental small-scale behaviours, such as orientation, and the physiological processes behind them. We aimed to determine if there is a relationship between the head orientation of the intertidal limpet *Cellana tramoserica* on steeply sloped, rocky surfaces (> 60º to the vertical) and desiccation or thermal stress. Across multiple sites and times, limpets were collected prior to immersion and their haemolymph extracted and analysed to quantify their level of desiccation stress. To test for a causal link between desiccation and orientation, limpets were rotated to alter their orientation and haemolymph osmolality was compared between differently orientated individuals. Thermal stress was assessed through the use of a thermal imaging camera and biomimetic limpet models positioned in different orientations. No link was found between the direction an individual limpet faces and either how desiccated that individual is or their body temperature. These results add to the growing knowledge that responses to desiccation and thermal stress may be less important than early researchers supposed.

Key words: gastropod, grazer, microhabitat, spatial positioning

Biology of the harlequin fish *Othos dentex* (Serranidae), with particular emphasis on sexual pattern and other reproductive characteristics

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Key biological characteristics of the harlequin fish *Othos dentex*, a representative of a monospecific genus of the Anthiinae (Serranidae), were determined from samples collected from around temperate reefs on the south coast of Western Australia. Females of this relatively long-lived species attained only a slightly greater maximum total length and age than males and neither the length nor age-frequency distributions showed a conspicuous sex-based bimodality. Furthermore, extensive histological examination of gonads demonstrated that they always comprised exclusively either ovarian or testicular tissue. Thus, *O. dentex* is a gonochorist, a sexual pattern only previously recorded definitively for one other anthiine serranid, i.e. *Epinephelides armatus*, which also occurs in south-western Australia. Like *E. armatus*, *O. dentex* possesses "solid" testes with a central sperm duct, thereby differing in structure from those typically found in serranids, in which there is a central membrane-bound 'ovarian' lumen and peripherally-located sperm sinuses. The gonadal characteristics and sexual pattern of these two gonochoristic anthiines are difficult to reconcile with a recent proposal for trends in the evolution of gonochorism and protogyny among the Serranidae. *Othos dentex* has indeterminate fecundity and a protracted spawning period (7 months). In the context of reproduction, the large spots on the lower half of the body of *O. dentex* have been shown to be similarly yellow in juveniles and adult females, but then become blue in males at maturity and intensify during the spawning period, and may play an important role in courtship interactions. As with several other co-occurring fish species, *O. dentex* matures at a relatively young age, which may reflect selection pressures for rapid early growth in response to high mortality among juveniles in reefs on the south coast of Western Australia. In contrast, total mortality is relatively low during later life, implying that, currently, fishing pressure on *O. dentex* is relatively light.

Key Words: Anthiinae, gonadal characteristics, gonochorism, sexual dichromatism, reproduction, longevity.

Destructive grazing on seaweed beds by herbivorous fish in Japan

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Herbivorous fish (HB) has been eaten in Japan for more than a thousand year as recorded in relics from kitchen middens. Destructive grazing by HB has been frequently reported from southern to central Japan since 1980's though the first record appeared in Kyushu as early as 1708. The loss of blades in *Eisenia* and *Ecklonia*, shortening to disappearance of *Zostera*, *Sargassum* (including intertidal species *S. fusiforme*) and erect fleshy red algae are attributed to their grazing. Seasonal loss of canopy and disappearance of seaweed beds seem to be the common symptoms in the seascape and resulted in the reduction of commercial fish, shellfish (abalone, lobster) and seaweeds. Four species, *Siganus fuscescens*, *Calotomus japonicus*, *Kyphosus bigibbus* and *Prionurus scalprum* are said to be effective on the algal vegetation. Among them, *S. fuscescens* has been found below 41°N; its destructive grazing on seaweeds has been known up to 38°N. Analysis of its catch data in Wakasa Bay in the Sea of Japan coast revealed the increase in autumn but the catch is highly dependent on water temperature. In southern Japan, mass mortality has been known in colder winters. Therefore, the most popular idea to explain the recent increase and/or activation of HB is the elevation of water temperature. However, extension of artificial coast (up to 40 % of national coast), building of artificial reefs (i.e., increase of habitat), decrease of wild seaweed/seagrass beds and seaweed culture, weakening of top down control (i.e., reduction of predatory fish and shellfish), changes in commercial circulation (including discard of herbivorous fish) and increase of warm waste from power plants should be examined. As a part of coastal management, utilization is promoted to enhance the catch of HB, but only enclosure or caging of limited areas is the effective way to restore and maintain seaweed beds.

A low-cost, versatile data logging system for ecological applications

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In the last decades, numerous studies looking at the relation between climatic patterns and physiological performance, meta-population structure and biogeographic shifts have relied on remote-sensed, large-scale climatic data. In many cases, however, there is a mismatch between the scale of the coarse climatic data and the environmental conditions actually perceived by the studied organisms. Therefore, there is the need for autonomous devices capable of collecting high-resolution, in situ data, during weeks, months or even years. Nonetheless, and despite recent advances in technology, these so-called data loggers still offer major challenges to researchers. One of the major drawbacks of deploying a network of data loggers is their individual price, which can actually limit the number of units deployed and consequently lead to less consistent data sets. Moreover, their hardware generally lacks customization options and their software has only a limited number of definable parameters. In this work, we introduce a new lightweight, small and modular data logger design that can be used to record a vast array of environmental and physiological parameters in the field or in the laboratory. The device is based on the open-source platform Arduino and its assemblage does not require extensive electronics knowledge. It can be built spending under $100 in parts, while most commercially available scientific loggers are at least one or two order of magnitude more expensive. The low price tag and versatility of the device can thus contribute to build networks of environmental loggers to monitor multiple parameters across large geographical scales.

Why live alone: Do sexually selected traits influence the spatial distribution and local population structure of amphipods?

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One of the greatest challenges in marine dispersing organisms is finding conspecifics to maximize chances of reproductive success. As settlement occurs, the number of individuals in an area increases, often resulting in more mating opportunities due to greater numbers of recruited individuals to a locality. Higher density may come at a cost via increased competition for resources (i.e., food, mates or space) where traits associated with better resource acquisition are selected for. Resource availability may differ depending on whether individuals are colonizing semi-permanently or aggregating temporarily, and the survival of some individuals may depend on their ability to gain indirect access to resources. For colonizing individuals, group-living has the potential to develop; however, it may only occur if the benefits of living within a group outweigh the costs of living alone. This cost/benefit ratio suggests that there may be a threshold where it is no longer beneficial to aggregate resulting in some individuals settling further away from existing colonies. We examined distributions of *Erichthonius* sp. to determine which traits influence colonization and how group-living influences local population structure. Crustaceans are well known for their sexually dimorphic traits and male-male competition, and prior research has shown that male *Erichthonius* sp. exhibit variation in claw size and colonization behaviour. We hypothesized that spatial distributions of amphipods would be most influenced by sexually selected traits and that aggressive, large-clawed males and females with high fecundity would occur more frequently in larger colonies. Settlement tiles were placed into the field and individuals within a tile were considered a local population. We observed the location and number of individuals colonized and measured traits of each individual (e.g., size, sex, fecundity, and aggression). By understanding the mechanism(s) driving amphipod colonization, we can begin to examine the effects of aggregation differences on ecological and evolutionary processes.

Horse mussel reef (*Modiolus modiolus*): an essential habitat for fish and shellfish

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Essential Fish Habitats (EFH) are areas of the seabed necessary for spawning, feeding or growth to maturity. Identifying and prioritising EFH for protection can help to sustain healthy fish stocks and provide food for an ever-growing human population. Horse mussels (*Modiolus modiolus*) are ecosystem engineers, and enhance biodiversity by providing a hard substratum for epifauna, and deposition of fine sediment supports a rich infaunal community. *M. modiolus* can occur in high densities to create biogenic reefs, which are recognised for their biodiversity conservation importance. However, very little is known about the functional role of these habitats in the ecosystem. The aim of this study was to investigate if *M. modiolus* reefs are Essential Fish Habitats. Baited traps and underwater visual censuses were used to measure the abundance of fish and shellfish on and off *M. modiolus* reefs. Stomach content analysis showed the relative importance of *M. modiolus* and the associated reef community in the diet of fish living on the reefs. By highlighting and quantifying the services provided by *M. modiolus* reefs in this experiment, we show the relative value of this type of biogenic reef habitat and discuss the benefits that they provide to society. Understanding habitat utilisation by commercially important fish species can provide the social mandate needed to support the protection of the most valuable areas of the seabed, and support sustainable use of marine resources.

Key words: Fisheries, habitat association, bivalve, marine protected areas.

Predicting larval dispersal using hydrodynamic models: Pattern-orientation in the absence of behavioural mechanisms

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Understanding the link between dispersal and demographic structure remains a fundamental challenge in population connectivity studies. Hydrodynamic models can be used to predict dispersal, but non-random vertical distribution patterns can decouple model estimates from patterns in nature. Simplified rules applied within a model in order to mimic non-random patterns have been used, but dispersal overestimates are common. Here, we test a novel alternative using two versions of a validated 3-dimensional passive hydrodynamic model, one that randomly simulates temporal variation in vertical distribution and another that incorporates field-based empirical observations of vertical distribution patterns to "pattern-orientate" the model. Significant reductions in dispersal distance in the structured model over the random model were revealed and a large proportion of larvae were retained short distances from their natal patch in high aggregations. Evidence suggests that the modification of a (random) physical model using pattern-orientation can generate realistic estimates of dispersal distance in lieu of complex descriptions of behavioural mechanisms.

Key words: modelling; *Mytilus edulis*; behaviour; passive; non-random distribution; dispersal kernel.

Sea urchin barrens in Western Australia: interplay of geological characteristics and prey preference by the western rock lobster *Panulirus cygnus*

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Benthic asssemblages on subtidal reefs in southwestern Australia are characterized by a high diversity and coverage of macroalgae and a relatively low abundance and diversity of invertebrate herbivores. Here, we present a synthesis of laboratory base prey preference experiments and field studies of benthic assemblage distribution patterns, including geological measures. It was found that large lobsters preferred crabs and mussels while medium and small lobsters preferred crabs over mussels, gastropods, and sea urchins. This suggests that strong predator-prey interactions between *P. cygnus* and crabs, but not sea urchins, may occur in the wild. Field studies on benthic assemblage distribution patterns varied at multiple spatial scales, but a weak, negative relationship between the abundance of sea urchins and the cover of kelp *Ecklonia radiata* was observed. The abundance of sea urchins was negatively related to the 'substrate cohesion strength' (a measure of limestone reef integrity), and weakly positively related to 'bioerosion' (a measure of fine scale limestone structure). Conversely, the percent cover of *E. radiata* was positively related to substrate cohesion strength, while the cover of *Sargassum* spp. was negatively related to fetch. Our results indicate that the distributions of key benthic organisms in temperate WA exhibit considerable spatial variability that may be driven, at least in part, by the physical structure of limestone reefs rather than through any biological interactions.

The coupling between phytoplankton production and zooplankton grazing: An experimental study in brackish coastal shallow water areas.

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Phytoplankton primary production forms the basis of the marine pelagic ecosystem's food web wherein zooplankton is an essential link between phytoplankton and higher trophic levels. The grazing rates of zooplankton are expected to largely depend on primary production. There have been surprisingly few in situ experiments that quantified both phytoplankton primary production and zooplankton grazing on phytoplankton. Consequently, many contemporary ecosystem models (e.g. EcoPath) are still solely based on either modelled data or laboratory measurements on single species. In this study, we experimentally evaluated the coupling between phytoplankton production and zooplankton grazing in three near coastal hard bottom embayments of the brackish Baltic Sea. Using a boosted regression trees modelling, we (1) quantified the functional form of the production-grazing relationship and (2) assessed how changes in water temperature, water currents, nutrient levels and phytoplankton biomass modulate the production-grazing relationship. The study showed that zooplankton grazing was primarily a function of phytoplankton production. Within the measured ranges of natural variability the grazing values increased linearly without any indication of food saturation. The grazing rates were almost equal to phytoplankton production values. Such a strong generic relationship was almost independent of ambient abiotic environmental variables and the composition of phytoplankton communities. This suggests that the studied coastal zooplankton communities are strongly food limited and practically all phytoplankton production is channelled to zooplankton grazing. The presence of a generic production-grazing relationship enables modelling of zooplankton grazing without any prior knowledge on the stock size and species composition of zooplankton.

Key words: phytoplankton production, microzooplankton, mesozooplankton, grazing, brackish water, Baltic Sea

Reproductive phenology of *Macrocystis pyrifera* (Laminariales, Phaeophyceae) in relation to wave-exposure.

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The reproductive patterns of *Macrocystis pyrifera* are strikingly different in the Northern and Southern hemispheres. In California, USA, *M. pyrifera* reproduces throughout the year, irrespective of wave-exposure. In northern Chile, in both wave-sheltered and exposed locations, it has a seasonal reproductive pattern in winter; in southern Chile, wave-exposed populations have continuous reproduction whereas in wave-protected sites the reproductive season is restricted to summer. The objective of this study was to determine the seasonal reproductive pattern of *M. pyrifera* in wave-sheltered and wave-exposed sites in southeastern New Zealand. This study was conducted from spring 2012 to winter 2013 in four sites: two wave-sheltered (Hamilton Bay and Macandrew Bay), and two wave-exposed (Karitane and Shag Point). From ten sporophytes, the total number and size of sporophylls, sorus area, spore release and 3-day-germination were measured. Statistically significant differences were found among the factors wave-exposure, season and site: (1) the number and size of sporophylls, sorus area, spore release and germination rate were higher in wave-sheltered populations; (2) sporophyll number, sorus area and spore release decreased from spring to winter, germination rate increased and sporophyll size was stable, except in one wave-sheltered site where it increased in autumn and winter; (3) three populations had fertile sporophylls (with sori) and viable spores (swimming spores and subsequent germination) during each of the four seasons, but in Shag Point *M. pyrifera* had infertile sporophylls (without sorus) in autumn and no sporophytes were found in that sampling area in winter. Similar to southern Chile, results of this study support the idea that the reproductive pattern of *M. pyrifera* is modulated by wave-exposure in the Southern hemisphere but the spore viability (germination rate) of each population is independent to the wave-exposure.

Key words: germination, seasonality, spores, sporophylls, sorus, viability

Environmental correlates of isotopic variation in primary producers and consumers within a temperate coastal ecosystem

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Stable isotope analysis is becoming a vital tool in determining the structure and functioning of marine ecosystems, and the development of management approaches at the ecosystem level. This is due to their ability to provide a time-integrated tracer of trophic interactions, environmental gradients, and carbon and nitrogen biogeochemical cycles. In most ecological applications, an essential step requires accurate measurements of isotopic ratios in organisms at or near the base of the food web, which act as basal reference points from which the isotopic data in higher trophic animals can be calibrated. Yet isotopic signatures at the base of the food web, particularly primary producers, reflect their surrounding biogeochemistry, which in temperate coastal systems is highly variable over space and time. Using temperate coastal reefs of SW Western Australia, a region that hosts one of the most bio-diverse and endemic marine biota in the world, we will present initial results of our study, firstly describing how isotopic ratios of "basal" organisms (e.g. primary producers) and consumers vary over space and time. These organisms include three species of algae, with genera common to temperate reefs globally, and invertebrates, including grazers and suspension feeders. Secondly, we present how these isotopic ratios relate to a suite of biogeochemical variables. Consequently, in the context of temperate coastal environments, we hope to provide a reference for deciphering accurate measurements of trophic position, the determination of appropriate sampling scale for food web research, and project the potential effect of different biogeochemical conditions on basal isotopic ratios.

Key words: Stable isotopes, spatial variation, temporal variation, trophic baselines, environmental correlates.

How far is too south? Larval connectivity at Western Australia's most southern coral reef

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Seawater temperatures along the Western Australian (WA) coastline has been above seasonal averages for the past 3 summers, with the 2010/2011 summer reported to be the warmest on record. These elevated sea temperatures have resulted in species range extensions, fish kills, kelp retractions, and significant coral bleaching being recorded, including the first recorded coral bleaching at the Houtman Abrolhos Islands (HAI). At a latitude of between 28°16'S and 29°00'S the HAI is the most southerly true coral reef in the Indian Ocean and supports a diverse tropical/temperate community, however the high latitude also raises interesting questions about the supply of recruits to this unique environment. For corals, it has been hypothesised that the supply of recruits would come from tropical northern reefs, but unlike the well-connected reefs of the East Australian coast, many WA reefs are relatively isolated by distance. As such, the recent warm water intrusions and coral bleaching on the WA coast raise important questions about the maintenance and recovery of coral populations at the HAI. Using simulations based on drift time from northern coral populations and published competency periods for coral larvae, we show that the coral populations at the HAI are likely largely driven by self-seeding from the local populations, with limited input from northern source-populations. Preliminary modelling suggests a dispersal time of between 100-160 days for larvae to reach the HAI, exceeding the known maximum coral larvae survival periods for species. Given the recent elevated sea temperatures and the predicted climate driven changes on the WA coastline. The low connectivity to northern reef sources suggested in the present study is likely to limit future recovery potential of the reef system due to the loss of local coral populations and thus local input of new recruits to the reef system, particularly if the frequency of bleaching events increases as predicted.

Key words: Dispersal, Heat wave, Climate Change, Bleaching, Resilience

Impact of construction of offshore wind farms on the structure of benthic communities of reef habitats in NE Baltic Sea.

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Construction of offshore wind farms in the NE Baltic Sea has been on the agenda for almost decade. Predicting environmental impacts of these large scale construction activities has been a challenge because the uniqueness of the marine environment in the Baltic Sea. Low seawater salinity, low water temperature, effects of sea ice, low biological diversity of both pelagic and benthic communities contribute to the complexness of the assessment. Shallow, hard bottom reef areas have attracted interest of developers of offshore wind energy in NE Baltic Sea. We have studied possible impact of large scale construction activities and introduction of new, manmade hard substrate on local benthic communities of Baltic shallow reef habitat. Long-term (2008-2012) benthic recolonisation experiments on shallow limestone reef of Neugrund demonstrated both short term and long term effects of mechanical disturbance of seafloor communities at several depths in the photic zone. Dynamics of recovery of disturbed hard bottom communities was different in different depth zones. Shallowest treatments showed short recovery period (up to one vegetation period/year) while deeper experimental plots showed difference from undisturbed communities even after four year observation. Colonisation experiments of new, manmade substrate performed in the northern part of Gulf of Riga using the foundation of wind measuring station showed that the colonisation processes are relatively fast and the structure of pioneer community depends on the timing of exposure of new substrate. Preliminary results show that effect of mechanical damage of native hard bottom communities and introduction of new manmade substrate can significantly alter the natural structure and dynamics of hard bottom reef communities in the NE Baltic Sea and the magnitude of environmental impact of construction of wind parks on hard bottom habitat should be carefully considered before licensing.

Key words: fouling communities, EIA.

Foraging movements of the herbivorous starfish *Parvulastra exigua*

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Starfish movements are usually associated with foraging, in which factors such as food availability and weather/waves may affect movement and foraging times. These patterns, however, were determined from studies on predatory and/or deposit-feeding starfish; much less is known about the feeding ecology of herbivorous starfish. We aimed to evaluate the foraging movements of the intertidal starfish *Parvulastra* (*Patiriella*) *exigua*. Many intertidal organisms, notably limpets, 'home' in that they return to their starting location after foraging. Homing in echinoderms is poorly understood, but this behaviour has been observed for the urchin *Diadema antillarum*, which returns to a known refuge. Homing usually benefits animals by decreasing the chances of dying due to competition for resources, shortage of food and predation. For any of the benefits to accrue to a population, we first must demonstrate that homing occurs. We quantified the foraging movements of the herbivorous starfish *P. exigua* between rock pools and emergent rocks to test the following models: 1) Individuals of *P. exigua* that forage around rock pools are starfish that inhabit rock pools; 2) Individuals that move outside of rock pools to feed during high tide return to the original site after foraging; 3) the fidelity of *P. exigua* to return to an original rock pool is positively correlated with the cover of biofilm available within the rock pool; 4) the distance displaced by the starfish from a rock pool will be negatively correlated with the cover of biofilm available within the rock pool. The results, for the first time, indicated the extent to which *P. exigua* show site fidelity to a particular pool; this is critical for quantification of the extent to which starfish are able to interact with other grazers.

Key words: Feeding behaviour, herbivore, grazing, sea star, intertidal habitats

Role of scavenging on growth, behaviour, and reproductive output of the common periwinkle (*Littorina littorea*)

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The effects of omnivory on population ecology are rarely studied, although scavenging can be expected in species that are obligated herbivorous to supplement dietary needs for improving their fitness and/or performance. In one field and two laboratory experiments scavenging effects on growth and reproductive success (mating frequency, daily number of eggs per female, hatching rate) of and the attraction to carrion were investigated for the intertidal herbivorous periwinkle *Littorina littorea*. In the field, *M. edulis* with cut adductor muscles (= opened; representing carrion) were significantly more frequently contacted by *L. littorea* than either intact *M. edulis* or *Ulva lactuca*, with no significant differences in contact frequency between the latter two. In the laboratory, *L. littorea* that were exclusively offered opened *M. edulis* grew significantly less than conspecifics that were either offered *U. lactuca* alone or that were kept on a mixed diet (= opened mussel and *U. lactuca*). Regarding reproductive output, *L. littorea* produced fewer eggs when offered opened *M. edulis* than conspecifics that were either kept on a mixed diet or exclusively on an *U*. *lactuca* diet. Mating frequency and hatching success of eggs was not significantly different between *L. littorea* kept on the three diets. Our results confirm a NW Atlantic study showing that *L. littorea* was attracted to carrion. Yet, missing significant differences in growth and reproductive output of periwinkles that were or were not allowed to scavenge (= mixed diet vs. exclusively *U. lactuca* fed) suggests neutral scavenging effects on periwinkle fitness and performance. Perhaps, scavenging by periwinkles could be important at higher levels of ecological organization, due to an increase in the frequency of interspecific interactions and/or a facilitated flow of energy and matter, all of which should add on stabilizing food web structure.

Key words: gastropods, trophic interactions, population dynamics

Linking adaptive morphological variation in a habitat-forming seaweed to critical environmental parameters

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Habitat-forming seaweed play an important role in temperate marine ecosystems because they create structurally complex habitats and support diverse and productive food webs. Tasmania is surrounded by a diverse coastline with distinctive physical and biological attributes and differing environmental parameters. We tested the hypothesis that the brown macroalga *Hormosira banksii*, one of the most important intertidal habitat-forming species in Tasmania, shows morphological differences at large and small spatial scales. We sampled *H. banksii* in 4 bioregions (100's of km) around Tasmania, at 3 different field sites (10's of km) within each bioregion and 2 different zones (10's of m; eulitoral and sublitoral). Thirty individuals were collected from each zone and 7 morphological variables measured. Multivariate patterns were analysed using PerMANOVA and multiple discriminant function analysis. Morphology varied across bioregions, sites within bioregions and even between zones. In particular, individuals from the north coast (Boags bioregion) showed a distinct morphology compared to other bioregions around Tasmania. Correlations between environmental parameters and morphology suggested that variable tidal parameters, major currents and nutrient availability on the north coast may have an impact on the morphology of *H. banksii* in Tasmania. In contrast to other studies, variable wave exposure was weakly correlated to the morphology of *H. banksii*. Our results suggest that environmental differences may be driving phenotypic variation but the role of genetic factors remains to be determined. Given the state's high vulnerability to projected climate change, it is important to understand the evolutionary response of marine habitat-forming species to improve their management in times of rapidly changing environments.

Key words: biogeographical scales, environmental change, phenotype, adaptation, hydrodynamic variability.

The effects of diet on the health of *Heliocidaris erythrogramma*

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In 2011, strong La Ninã conditions caused abnormally high temperatures along the coast of Western Australia for eight weeks. This resulted in substantial changes to seaweeds including a 100 km southward range contraction of the habitat forming fucoid, *Scytothalia dorycarpa* - which constitutes an important part of the diet for invertebrates such as sea urchins (*Heliocidaris erythrogramma*). This has the potential to have significant trophic impacts throughout the food web in the region. Research on the 2011 heatwave has so far focused on physical changes to the ecosystem. Here we take a different approach looking at potential trophic impacts. I will present preliminary results from a study aiming to investigate the fine scale trophic impacts of diet at the primary consumer level. This was done with a six week long feeding trial in which urchins were fed either by *S. dorycarpa*, *Ecklonia radiata* or *Hennedya crispa*. The health effects of diet were assessed using a gonadal index and weight change measurements. Sea urchin gonads have roles in nutrient storage as well as reproduction making them a strong proxy for the overall impact of diet.

Key words: herbivory, feeding preferences, sea urchins, trophic role, gonadal index

An industry-based approach to regional-scale monitoring of benthic ecosystems

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Knowledge of the relationships between exploited species and the habitats that support them is critical to effective fisheries management. However, the acquisition of the spatially explicit habitat information required is typically expensive. We describe a novel camera system capable of collecting geo-referenced oceanographic information including video of benthic habitats and demersal fish assemblages. The systems, based on inexpensive components and open-source software are fully programmable and capable of long deployment times (months). Low per unit costs and a small and robust design allow widespread deployment of multiple units and encourage diverse research applications. Within the Western Rock Lobster Fishery, camera units have been attached to the lobster pots of commercial fishers, with no added cost or interruption to their fishing operation. The combination of spatially specific catch data with fine scale habitat information has refined understanding of the influence of benthic habitats on lobster demographics. In addition, the collated habitat information will provide a map of the key habitats fishers operate in across the extent of the fishery. In addition to mapping habitat, these systems are capable of collecting a range of other important data including spatially specific environmental data (information on salinity, water temperature and depth) and the relative abundance / species composition of finfish in that area. This increased understanding of the way habitats influence the demographics of exploited species and continuous system of monitoring habitat changes will enhance the capacity of fisheries management to adapt to issues such as climate change. These technologies have far reaching applications across other areas of marine science.

Key words: remote technology, benthic assemblage, habitat mapping, demersal fish, spiny lobster, *Panulirus cygnus*, ecosystem based fisheries management.

The Lyme Bay experimental potting project

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In recent years, the impact of bottom-towed commercial fishing gear on the marine environment has been realised. In an attempt to mitigate habitat loss, Marine Protected Areas (MPAs) have been identified as tools for marine conservation. In 2008, in order to protect vulnerable and valuable temperate reef communities, a 200km^2 'Statutory Instrument' was designated within Lyme Bay, South-West England. As a result of excluding bottom-towed fishing, the inshore reefs have shown early signs of recovery (Attrill et al 2011). However as a result, the use of static fishing gear (pots, nets) has increased to a level that could potentially threaten reef recovery. This raised concerns of local fishermen who are keen to manage levels of static fishing for a sustainable future. The Lyme Bay experimental potting project is an innovative 3 year programme funded by Blue Marine Foundation, which aims to assess the impact of potting on seabed biodiversity and associated target species within the Lyme Bay MPA. This project is pioneering in both its methodology and its partnership between scientists and local fishermen. To develop a static gear management policy, the level of impact that potting has on seabed biodiversity and, in particular, targeted crabs and lobster populations has to be determined. By controlling the density of potting activity within experimental areas within the MPA (from no potting to high potting intensity) the project will determine a sustainable level of potting for this region. Fishermen from local ports are involved in designing and maintaining the project, as well as collecting data. Baited and towed video sampling is used to assess changes in benthic biodiversity and populations of associated mobile fauna. It is expected that our results will influence local management policy and potentially be replicated nationally. This project demonstrates successful collaborative science, a necessary approach for successful MPA success.

Key words: Citizen science, ecology, human impact, reserve, temperate

Comparison of sight, sound and scent attractants for pelagic fishes to remote mid-water video stations

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Patchily distributed taxa represent a significant challenge to adequately census. Near-shore pelagic fishes fit this description; as they are fast swimmers capable of avoiding conventional survey gear, occupy challenging habitats and display high spatial and temporal variation in their patterns of distribution. As a result little is known about the ecology of these fished species over seascape scales within coastal environments. To address this knowledge gap, baited remote underwater video stations (BRUVs) are becoming increasingly used to survey pelagic fishes. However, critical methodological questions, such as the importance of attractant type for these species remain unanswered. This study quantified the abundance of pelagic fishes using remote underwater video stations (RUVs) with 4 different attractant treatments (crushed pilchards, metallic reflectors, baitfish sound and a combination of all attractants) and a control with no attractant on the open coast of Jervis Bay Marine Park, Australia. We tested the hypothesis that the total abundance of pelagic fishes and the abundance of two pelagic fish species were dependent on attractant type. Univariate PERMANOVA detected significant effects of attractant type on the total abundance of pelagic fishes, primarily driven by the abundance of Yellowtail scad. A significant interaction between attractant type and oceanographic conditions was detected for Australian bonito. Attractant type had no effect on Yellowtail kingfish, however their abundance was significantly influenced by oceanographic conditions. In general, greater abundances of pelagic fishes were observed on RUVs containing all attractants and during periods of warm oceanic water. Additionally, Yellowtail scad, Australian bonito and Yellowtail kingfish displayed their highest detection rate on RUVs containing all attractants. Surprisingly bait alone was not an effective attractant. Our findings highlight the importance of attractant type and oceanographic conditions when surveying near-shore pelagic fishes with RUVs.

Regional extinctions and invaders' domination: an ecosystem phase-shift of Levant reefs

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Using past sporadic data and data from current (2009-2013) extensive surveys and a monitoring program along the entire Israeli coast I show that the previously Atlanto-Mediterranean dominated biota of the Levant rocky reefs (intertidal and subtidal) on the Israeli shore is going through recent major shifts in its biodiversity. Several ecologically-important species (a reef-building vermetid gastropod, sea urchins and a large predatory snail) exhibited major population collapses while several key taxonomic groups (gastropods and bivalves and to some extent fish) are completely dominated by IndoPacific invaders. I suggest that this biogeographic shift may be partly driven by global climate change. The southeastern coastal waters of the Mediterranean have warmed by 2-3 °C in the past 2 decades and may have become too hot for some indigenous species and more hospitable to tropical species. This means that the climatic envelope of the native species may have shrunk or shifted. Recent lab and field experiments indicate that the abundant sea urchin, Paracentrotus lividus, is indeed dying during peak summer SST on the Israeli coast, and its feeding and reproductive potential are reduced by invasive herbivorous fish. Performance curves (e.g., photosynthesis) of several still-abundant (mainly during colder months) native species show that their physiological activity is greatly reduced when exposed to peak and future summer temperatures. Clearly, the ecological implications of these species collapses and invasions, including their effects on ecosystem functions, must be profound and are currently studied.

Response and resistance to climate change: the role of temperature in controlling species distributions at multiple life stages.

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Species' distributions are frequently determined by temperature and thus species' range limits experience expansions and contractions as climate changes. Shifts in range limits are not always linear and rare climatic events can potentially counteract or exacerbate the effects of climate change on species' distributions. We assessed the effects of recent cold winters, which promote reproduction, and cold summers, which reduce mortality, on the southern range limits of the acorn barnacle, *Semibalanus balanoides*, in Southwest England. Additionally, we examined the historical frequency of such events to determine whether rare cold events could be responsible for observed historical and contemporary oscillations in the density and southern range limit of *S. balanoides*. We found the recent cold winters have led to a range expansion of *S. balanoides,* however, the frequency of such cold winters, which are necessary for *S. balanoides* persistence in the area, has declined over the past 30 years. If repeated cold events occur within the lifespan of *S. balanoides,* there is a potential for a storage effect and the species could persist in the area, even when faced with unsuitable years caused by warming. This study demonstrated the importance of considering the role of rare events in controlling species' distributions, particularly when they oppose the overall trend of climate change.

Development of a novel sediment trap to measure particle flux to organisms living in benthic boundary layers

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The vertical flux of particles through the water column is a necessary part of benthic–pelagic coupling from mixed surface layers to deeper water and the seabed. Quantifying the rate and properties of this downward flux allows for estimation of the food supply to benthic organisms. The food available to animals at the boundary layer will, in part, structure the community, according to which organisms are able to withstand/utilise the prevailing conditions. In short, it may be expected that sediment regimes are a key driver of marine productivity.

Obtaining accurate and precise measurements of sedimentation has been surrounded by much controversy. Significant questions remain over sediment trap performance and the interpretation of sediment trap data. The current “standard” cylinder traps cannot be used in close proximity to the substratum; cannot be used in non-vertical orientation; nor can they be used to represent the “exposure environment” of important encrusting fauna. Thus, they are unlikely to be useful in characterising near-bed sediment dynamics in relation to food supply in shallow water, and most especially turbulent, systems. An alternative design is, therefore, desirable.

The design for a novel sediment trap comprised of artificial grass is presented here. Testing has shown >90% recovery of sediments (silt/fine sand). Recovery and retention rates show low variation over flow speeds of 0–1.4 ms^{-1}. The particle size of the recovered material does not vary as function of current speed or sediment dosage and no particle size bias occurs in terms of retention. Comparison with traditional cylinder traps shows that artificial grass traps are less variable in terms of sediment mass and particle size than cylinders over small spatial scales. Overall, the traps provide an economic means to measure sedimentation over a large-scale e.g. marine renewable energy arrays, and will be applicable in a range of environments.

Pelagic stereo-BRUVS: looking at those that swim above the reef.

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Understanding the abundance, demographics and composition of pelagic fish communities has historically relied on fisheries catch data or destructive fishery-independent methods. Here, we test and validate the use of a pelagic stereo-Baited Remote Underwater Video system (BRUVs) as a non-destructive, fishery-independent approach to study pelagic fish assemblages. We investigated whether differences in the vertical composition of fish assemblages could be detected with pelagic stereo-BRUVs by sampling at different depths in the water column. The effects of soak time and replication on the precision and cost of sampling were explored to allow for the optimization and standardization of future pelagic stereo-BRUVs studies. This method has been used effectively to survey fish assemblages in the mid-water along the coast of Western Australia. The fish assemblages sampled at two mid-water depths, 5 and 20 metres, were significantly different demonstrating that this method could be used to investigate the vertical distribution and diel migration patterns of both pelagic and demersal fishes. Precision estimates under different sampling regimes showed that a soak time of 120 minutes and a sample size of at least 8 replicates per treatment would be optimal for sampling using pelagic BRUVs. In order to account for the spatial and temporal variability of the system and to facilitate future comparisons across studies using this method, we encourage maximizing replication given the resources available while standardizing the soak time. Pelagic stereo-BRUVs may provide a useful, non-destructive method to improve our understanding on the ecology and behaviour of fishes in pelagic ecosystems.

Effect of multiple stressors including climate change on oysters in Port Jackson, Sydney

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It is well established that anthropogenic CO_2 emissions are increasing, and as a result oceans are warming and acidifying. Calcifying organisms, especially molluscs, are expected to be the biggest losers in a warm and acidic ocean. The number of studies documenting the negative effects of ocean acidification on molluscs is rapidly growing, yet relatively little is known about how these effects will combine with other anthropogenic stressors.

Port Jackson, including Sydney Harbour, is one of the world's most polluted estuaries, yet it boasts a large degree of biodiversity including a resurgence of native Sydney rock oysters (*Saccostrea glomerata*) and the invasive Pacific oyster (*Crassostrea gigas*). Oysters are vital in almost all global estuarine systems, thus it is crucial to understand how they will respond to current and future environmental stress. The aim of this project is to understand how the seemingly resilient oyster populations of Sydney Harbour, already under stress from anthropogenic contamination, will respond in the near future to increased seawater acidity and temperature against a background of anthropogenic stress. Previous studies have shown single and multiple generational adaptions of oysters to many environmental stressors. It is thus hypothesised that oysters experiencing a background of anthropogenic environmental stress, such as metal contamination in Sydney Harbour, may produce offspring which are more, rather than less resilient to the challenges of a warmed and acidified ocean. If, however, these additional stressors are too much for the organisms to cope with, the native and invasive oyster populations may once again decline. Field studies will be used to identify the level of environmental impact on endemic oyster populations, followed by laboratory exposure to elevated pCO_2 and temperature. The findings of this study will allow a greater understanding of how oyster populations in Sydney harbour may react to future climate conditions against a background of already multiple environmental stressors.

Key words: Sydney Harbour, climate change, environmental contaminants, pollution, ocean acidification, adaption

Temporal variation in sessile marine invertebrate assemblages at Garden Island, Western Australia

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The distribution of species greatly depends on the organisms' ecological attributes such as its physiological response to environmental conditions, abiotic thresholds and biotic interactions. The distribution of introduced species is also dependent on vectors. These interactions vary across time and space. Biotic interactions can affect species response to abiotic environmental changes differently along environmental gradients, and abiotic environmental changes can likewise influence the nature of biotic interactions. Therefore documenting fine scale species assemblages along environmental and temporal gradients is important for understanding how biotic interactions and environmental changes affect broad scale species distribution.

Using settlement panel arrays, this study will generate assemblage-level metrics (e.g. biomass, abundance, richness) across time at six sites around Garden Island, Western Australia. It will later be combined with similar data across the latitudinal gradient of the Western Australian coast from Broome to Albany. Describing population structure in relation to biogeography and temporal change will aid in identifying environmental drivers of population success.

Key words: Invasive species, fouling,

Spatial variability of marine macroalgal assemblages in the Onagawa Bay, northeastern Japan, in relation to coastal sedimentation

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Sedimentation on rocky substrata can strongly affect the structure of marine macroalgal assemblages, especially at sheltered sites and deeper depths. Sediments might also affect the composition of marine macroalgae indirectly via changing distribution of herbivorous sea urchin. However, few studies showing spatial variability of marine macroalgal assemblages have taken into account these abiotic and biotic factors simultaneously. We examined the coverage of marine macroalgae in relation to sediment cover, wave exposure (13 sites including both exposed and sheltered sites), depth (11 depth zones within 0-10m), and sea urchin density in Onagawa Bay, northeastern Japan, one year after the 2011 Tohoku Tsunami, which caused coastal sedimentation to the bay. The results from canonical correspondence analysis (CCA) showed that species compositions of macroalgal assemblage at deeper depths differed between exposed and sheltered sites, while those at shallower depths were similar between both sites. The deeper depths at the exposed sites with high sea urchin densities were dominated by crustose coralline red algae and Dictyotales brown algae, which are known to be resistant to herbivore grazing pressure. On the other hand, the sheltered sites with high sediment cover were colonized by opportunistic species such as filamentous red algae and large annual brown algae *Desmarestia viridis* and *Saccharina japonica*. These results suggest that the composition and structure of the macroalgal assemblages in the bay greatly vary with depth and wave exposure in relation to distribution of sediments and sea urchins.

Key words: Sedimentation, Rocky coast assemblage, Subtidal macroalgae, spatial heterogeneity, wave exposure gradient

Epiphytic faunal communities of Sargassum beds in Onagawa Bay, northeastern Japan, after the 2011 Tohoku Earthquake Tsunami

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Surveys were conducted in March 2012 in Onagawa Bay, Miyagi, Japan, which was badly hit by the 2011 Tohoku Earthquake and tsunami. At eight sites distributed across the bay, macro- and meio-benthic animals on three *Sargassum* species (the annual *S. horneri* and perennials *S. micracanthum* and *S. yezoense*) were examined for abundance, biomass, faunal diversity and evenness. Cluster analyses revealed two major clusters: Cluster A (mainly *S. horneri* as substratum), and Cluster B (mainly *S. micracanthum* and *S. yezoense* as substratum). Species richness and evenness of Cluster B was significantly higher than those of Cluster A. Substrate algae of Cluster B have a smaller number of wider leaves in the unit dry weight than those of Cluster A. According to SIMPER analyses for the difference between these two clusters, foraminiferans, nematodes and ostracods contributed to the difference in abundance, while gastropods, caprellids and isopods contributed mostly to biomass. No differences were found for environmental factors such as openness, mud deposition, depth or water temperature. Comparing the Onagawa Bay communities with pre-earthquake epiphytic faunal communities of other 29 areas in Japan, Cluster A communities in Onagawa Bay have a higher density and lower faunal diversity. The hypothesis is proposed that the structural complexity or the life history of the algal substratum are the most likely controlling factors affecting the formation of epiphytic faunal communities in post-earthquake Onagawa Bay.

Key words: seaweed forest, species diversity, meiofauna, plant-animal interactions, microhabitat, colonization

The role of overgrazing and anthropogenic disturbance in shaping spatial patterns of distribution of an invasive seaweed

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Disturbance is widely acknowledged as a key process facilitating biological invasions. Nonetheless, the role of spatial patterns of compounded disturbances in shaping invasions has been poorly investigated experimentally. We simultaneously exposed *Posidonia oceanica* meadows to disturbances (namely mimicking overgrazing and rhizome uprooting from vessel anchoring) that differed in spatial extent and degree of autocorrelation. Using the framework of 1/f noise models, we assessed their influence on the establishment and spread of the invasive seaweed, *Caulerpa racemosa*. The establishment and spread of *C. racemosa* were evaluated with mixed effect models relating spatial patterns of disturbance with those of the invader, quantified through spectral coefficients. Our results showed that the spatial distribution of *C. racemosa* mimicked that of overgrazing, displaying positive autocorrelation. Yet, *C. racemosa* was unable to disperse from disturbed patches into adjacent intact areas. Also, the sole uprooting of rhizomes did not promote the establishment of *C. racemosa*, but magnified the proliferation of the exotic seaweed when applied in combination with overgrazing. Thus, the loss or length reduction of *P. oceanica* leaves, caused by overgrazing, is sufficient to lessen the resistance of seagrass beds to the invasion by *C. racemosa*. Rhizome uprooting due to boat anchoring would have negligible effects on *C. racemosa*, when occurring in intact meadows. In contrast, it may foster the abundance of *C. racemosa* in areas where the growth and density of *P. oceanica* leaves is depressed due to either adverse environmental conditions or high consumer pressure. Our study shows that native herbivores may indirectly facilitate invasion by reducing the resistance of resident communities and suggests that strategies for controlling the establishment and spread of invasive species should not be limited to the management of anthropogenic pressures, but should also consider natural sources of disturbance.

Key words: herbivory, Mediterranean Sea, spectral analysis

Effects of physical disturbance on the ecological performance of *Caulerpa* spp. from Western Australia.

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The genus *Caulerpa* (Chlorophyta) is highly species rich in Western Australia. Most of these species are relatively uncommon on local reefs and have been poorly studied. However, a few species (e.g., *C. racemosa*) have been introduced to other parts of the world where they have become invasive pests with negative impacts on local community structure and ecosystem functioning. It has been suggested that the success of invasive *Caulerpa* species, and their impacts, are related to human activities, such as physical disturbances. We tested if physical disturbance affected the performance (colonization) of *Caulerpa* communities on kelp dominated reefs. More specifically, we tested the effect of spatial extent (1, 2, 4 m diameter) and intensity (75, 100% canopy clearing) of physical disturbance on 'natural' colonisation of *Caulerpa* spp. on shallow subtidal reefs (~10 m). We also compared colonization patterns to 'mature' *Caulerpa* assemblages found in scattered patches on the same reefs. Our results show that physical disturbance was required for any *Caulerpa* species to colonise reefs. The number of colonising species and their density increased with increasing extent and intensity of disturbance. Interestingly, there was a mismatch between *Caulerpa* species colonizing the new gaps (e.g., *C. longifolia*) vs. the species found in large colonies in natural gaps (e.g., *C. obscura*). *Caulerpa* species with high colonisation potential (e.g., *C. longifolia*) could become invasive if introduced to new regions.

Key words: Con-generic co-existence, recruitment, colonisation, kelp forest,

High latitude corals on the move: A post heat wave assessment

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Tropicalisation of temperate marine communities has been identified as one of the major consequences of increasing seawater temperatures. A 2011 marine heat wave has reshaped marine communities at the warmer range of temperate systems in Western Australia. To date, substantial decreases in habitat-forming cool-water seaweeds and increases in warm-water fish species have been documented. Here we compare pre- and post-heat wave coral communities based on transect data from 2006 and 2013. We found a two-fold increase in the abundance of corals from 2006 to 2013, which was mainly due to a greater abundance of *Plesiastrea versipora*, a species often found in temperate habitats. This change corresponded with a large increase in the number of small *P.versipora* individuals at most sites, suggesting a flux of recruitment between 2006 and 2013. There were new presence recordings of species of tropical affinity, such as *Acropora millepora*, however it is unknown when these might have recruited. This demonstrates that coral communities changed significantly between 2006 and 2013, and that this could be a consequence of the marine heat wave. However, it is still unknown if the increase in recruitment and community change was a direct positive effect of warming on coral spawning and recruitment success or the indirect effect of relaxed competition for space with seaweeds.

Live fast, die young: survival strategies of a limpet, *Cellana toreuma,* in a highly stressful environment

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In Hong Kong, many intertidal species, including the limpet *Cellana toreuma,* suffer heavy mortality with the onset of summer. This mortality is associated with the highly stressful, hot conditions experienced when spring low tides fall in the afternoon and rock temperatures can exceed 50 °C. Physiological experiments showed that overall thermal tolerance is low in *C. toreuma*, but differs between size classes. Under heat stress, heart rates, water loss and haemolymph osmotic concentrations were greater in small (20 mm) than larger-sized (35 mm) individuals, while Arrhenius breakpoint temperatures indicated a lower thermal threshold for small (~38 °C) as compared to larger limpets (~41 °C). Whilst many other species persist through the stressful summer, and have populations composed of 3-4 year classes, *C. toreuma* shows a highly dynamic annual population pattern, with a sharp decline in abundance with the onset of summer (from ~100 ind m^{-2} in winter to ~1.2 ind m^{-2} in summer). Although some individuals survive the summer, the majority of the population recruits in November and December when juveniles settle to form the dominant cohort, accounting for 40 - 90% of the population. Growth is maximal in February - March and individuals spawn in April – May preceding the summer die-off. Gonadosomatic index (GSI, %) values show that *C. toreuma* invests heavily into reproduction (max GSI = 53%). *C. toreuma* has a very different life history strategy as compared to Hong Kong's other limpet species, exhibiting an almost annual pattern. Such a strategy reflects how *C. toruema* is able to survive in this highly stressful dynamic environment despite being thermally sensitive, by investing heavily in fast growth and reproduction, but also illustrates that this species relies on annual settlement of juveniles, and any subsequent failure in supply or recruitment may result in local extinction.

Key words: Life history strategy, reproductive allocation, temperature, tropical rocky shore

Biodiversity responses associated with the potential spread of a native macroalgae in Eastern Australia

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In marine ecosystems, invasive macrophytes have a broad range of negative impact effects. In particular, several species of the genus *Caulerpa* are notorious invaders. Also common, but less recognized, are native species that are rapidly spreading within and outside their historical distribution. These have also been termed 'native invaders'. In temperate south-eastern Australia, the native green macroalgae *Caulerpa filiformis* is undergoing a potential range expansion and may be replacing species of brown algae. *C. filiformis* forms dense mats in the lower intertidal and shallow subtidal zone. The spread of *C. filiformis* is of concern for biodiversity because it is structurally very different from species it competes with and it is chemically defended. However, little is known about *C. filiformis'* current distribution, habitat preference, and potential impacts on native biodiversity. The distribution of *C. filiformis* was documented at several sites along the NSW coast, and high densities of >1000 blades per m^2 were found in patches of up to several 100s m^2. In addition, results showed a preference of the alga for of the shallow subtidal zone and rocky substrates. We compared assemblages in *Caulerpa* and two widespread and abundant co-occurring macrophytes in intertidal habitats at multiple sites in NSW. Against our expectations, Shannon-Wiener indices showed similar diversity in *Caulerpa* compared to the other macrophytes. However, multivariate analyses indicated that assemblages in *C. filiformis* were different from the other macrophytes at all sites. Communities in *Caulerpa* were dominated by gastropods but had reduced crustacea communities. This may be driven by increased sediment entrapment, possibly changing the function of coastal habitats where *C. filiformis* is abundant.

Key words: Invasive species, native invader, habitat modelling, substrate, ecosystem engineer, seasonal variation.

Mechanisms of nearshore retention and offshore exportation of mussel larvae over the Agulhas Bank, South Africa.

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Ecological connectivity is critical to the understanding of population dynamics but in many benthic species it is complicated by the a planktonic larval phase, the dispersal of which remains poorly understood. We used a plankton pump to examine the distribution of the larvae of intertidal mussels along three axes: alongshore, on/offshore and depth during a large scale (500km) cruise over the Agulhas Bank off southern Africa in August/September 2010. As a general pattern, higher veliger abundances were found close to the coast. Our analyses of nearshore flow, estimated from ADCP data, and the vertical distribution of larvae with respect to a set of environmental variables show that onshore larval retention may be mediated by active vertical swimming behaviour through the water column guided by light and wind-induced turbulence. A massive seawards exportation of larvae off St Francis Bay was however observed following the trajectory of an Agulhas Current meander which reached inner shelf waters. We hypothesize that by increasing flow and homogenizing it through the water column, the Agulhas Current may erase the effects of larval vertical positioning on onshore retention and transport larvae offshore. Such export events may represent major larval losses for coastal populations and probably influence connectivity patterns. Our study highlights the need to integrate the effects of complex, regional-specific physical dynamics with the swimming behaviour of the organisms in order to explain spatial distribution, population connectivity and understand the potential consequences for population dynamics.

Key words: Mytilids, Natal Pulse, Larval swimming abilities, Turbulence avoidance, Diel vertical migration

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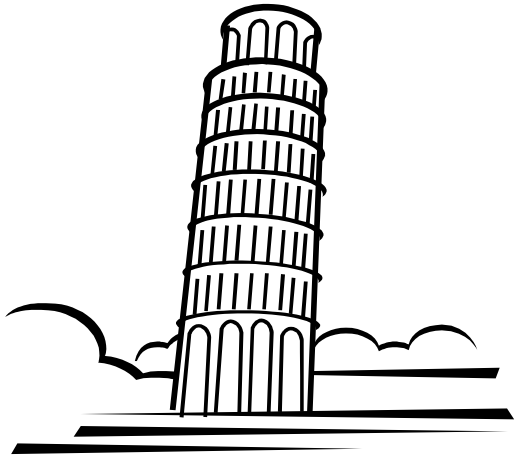
See you again



In Pisa 2016!!