
6TH INTERNATIONAL
TEMPERATE REEF SYMPOSIUM
CHRISTCHURCH NZ 2003
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UNIVERSITY OF CANTERBURY / NATIONAL INSTITUTE OF WATER & ATMOSPHERIC RESEARCH
CEAME
Centre of Excellence in Aquaculture & Marine Ecology

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TEMPERATE REEF SYMPOSIUM
CHRISTCHURCH NZ 2003

WELCOME to the University of Canterbury for this gathering of marine ecologists. This is the second International Temperate Reef Symposium to be held in New Zealand (the other was in Auckland) but the first to be held in Christchurch. This conference is hosted by the University, the *Marine Ecology Research Group* and the University/National Institute of Water & Atmospheric Research *Centre of Excellence in Aquaculture & Marine Ecology*. On behalf of them I welcome you to our campus.

In planning this Sixth International Temperate Reef Symposium we asked previous participants what they would like in terms of format. Most responded that they did not want ITRS to devolve into "just another conference". Instead, they wanted debate and discussion about issues and a good representation of the world's temperate reef ecologists. Accordingly, we have returned to an earlier format in which we have many single-session mini-symposia with plenty of time for discussion of topical issues.

Having a discussion format is challenging with ever-increasing numbers of participants, and the price of these single sessions is the multiple sessions for the remainder of the talks. As always, putting together a large number of cohesive sessions presented challenges because of the wide range of topics and varying number of presentations within each. We considered drawing names randomly for the placement of the "general" talks but, in the end, reckoned that the potential for vilification outweighed any benefits in making the program easier to put together. Instead, we have tried to put together thematic sessions, with the likelihood of misplacing some talks and having simultaneous sessions that all want to attend. I can only hope that no one feels overly aggrieved at the placement of talks.

6ITRS has participants from 10 countries (New Zealand, Australia, South Africa, Chile, USA, England, Ireland, Germany, Italy and Korea). I am delighted that you made the effort to come such a long way to participate in this conference and share your skills, knowledge and ideas with other participants. We have strived to make 6ITRS topical, interesting, inclusive and (of course) as much fun as possible.

Very special thanks are due to the members of the Marine Ecology Research Group who did so much work on this conference, especially Spencer Wood for the great web site and for handling the abstracts, John Pirker for venues and liaising with all service providers, and Dave Taylor for arranging the logo and gear. Thanks to Mike Hickford for arranging the program scheduling. I thank mini-symposia organizers for their work in getting the eight special sessions together. We thank Bill Robertson and the Andrew W Mellon Foundation for their continued support of coastal ecology. Finally, we thank Roger Beattie and Sea-Right Investments (the paua pearl company) for providing the only external sponsorship we were able to secure in these tight financial times.

I wish you all the best for a very good time while in New Zealand.

David Schiel
(Conference Organizer)

Previous International Temperate Reef Symposia
1990, First ITRS, Melbourne, Australia (Organizing chair: Mick Keough)
1992, Second ITRS, Auckland, New Zealand (Organizing chair: Bob Creese)
1995, Third ITRS, Sydney, Australia (Organizing chair: Tony Underwood)
1997, Fourth ITRS, Santiago, Chile (Organizing chair: Jaun Carlos Castilla)
2000, Fifth ITRS, Cape Town, South Africa (Organizing chair: George Branch)

Sunday 12th January

17:00 - 19:00	**Registration & mingle (Staff Club, Ilam Road) - Cash bar, snacks provided**

Monday 13th January

07:30 - 08:10	**Registration: C block foyer**	
	Theatre: C1	
08:15 - 08:30	**Welcoming Address**: Schiel, David R. .	
08:30 - 09:00	**Keynote Address:** Lubchenco, Jane. The blue report: ocean challenges for scientists.	
09:00 - 11:20	**General Symposium 1: Climate change and temperate reef ecosystems: integrating space and time.**	
	Hawkins, Steven J.*, Mike T. Burrows, Mike A. Kendall, Nova Mieszkowska, Pippa Moore, Alan J. Southward, Richard C. Thompson and Rebecca Leaper. An overview of global change and temperate reefs: patterns, processes and possibly predictions.	
	Helmuth, Brian S.T.*, Christopher D.G. Harley, Patti Halpin, Michael O'Donnell, Gretchen E. Hofmann and Carol A. Blanchette. Climate change and latitudinal patterns of thermal stress in the rocky intertidal zone: why life is not always hotter at lower latitudes.	
	Lubchenco, Jane* and Menge, Bruce. Climate change and north eastern Pacific rocky shores: Insights from the Pacific Decadal Oscillation	
	Leaper, Rebecca*, Mike T. Burrows, Mike A. Kendall, Nova Mieszkowska, Pippa Moore, Alan J. Southward, Richard C. Thompson and Steven J. Hawkins. Can intertidal species be used as indicators of global climate change? Measuring and predicting responses of marine ecosystems in the North East Atlantic.	
	Underwood, Antony J.*. Research agendas for coastal ecological consequences of global warming.	
	Kingsford, Mike*. The influence of El Nino on temporal patterns of reef fish abundance.	
	Discussion	
11:20 - 11:40	TEA	
	Theatre: C1	**Theatre: C2**
	Session A1: Techniques	**Session B1: Subtidal Ecology Themes**
11:40 - 12:00	Habeeb, Rebecca L.*, Craig R. Johnson, Simon Wotherspoon, Jessica Trebilco and Piers K. Dunstan. Robustness of characteristic length scale estimates of marine systems.	Spalding, Heather L.*. Deep-water macroalgae, light, and the space-time continuum: temporal and spatial patterns in central California.
12:00 - 12:20	Trebilco, Jessica*, Craig R. Johnson, Simon Wotherspoon, Rebecca L. Habeeb and Piers K. Dunstan. Techniques to estimate characteristic length scales of real marine systems.	Hurd, Catriona L.*, Steven Wing, Christopher Hepburn, James Holborow and Russell Frew . Seasonal mass-transport limited growth of the giant kelp Macrocystis pyrifera.
12:20 - 12:40	Anderson, Marti J.* and Angus A. Thompson. Multivariate control charts for ecological and environmental monitoring.	Fowler-Walker, Meegan J.* and Sean D. Connell. Does the structure of marine forests predict understorey assemblages of algae across temperate Australia?
12:40 - 13:40	LUNCH	

	Session A2: Urbanisation	**Session B2: Subtidal Ecology Themes (cont.)**
13:40 - 14:00	Chapman, M. Gee*. Intertidal seawalls as surrogate habitats for rocky intertidal shores.	Irving, Andrew D* and Sean D. Connell. Direct and indirect effects of subtidal forests on mobile invertebrates.
14:00 - 14:20	People, Julie C.*. City living: the ecology of organisms associated with mussel beds in urban areas.	Goodsell, Paris J.* and Sean D. Connell. Local and regional patterns of diversity in response to habitat heterogeneity.
14:20 - 14:40	Johnston, Emma L.*. Competition modifies the response of organisms to toxic disturbances.	Wahl, Martin* , Markus Molis, Andy Davis, Sergey Dobretsov, Simone Dürr, Josefin Johansson, Jeff Kinley, David Kirugara, Matthias Langer, Heike Lotze, Martin Thiel, Boris Worm and Dafna Zeevi. Impact of natural UV-radiation on shallow marine hard-bottom assemblages: a global approach.
14:40 - 15:00	Clynick, Brianna*. The value of marinas and associated structures as habitat for fish.	Connell, Sean D.*. Suppression and exclusion of taxa from the assembly of alternate states of habitat.
15:00 - 15:20	TEA	
	Session A3: Urbanisation (cont.)	**Session B3: Recruitment**
15:20 - 15:40	Blockley, David*. The effect of wharves and jetties on the assemblages living on intertidal seawalls in Sydney Harbour.	Blanchette, Carol A.* and Steven D. Gaines. Contrasting contributors to nearshore marine community structure around Pt. Conception, California.
15:40 - 16:00	Crowe, Tasman P.* . Mussels, pollution and biodiversity on UK rocky shores.	Krenz, Christopher*, Maxine L. Chaney and Wayne R. Wood. Does spatial variation in barnacle and mussel recruitment affect rocky intertidal community dynamics?
16:00 - 16:20	Chapman, M. Gee*. Using artificial structures and constructed boulder fields to test hypotheses about colonization of mobile animals to intertidal boulders.	Broitman, Bernardo R.*, Sergio A. Navarrete, Carol A. Blanchette and Steven D. Gaines. Recruitment dynamics of intertidal invertebrates in the temperate East Pacific.
16:20 - 17:45	**General Symposium 2: Perspectives on scale in ecology.**	
	Levin, Simon A.* and Jerome Chave. Perspectives on scale in marine systems.	
	Underwood, Antony J.*. Hierarchies, confusion and issues in analyses of spatial patterns in ecology.	
	Discussion	
18:30 - 21:15	Social function at the International Antartctic Centre (specifics to be announced)	

Tuesday 14th January

	Theatre C1		
08:30 - 11:00	**General Symposium 3: The role and effectiveness of marine protected areas**		
	The Science of Marine Reserves: video and brochure. Introduced by Jane Lubchenco		
	Beattie, Roger. Business and fishing perspectives on marine conservation		
	Babcock Russell C*. and Shears Nick T. Significant time lag in the indirect response of kelp communities to large- scale predator manipulations.		
	Branch, George M.*. What is it that Marine Protected Areas can (and can¹t) achieve?		
	Gaines, Steven D.*. Making connections: design criteria for marine reserve networks.		
	Leslie, Heather*. A critical evaluation of marine conservation planning approaches.		
	Discussion		
11:00 - 11:20	TEA		
	Theatre C1	**Theatre C2**	**Theatre C3**
	Session A4: Urbanisation effects	**Session B4: Defence**	
11:20 - 11:40	Schiel, David R* and Wood, Spencer. Sedimentation on coastal reefs affects early post-settlement stages of dominant algae	Ferguson, Adrian* and Andy Davis. Invertebrates with attitude: spicule armament and defense in temperate reef sponges.	
11:40 - 12:00	Stevens, Craig*, Murray Smith, David Schiel, Spencer Wood and Iain MacDonald. The fluid mechanics of propagule transport in the rocky intertidal zone.	Bers, A. Valeria* and Martin Wahl. Do microstructures of marine organisms influence recruitment of epibionts?	
12:00 - 12:20	Wood, Spencer A.*, David R. Schiel, Murray J. Smith and Craig L. Stevens. How early life stages of algae attach and survive in wave-dominated environments.	Taylor, Richard B.* and Peter D. Steinberg. Mesograzer specialization on seaweeds: a test of current theory using Australasian Temperate rocky reef systems.	
12:20 - 12:40	Airoldi, Laura*. Sedimentation and community structure on rocky reefs.	Halpern, Benjamin S.*. Juvenile habitat as a limiting resource.	
12:40 - 13:40	LUNCH		
	Session A5: Intertidal algae	**Session B5: Predators, prey and preferences**	**Session C5: Subtidal Ecology**
13:40 - 14:00	Coleman, Melinda A.* and Susan H. Brawley. Population genetic structure of *Fucus distichus* from high shore rockpools and its correlation with dispersal of gametes.	Pederson, Hugh* and Craig R Johnson. Effects of fishing lobsters on the population dynamics of the sea urchin Heliocidaris erythrogramma on the east coast of Tasmania.	MacDiarmid, Alison B.*, Rod Bertelsen and Mark J. Butler IV. Does removal of large males in fished populations of two species of spiny lobsters, Jasus edwardsii and Panulirus argus, reduce brood size in females?

14:00 - 14:20	McConnico, Laurie A.*. Ecology and reproductive phenology of *Alaria marginata* along the Big Sur coast: the population dynamics of an exposed kelp, exposed.	Lafferty, Kevin D.*. Trophic cascades alter density thresholds for urchin disease.	Raethke, Natalie* and John D. Booth. Sociality and conspecific attraction in juvenile Jasus edwardsii (Palinuridae).
14:20 - 14:40	Samuela, Aletha T.* and T. Alwyn V. Rees. Environmental factors that influence egg release in *Hormosira banksii* .	Connell, Sean D.*. Density-dependent growth and survival is more than just competition.	Steller, Diana, L.*. Contributions of rhodolith beds to a commercial scallop fishery: the importance of reefs that rock and roll.
14:40 - 15:00	Mei, Junxue*. Novel adaptations for survival of *Polysiphonia adamsiae* and *Polysiphonia strictissima* in southern New Zealand	Coleman, Ross*. Why do limpets clump?	Mackie, Joshua*, Michael Keough and Leslie Christidis. Phylogeography of the bryozoan Mucropetraliella ellerii: the effect of Pleistocene cycles on genetic differentiation in south-eastern Australia.
15:00 - 15:20	Dunmore, Robyn A.*, David I. Taylor and David R. Schiel. Small scale variation in reproduction, dispersal, and early stage survival of large brown intertidal seaweeds produces large scale differences in their distribution and abundance.	Wellenreuther, Maren* and Sean D. Connell. Response of predators to prey abundance: separating the effects of prey density and patch size.	Hill, Andrew F.* and Neil L. Andrew. Mapping subtidal habitats using acoustic and photographic techniques.
15:20 - 15:40	Coleman, Melinda A.*. Effects of ephemeral algae on coralline recruits in intertidal and subtidal habitats.	Underwood, Antony J.*. "Preference" in ecological analyses: a much mis-used term!	Bone, Elisa K.* and Michael J. Keough. Colony fragmentation and colonial integration in three species of encrusting bryozoan.
15:40 - 16:00	TEA		
16:00 - 18:00	**General Symposium 4: Assessing chronic local impacts: getting down to details**		
	Carey, Janet M* and Michael J Keough. The variability of estimates of variance, and its effect on power analysis in monitoring design.		
	Steinbeck, John*, David Schiel and Mike Foster. Are long-term impact studies long enough?		
	Stewart-Oaten, Allan*. Roles for controls: precision and robustness.		
	Syms, Craig*. Spatial pattern analysis as a stop-gap approach to dealing with messy impact assessment data: is it really as easy as it sounds?		
	Underwood, Antony J.*. Analysing potential impacts: complications about spatial scales.		
	Discussion		
Evening	**Student Symposium** (details to be announced)		
	Evening free		

Wednesday 15th January

Today is a trip to Kaikoura (full details will be announced)

Buses will be provided to and from Kaikoura, but arrangements are your own

07:00 Assemble at designated departure point

17:00 Assemble at designated departure point in Kaikoura

Evening free

Thursday 16th January

	Theatre C1	
08:00 - 08:30	**Keynote Address:** Foster, Michael S. The kelp forest in Stillwater Cove: 70 years and still standing.	
08:30 - 10:00	**General Symposium 5: Patterns and consequences of contrasting demographies**	
	Reed, Dan* Sally Holbrook and Carol Blanchette. Differential reproductive responses to environmental fluctuations in three species of marine plants with contrasting demographies.	
	Schiel, David R. When is the demography of key species a major driver of community structure? Comparisons and examples from the intertidal zones of New Zealand and Oregon.	
	Schroeter, Steve*, Dan Reed, Danielle Toole and David Huang. Experimental studies on factors affecting the recruitment of two structure-forming reef species with contrasting demographies.	
	Discussion	
10:00 - 10:20	TEA	
	Theatre C1	
10:20 - 12:10	**General Symposium 6: What can introduced species tell us about the ecology of native ecosystems**	
	Creese, Bob*. Invasions of temperate waters by the tropical seaweed *Caulerpa taxifolia*: complexities, responses and ecological impacts	
	Inglis, Graeme J.*. Finding an invader before it becomes invasive: tools for the design and implementation of marine pest surveys	
	Branch, George M.* and Nina Steffani. How good are we at predicting the effects of alien species? A case history of invasion by the mussel Mytilus	
	Scheibling, Robert*. Synergistic interactions among introduced species mediate a phase shift in the rocky subtidal ecosystem off Nova Scotia	
	Discussion	
12:10 - 13:00	LUNCH	
	Theatre C1	**Theatre C2**
	Session A6: Invasive species	**Session B6: Fish Ecology**
13:00 - 13:20	Campbell, Marnie L.* and Chad L. Hewitt. Invasions coupled with biodiversity: did Elton get it wrong?	Clements, Kendall D.* and Anthony J.R. Hickey. Ecological speciation in New Zealand triplefin fishes.
13:20 - 13:40	Dunstan, Piers K.* and Craig R. Johnson. Relationships between stability, species richness and invasibility depend on species-specific size-dependent mortality in a marine epibenthic community.	Hickey, Anthony J. R.*, Shane Lavery, C. Scott Baker and Kendall D. Clements. Molecular tools for reef ecology: from larval recruitment to invasive species.
13:40 - 14:00	Valentine, Joe* and Craig R. Johnson. Establishment of dense stands of the introduced kelp *Undaria pinnatifida* in Tasmania depends on disturbance to native algal assemblages.	Feary, David A.* and Kendall D. Clements. Habitat use by triplefin species (Family Tripterygiidae) on rocky reefs in New Zealand.
14:00 - 14:20	Thompson, Glen A.*. Mechanisms of invasion: facilitation and inhibition of the invasive alga *Undaria pinnatifida* in New Zealand.	Cole, Russell G.*, Niki K. Alcock, Glen Carbines, Rob Stewart and Neil L. Andrew. Links between habitat and fish assemblage structure in central New Zealand
14:20 - 14:40	Thomsen, Mads* and Karen McGlathery. *Codium fragile* - an invasive species in Hog Island Bay, Virginia, US.	Griffiths, Shane P.*, Andrew R. Davis and Ron J. West. Influence of habitat complexity on fish assemblages in temperate Australian intertidal rockpools.
14:40 - 15:00	TEA	

	Session A7: Long term change	**Session B7: Fish Ecology (cont.)**
15:00 - 15:20	Zemke-White, W. Lindsey* and Kendall D. Clements. Long term temporal changes in kelp abundance	Webster, Michael S.*, Bruce A. Menge and Jane Lubchenco. Effects of regional variation in recruitment and community structure on intertidal fishes.
15:20 - 15:40	Edwards, Matthew, S.*. Factors regulating the southern range limit of giant kelp in the North Pacific Ocean.	Shima, Jeffrey S.*. Cryptic density dependence: effects of spatiotemporal covariation in settlement intensity and quality in reef fish.
15:40 - 16:00	Hofmann, Gretchen E.* and Mary A. Sewell. Stress along environmental gradients: Indicators of physiological stress in the purple sea urchin Strongylocentrotus purpuratus in an intertidal to subtidal gradient.	Burford, Martha O.*. Genetic population structure and year-class formation in two nearshore species of rockfish (Sebastes) along the California coast.
16:00 - 16:20	Kinlan, Brian P.*. Spatial and temporal variation of kelp forest habitat structure in the Northeast Pacific.	Gillanders, Bronwyn M.*. Determining the spatial extent of connectivity between juvenile and adult fish populations.
16:20 - 16:40	Taylor, David* I., Robyn A.Dunmore and David R. Schiel. A hemispheric comparison of grazing and growth of habitat-forming algae across exposure gradients.	
16:40 - 17:50	**General Symposium 7: Moving from quadrats to pixels: application of remote sensing technologies to studies of temperate reef dynamics**	
	Pinkerton, Matt*, Philip Boyd and Kenneth Richardson. Ecological observation on appropriate scales: ocean colour remote sensing in the New Zealand coastal zone.	
	Zimmerman, Richard C.*. Hyperspectral remote sensing of optically shallow waters	
	Discussion	
18:50	Conference Dinner:Arts Centre Great Hall, Worcester Street	

Friday 17th January

	Theatre C1	
08:30 - 10:20	**General Symposium 8: Testing bottom-up influences in nearshore communities**	
	Gaines, Steven D.*. Subsidies in marine communities do not just come from the bottom up	
	Menge, Bruce A*, Tess L Freidenburg, Melissa Foley, Greg Hudson, Matt Bracken, Karina Nielsen, Francis Chan and Jane Lubchenco. Coastal oceanographic regime predicts rocky intertidal community dynamics.	
	Navarrete, Sergio A.* and Evie A. Wieters. Upwelling and Shadows: spatially dynamic community regulation and the fuzzy signal of bottom-up factors over meso scales.	
	Wing, Stephen R.*. Population networks in the New Zealand fjords: an example of source sink structure across an environmental gradient.	
	Discussion	
10:20 - 10:40	**Theatre C1**	**Theatre C2**
	Session A8: Dispersal and primary production	**Session B8: Diversity**
10:40 - 11:00	Whitmer, Allison C.*. Genetic analysis of population growth in an intertidal alga, Postelsia palmaeformis, using microsatellite markers.	Russell, Roly*. The ecological importance of biological diversity for system functioning and stability: evidence from experiments with intertidal algal assemblages.
11:00 - 11:20	Goldstien, Sharyn*. Molecular genetics of larval ecology.	Harley, Christopher D.G.*. Abiotic stress and predation interact to create a regional scale gradient in species richness.
11:20 - 11:40	Chan, Francis*, Bruce Menge, Karina Nielsen, Brian Grantham and Jane Lubchenco. Nutrient use efficiency regulates pelagic production in coastal ecosystems: patterns along the Oregon and New Zealand Coasts.	Hirst, Alastair J.*. Interactions between diversity, composition and morphology of subtidal algae influence epifaunal diversity by mediating faunal abundance.
11:40 - 12:00	Nielsen, Karina J.*, Bruce A. Menge, Brian A. Grantham and Jane Lubchenco. Macrophytes, phytoplankton, and upwelling: light limitation in the intertidal	Dürr, Simone*, Martin Wahl and Andrew R. Davis. Are conditions at early development important for the later assemblage?
12:00 - 12:20	Bracken, Matthew*, Bruce A. Menge, Melissa M. Foley, David R. Schiel and Jane Lubchenco. Variation in benthic-pelagic coupling along productivity gradients.	Schreider, Maria J.*, Rohani Ambo Rappe and Matthew Anderson. The effect of patch size and proximity to Zostera beds on the abundance and diversity of epifauna.
12:20 - 13:20	LUNCH	
	Session A9: MPA	**Session B9: Scale**
13:20 - 13:40	Halpern, Benjamin S.*. The impact of marine reserves: a synthesis of global evidence.	Petraitis, Peter S.*. Scale-dependent successional changes in experimental clearings.
13:40 - 14:00	Shears, Nick T.* and Russell C. Babcock. Marine reserves and the generality of the predator-urchin-kelp paradigm in northeastern New Zealand.	Benedetti-Cecchi, Lisandro*. How can we incorporate tests of hypotheses about changes in the variance of predictor variables in our experiments?
14:00 - 14:20	Schroeder, Donna M.*, Guy R. Cochrane and Mary S. Fangman. Application of benthic habitat mapping inside marine protected areas using textural analysis of sidescan sonar data.	Johnson, Mark P.*, Matthew Mosley, Mick Hanley and Stephen J. Hawkins. Spatial scales and temporal synchrony of populations on rough and smooth surfaces.

		Session B9A: Intertidal ecology
14:20 - 14:40	Langlois, Timothy J.*, Marti J. Anderson and Russell C. Babcock. Reef associated predators influence adjacent soft sediment communities.	Fairweather, Peter, G.*. How far up? Extent of impinging upon rocky intertidal reefs by the Bonney Coast upwelling.
14:40 - 15:00	Schroeder, Donna M.* and Milton S. Love. Is recreational fishing a low impact activity and compatible with MPAs? A review of evidence from California, USA.	Salomon, Anne K.*. Bottoms-up to top-down: linking the role of species interactions and recruitment in structuring temperate intertidal communities.
15:00 - 15:20	Kim, Jeong Ha*. Introducing Korean coastal habitats and current ecological research.	Readdie, Mark D.*. Shifting zones: how species upper limits can vary vertically on rocky shores.
15:20 - 15:40	TEA	
	Session A10: MPA (cont.)	**Session B10: Intertidal ecology (cont.)**
15:40 - 16:00	Denny, Chris M*, Trevor J Willis and Russ C Babcock. Marine reserves protect targeted fish species.	Thompson, Richard C.*, Steve J. Hawkins and Trevor A. Norton. Pattern and process in benthic biofilms: the relative importance of physical forcing and biological interaction.
16:00 - 16:20	Behrens, Michael D.* and Kevin D. Lafferty. The kelp forest barrens dichotomy: multivariate description, community patterns, and the effects of reserves.	Bulleri, Fabio*. Effects of habitat structure on the development of intertidal epibenthic assemblages at different heights on a shore.
16:20 - 16:40	Barrett, Neville*, Graham Edgar, Colin Buxton and Alastair Morton. Changes in Tasmanian Marine Protected Areas following a decade of protection.	Rilov, Gil*. Top-down or bottom-up regulation of the New Zealand intertidal community? Hints from mussel population structure and predation experiments.
16:40 - 17:00	Freeman, Debbie, J.*. Population dynamics and predation effects of spiny lobsters (*Jasus edwardsii*) in two East Coast New Zealand marine reserves.	Robles, Carlos, D.* and Jeff Shima. Alongshore dispersal of the sea star *Pisaster ochraceus* in intertidal landscapes with varying wave exposures and prey availabilities.
17:00 - 17:20	Stewart, Romola* and Hugh Posingham. The opportunity cost of *ad hoc* marine reserve system design: an example from South Australia	Phillips, Nicole E.*. Variability in larval condition at settlement: influences on post-settlement performance and patterns in the field.
17:20 - 17:40	Egli, Daniel P.*. Ultrasonic tracking reveals multiple behavioural modes of snapper in a marine reserve: implications for conservation and fisheries management.	Schroeter, Steve C.*, Susan L. Swarbrick and Joseph H. Connell. The role of catastrophes in structuring marine rocky intertidal communities.
17:40 - 18:00	Closing ceremony	

Keynote Addresses

Foster, Michael S.[1]

The kelp forest in Stillwater Cove: 70 years and still standing.

Recent papers suggest that the top-down/apex predator/keystone species/predator control paradigm in marine ecology is being launched under a new guise: collapsing fisheries lead to a collapse of nearshore ecosystems, including kelp forests in California. Historical observations (since 1911) and data (since 1934) from the giant kelp forest at Stillwater Cove in central California suggest that populations of the dominant seaweeds and non-fished invertebrates have remained similar since 1934 and perhaps longer. This has occurred even though fisheries have declined, sea otters were absent from the late 1800's until the late 1950's, there have been numerous El Ninos, oceanographic regime shifts, and a rise in average sea surface temperature. Single surveys and another long term study at other sites in central California further indicate temporal and spatial consistency. Observations from numerous sites throughout California in areas without sea otters indicate that predator effects may be generally small. The available data suggest that, historically, water quality and storms have had the largest effects. In my opinion, the "collapse-collapse" paradigm has consequences beyond the usual scientific debates: advocacy in the spirit of conservation has the potential for collapsing ecology into environmentalism with a consequent further diminution of the role of science in the resolution of environmental issues.

(1) Moss Landing Marine Labs, Moss Landing, CA, USA.

Lubchenco, Jane[1]

The blue report: ocean challenges for scientists.

This address will launch the symposium by presenting an overview of the status of oceans today and the consequent challenges to marine scientists.

(1) Department of Zoology, Oregon State University, Corvallis, OR 97331, USA.

General Symposia

Babcock, Russell C.*[1] and Nick T. Shears[1]

Significant time lag in the indirect response of kelp communities to large-scale predator manipulations.

Marine reserves in Northeastern New Zealand constitute large-scale predator manipulations and have provided several insights into important processes structuring shallow subtidal reefs in this region. Increased abundances of snapper (*Pagrus auratus*) and spiny lobster (*Jasus edwardsii*) probably stabilised within five to eight years of protection. Both of these species are significant urchin predators but urchin (*Evechinus chloroticus*) populations maintained high densities in many parts of the reserve for a further ten years. Once urchin densities fall below approximately 1 m-2 kelp populations can re- establish and habitat state changes from urchin dominated barrens to kelp forest. Some areas were still in transition to kelp forest as late as 2001, 25 years after full protection.
The time lag between the recovery of predator populations and the indirect effects on algal community structure was much longer than those commonly described in intertidal manipulations. This is likely to be related to the feeding behaviour of urchin predators, and to the response of urchins to these predators. Urchins adopt a more cryptic lifestyle to avoid predators and both snapper and lobster prefer small urchins. It is important to understand such relatively complex interactions in order to predict the response of kelp forest communities to varying levels of predation. Further longitudinal studies of marine reserves are necessary in order to assess whether such time lags are common in subtidal rocky reef ecosystems.

(1) Leigh Marine Laboratory, University of Auckland, PO Box 349, Warkworth, New Zealand.

Branch, George M.*[1]

What is it that Marine Protected Areas can (and can't) achieve?

Marine protected Areas (MPAs) can provide for biological conservation and fisheries control while at the same time serving a range of other human needs including research, education, recreation, cultural conservation and tourism. In this overview, I concentrate on six outcomes that relate to the first two of these objectives conservation and fisheries and the contexts in which these outcomes are likely to be achieved. I draw on both empirical data and models to provide a perspective of just how certain we are about each of the outcomes. (1) Do MPAs allow recovery of depleted stocks and what influences the magnitude of recovery? (2) Is the success of MPAs influenced by the distance between them? Does it relate to dispersal and migration distances, sources and sinks, and connectivity between MPAs? (3) Does the size of individual MPAs influence success and is that influenced by the mobility of species? (4) Do spillover of adults and larval dispersal from MPAs enhance yields outside reserves? (5) What are the ecosystem effects of MPAs? (6) What are the consequences of MPAs on fisheries yields compared to other conventional means of control such as TACs?

(1) Marine Biology Research Institute, Zoology Department, University of Cape Town, Rondebosch 7701, South Africa.

Branch, George M.*[1] and Nina Steffani[1]

How good are we at predicting the effects of alien species? A case history of invasion by the mussel *Mytilus galloprovincialis*.

In the 1970¹s the Mediterranean blue mussel *Mytilus galloprovincialis* arrived on the shores of South Africa. Its impacts have been described elsewhere, but here I ask how good were we at forecasting its effects? Experience elsewhere warned that it was likely to be invasive, and indeed it was. Several characteristics provide it with an edge over indigenous mussels, including fast growth, very high reproductive output and high tolerance to desiccation. From McQuaid¹s work on trophic structure and Bustamante¹s analyses of biomass on rocky shores, we predicted that *M. galloprovincialis* would achieve ascendancy on wave-exposed shores. Long-term monitoring and Steffani¹s analysis of its interaction with an endemic limpet, *Scutellastra argenvillei*, confirmed this. Moreover, measurements of growth, condition and settlement amplified our understanding of the underlying reasons. A second factor that successfully forecasted other outcomes was the relative size of the mussel and other spatial competitors. Large competitors were excluded; but small ones successfully used the mussels as a secondary substratum. Interaction between *M. galloprovincialis* and a small limpet, *S. granularis*, illustrates the point. Thus, (1) history, (2) population dynamics, (3) wave action and (4) relative size were all successfully used to predict the effects of this invasive. Before back-patting sets in, however, one last effect of *M. galloprovincialis* needs to be recounted its influence on the predatory sandy-beach crab *Ovalipes trimaculatus*. Rather than spilling the beans, I issue a challenge: given the contrasting biology of these species, what predictions would we have made about the outcome of this interaction?

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Carey, Janet M.*[1] and Michael J. Keough[2]

The variability of estimates of variance, and its effect on power analysis in monitoring design.

Power analysis can be a valuable aid in the design of monitoring programs. It requires an estimate of variance, which may come from a pilot study or an existing study in a similar habitat. For marine benthos, natural variation in abundances can be considerable, raising the question of the reliability of variance estimates. We used two existing monitoring programs of marine benthos (although these were soft-sediment rather than reef assemblages) to generate multiple estimates of variance. These estimates were found to differ from nominated best estimates by 50% or more in 43% of cases, in turn leading to under or over-estimation of sample size in the design of a notional monitoring program. The two studies, from the same general area, using the same sampling methods and spanning a similar time scale, gave estimates varying by more than an order of magnitude for 25% of taxa. We suggest that pilot studies for ecological monitoring programs of marine benthos should include at least two sampling times.

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Creese, Bob*[1]

Invasions of temperate waters by the tropical seaweed *Caulerpa taxifolia*: complexities, responses and ecological impacts.

Caulerpa taxifolia was first reported in temperate Australian waters in 2000. It is now established in seven locations in New South Wales and one in South Australia. Prior to its discovery in temperate Australia, this species had been classified as a 'marine pest' based on its rapid spread and domination of several subtidal areas in the Mediterranean. It had also been found at 2 locations in southern California. The history of these invasions and the responses by the relevant agencies is briefly reviewed.
In Australia, the situation is complicated because *C. taxifolia* occurs naturally in tropical waters, extending into the subtropical areas of southern Queensland. Until recently, the origin of the 'introduced plants' was uncertain, but recent genetic analysis confirms that the source was almost certainly Australia. *C. taxifolia* and seagrasses have co-existed in Moreton Bay for many decades, calling into question the extent to which the former can outcompete the latter in Australian waters. Never-the-less, the species is classified as a noxious pest in southern states and programs to attempt its eradication in NSW and South Australia have been initiated. Possible eradication techniques for *C. taxifolia* are currently being trialed in NSW. These trials, along with detailed mapping procedures, are also being used to assess spatial and temporal variability in natural communities and their responses to perturbation. Preliminary results show that the spread of *C. taxifolia*, can be severely constrained by application of common salt. The consequences of such a treatment are discussed in terms of the natural functioning of estuarine systems

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Gaines, Steven D.*[1]

Subsidies in marine communities do not just come from the bottom up.

Benthic marine ecosystems receive a diverse array of contributions from the water column - nutrients, particulate food, and planktonic larvae. This range of materials subsidises the population growth rates of most benthic marine species. In many ways, these subsidies are analogous to the nutrient subsidies that form the conceptual basis for bottom-up control of other ecosystems. The primary difference, however, is that the subsidies of marine ecosystems do not all enter at the bottom of the food web. Species throughout the trophic web can have planktonic dispersal stages that arrive to subsidise local populations. In addition, nutrients enter benthic food web dynamics in two competing ways - one directly through uptake by macroalgae, which is analogous to nutrient subsidies of terrestrial food webs, and the other indirectly through the planktonic part of the food web, which generates the particulate food used by filter feeding invertebrates. The complexity of these alternative subsidies can have profound influences on the structure of benthic communities that differ substantially from the simple bottom-up framework of community regulation. I will use examples from upwelling ecosystems along the west coast of the US to highlight some of these effects and argue that we need a comprehensive framework for dealing with subsidies to ecosystems when they do not occur at the bottom.

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Gaines, Steven D.*[1]
Making connections: design criteria for marine reserve networks.

Marine reserves are being established around the world in attempts to enhance marine conservation and promote more sustainable fisheries. Reviews of their impact suggest they are broadly successful in increasing the number, size and diversity of fish and invertebrates living within their borders. The collective impacts of existing reserves, however, are at best modest because such a small fraction of most species range is protected. The conservation and fisheries benefits of reserves can only grow if the collective area in reserves grows. Several global efforts to create large networks of marine reserves are now emerging. One critical roadblock to the success of these efforts is the lack of a scientific framework for the design of effective networks. Although considerable scientific attention has focused on design criteria for individual reserves, the science of marine reserve networks is still rudimentary. In this talk, I will take several approaches to develop design criteria for marine reserve networks. Using data on patterns of dispersal, models of coastal populations, and data on catastrophes, I argue that some simple scientific guidelines are clear, but also that inherent compromises in reserve design will emerge because of life history differences among species and conflicting goals for reserve establishment.

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Hawkins, Steven J.*[1], Mike T. Burrows[2], Mike A. Kendall[1], Nova Mieszkowska[1], Pippa Moore[1], Alan J. Southward[1], Richard C. Thompson[3] and Rebecca Leaper[1]
An overview of global change and temperate reefs: patterns, processes and possibly predictions.

There is now an unequivocal acceptance in most countries that global change is occurring and linked to the waste products of human activities. In marine ecosystems temperature rises have been observed and sea level is expected to rise. Using mainly North East Atlantic examples, this paper sets the scene for the rest of the session, by outlining the rates of physical change, known responses both offshore and onshore and debating likely consequences for temperate reefs. We emphasise the need to examine recent change in the context of longer-term trends, including recent periods of cooling as well as warming. The use of intertidal organisms as indicators of change offshore is introduced and possible approaches to prediction/forecast outlined. The need for long-term data sets is emphasised throughout. Some putative mechanisms driving responses of temperate reef species to climate change are proposed. These should enable both qualitative and quantitative forecasts of likely rates of change in relation to climate change scenarios produced both by the UK Climate Impacts Programme and the Intergovernmental Panel on Climate Change.

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Helmuth, Brian S.T.*[1], Christopher D.G. Harley[2], Patti Halpin[3], Michael O'Donnell[2], Gretchen E. Hofmann[3] and Carol A. Blanchette[3]

Climate change and latitudinal patterns of thermal stress in the rocky intertidal zone: why life is not always hotter at lower latitudes.

Rocky intertidal organisms are thought to live very close to their thermal tolerance limits, making the intertidal zone a potentially important ecosystem for examining the effects of climate change on natural communities. However, despite the observation that physiological stress due to high temperatures occurs almost exclusively during aerial exposure at low tide, most studies of the effects of climate on intertidal communities have focused on sea surface temperatures. We deployed a series of temperature loggers designed to mimic the thermal characteristics of intertidal mussels at sites spanning 14° of latitude, along the west coast of the U.S. Our results show that the interaction of terrestrial climate with the timing of low tides creates a complex mosaic of thermal environments, in which high latitude sites can be more thermally stressful than lower latitude sites, organismal temperatures are often quite different from air temperature, and within-site variability due to the effects of substratum angle exceeds differences spanning several thousand km. As a result, patterns of thermal stress based on body temperature at low tide vary dramatically from those predicted by water or air temperature alone. Climate change may thus not lead to a poleward shift in the distribution of intertidal species in the Northeastern Pacific, but instead may cause localised extinctions at a series of "hot spots." Patterns in exposure to extreme climatic conditions are shown to be temporally variable, and tidal predictions suggest that in the next 3-5 years "hot spots" are most likely to appear at several higher latitude sites.

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Inglis, Graeme J.*[1]

Finding an invader before it becomes invasive: tools for the design and implementation of marine pest surveys.

Rates of population growth and range expansion are highly variable among alien species. Many appear to remain in small abundance and do not spread far from their initial point of introduction. Others spread rapidly to become abundant across a wide area and range of habitats. By definition, only this latter class is considered invasive and it is these species that managers of natural resources are most concerned with. Interventions to reduce their impacts on native species are usually only practical if the invader can be detected early, while it is still locally rare. In this paper I examine patterns of prevalence of a range of invasive and non-invasive marine species and discuss the practicality of early detection in marine environments. Case studies are used to illustrate the utility of a range of statistical and predictive tools for estimating and improving detection probabilities in marine pest surveys.

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Kingsford, Mike*[1]

The influence of El Nino on temporal patterns of reef fish abundance.

Variation in climatic conditions is thought to have a major influence on the structure of reef fish populations. Patterns of abundance of a reef fish, *Parma microlepis* (Pomacentridae) were estimated over a 15 year period. In this time there were multiple La Nina and El Nino events. The Southern Oscillation Index (SOI) is used as a proxy for variation in climatological conditions. It was hypothesised that climatic change could cause variation in the quality of habitat and the recruitment of fish by influencing the survival of larvae. Total abundance of fish showed little variation despite some changes in habitat quality. Recruitment varied among years in Botany Bay, Australia, but there was no relationship with SOI at small spatial scales. Fish were collected at larger spatial scales of tens to hundreds of kilometres and were aged using otoliths. There was a significant relationship (17-20%) between size of a recruitment cohort and SOI, recruitment was generally greatest in El Nino conditions. Relationships between climate and population variables, therefore, are scale dependent. Despite variation in postsettlement process, the signal from climatic variation is robust enough to be detected in a species that have 'storage effects' of up to 47 years.

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Leaper, Rebecca*[1], Mike T. Burrows[2], Mike A. Kendall[1], Nova Mieszkowska[1], Pippa Moore[1], Alan J. Southward[1], Richard C. Thompson[3] and Steven J. Hawkins[1]

Can intertidal species be used as indicators of global climate change? Measuring and predicting responses of marine ecosystems in the North East Atlantic.

In recent years global warming has caused rapid changes in the maritime climate of the North East Atlantic, which are predicted to accelerate over the next century. Whilst these rapid changes are predicted to have large effects on marine biodiversity, through alteration in the distribution and abundance of marine organisms, to date few studies have examined climate change impacts explicitly. Experimental approaches are difficult, and often we have to look at circumstantial evidence, comparing the past record of changes in distribution patterns and relative abundance of different species in relation to measured changes in the environment. Offshore to Plymouth we are fortunate to have long term records that show a period of warming (1950's), followed by cooling (1980's) and then recent accelerated warming and we have assembled a variety of biological data sets collected over the same time period for the whole UK. They include broad scale semi-quantitative surveys, quantitative surveys of abundance at a limited suite of sites and descriptions of population structure. These are used to demonstrate the advantages and limitations of intertidal species as indicators of responses of biodiversity to climate change. Some species such as barnacles are shown as good indicators. Southern trochid species have shown recent range extensions and a southern limpet (*Patella depressa*) has also increased in abundance compared to the 1980's and is now comparable in abundance to the 1950's. Whilst we must maximise the use of existing data, of great value but collected in a less statistical rigorous manner, new programmes must incorporate sufficient statistical power to separate local from regional and global change.

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Leslie, Heather*[1]
A critical evaluation of marine conservation planning approaches.

Choosing priority areas for conservation action has been largely ad hoc, based on opportunistic rather than strategic choices. In terrestrial environments, conservation practitioners have developed multiple approaches that have been implemented in a limited manner by international conservation organisations (e.g. Myers and colleagues' 'hotspot approach', and Olson and Dinerstein's 'Global 200'). In marine systems, however, conservation planning has not been as well documented or as prevalent. Information is scattered throughout the peer-reviewed and grey literature, and in the heads of individual scientists and managers. Consequently, compilation and careful evaluation of these data are tremendously important, so that future marine conservation activities build on lessons learned in earlier efforts and make the best use of limited resources.
To evaluate the contexts in which different approaches can be used most effectively, I have assembled a database of marine conservation cases based on the literature and interviews with conservation professionals. The 25 focal cases, spanning three decades and including planning areas of <100 to >1,000,000 km^2, include implementation of marine reserves, siting of other marine protected areas, and priority-setting exercises. Lack of available data has not only influenced the approaches taken, but also currently impedes full evaluation of existing knowledge as the majority of these cases have not been well documented. Nonetheless, the data suggest international non-governmental organisations and national governments are among the leaders in implementing systematic conservation approaches in the sea, and that the majority of initiatives are regional in nature, i.e. transcending state, provincial or national boundaries.

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Levin, Simon A.*[1] and Jerome Chave[2]
Perspectives on scale in marine systems.

This lecture will discuss how perceptual scale affects our description of marine systems, and the interplay among processes operating on distinct scales of space, time and organisational complexity. It will briefly review scaling laws in natural systems, and problems of detecting scales. It will then discuss the adaptive significance of scale, and the emergence of power laws. The relationship among processes on different scales will be explored by means of statistical mechanical and other methods. Finally, the lecture will discuss scale and complex adaptive systems.

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Lubchenco, Jane*[1] and Bruce Menge[1]

Climate change and North Eastern Pacific rocky shores: insights from the Pacific Decadal Oscillation.

Climate change is likely to result in multiple alterations to the physical environment that affects coastal marine ecosystems, including changes in the thermal regime, sea level, patterns of precipitation, winds, currents, waves and storminess. For coastal upwelling systems, changes in ocean circulation and in patterns of wind-driven upwelling may have especially profound consequences. Differences in the frequency and intensity of upwelling is now known to have strong impacts on patterns of productivity, recruitment, intensity of biological interactions and overall patterns of community structure and dynamics. The recent shift in the Pacific Decadal Oscillation, and accompanying alteration in the patterns of upwelling, appears to be influencing the nearshore ecosystems of Oregon in ways that may provide insight into effects of climate change on these and similar coastal ecosystems.

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Lubchenco, Jane
On behalf of The Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO). The science of marine reserves: video and brochure.

Interest in marine reserves is increasing around the world, due in part to the burgeoning awareness that many ocean ecosystems are becoming seriously degraded and disrupted. For example, in the US, more and more scientists are being asked by citizens, policy makers, fishermen and conservation groups to explain what marine reserves are, what is known about their track record and what factors should be considered in siting reserves or networks of marine reserves. At the same time, new scientific information about reserves is emerging rapidly, from multiple disciplines.
"Marine Reserve" is defined as "an area of the ocean that is permanently and completely protected from any destructive or extractive activities, except as needed for research or monitoring purposes." Reserves are also called "no-take" areas. Marine Reserves are a special category of Marine Protected Areas (MPAs). An MPA is "any are of the ocean that is managed with some conservation intent." A "Network of Marine Reserves" is a group of reserves within a biogeographic area that is connected by larval dispersal or juvenile or adult migration, or all three."
In order to help share new scientific knowledge about reserves directly with the interested, lay public, the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) recently developed a 15 minute video and accompanying brochure, both entitled "The Science of Marine Reserves." The Video was produced by Sea Studios. Information on both products or copies of either are available from http://www.piscoweb.org Both video and brochure reflect much of the newly developed or synthesised scientific information on reserves that emerged from the first Working Group on The Science of Marine Reserves held at the National Center for Ecological Analysis and Synthesis (NCEAS), in Santa Barbara, CA, USA. A Special Issue of Ecological Applications consisting of 18 papers from this NCEAS working group will be published in early 2003.

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Menge, Bruce A.*[1], Tess L. Freidenburg[1], Melissa Foley[1], Greg Hudson[1], Matt Bracken[1], Karina Nielsen[1], Francis Chan[1] and Jane Lubchenco[1]

Coastal oceanographic regime predicts rocky intertidal community dynamics.

In recent years, ideas on how "model" systems such as rocky intertidal communities are structured has shifted from a predominantly "top-down" perspective, emphasising consumer-prey interactions as the primary determinants of structure, to a coupled "top-down/bottom-up" perspective, where top-down effects are a consequence of processes operating at the base of the food chain, such as nutrients, production, and the supply of propagules. This paradigm shift reflects efforts to examine the dynamics of rocky intertidal communities at larger spatial scales, and the realisation that "meso-scale" (10's to 100's of km) variation in oceanographic conditions has major ecological consequences. Oceanographic processes impact coastal communities through several "channels," delivering nutrients for primary producers, particulates (phytoplankton, zooplankton, detritus) for filter-feeding invertebrates, and propagules ("recruitment") for macrophyte, invertebrate, and fish populations. A "multi-channel model of benthic-pelagic coupling" for shallow hard-bottom marine ecosystems focuses on several issues, including determination of the relevant oceanographic transport mechanisms and the differential responses of propagules, particulates and nutrients; evaluation of the relative impacts on community structure of the different channels; determination of the generality of the model in space and time; and the application of new insights to issues of human concern. Tests of the model in coastal ecosystems along the west coasts of the US and the south island of New Zealand support predictions that the strongest bottom-up and top-down effects occur on coasts adjacent to intermittent upwelling, weak effects occur in downwelling regions, and that only nutrient effects are strong in persistent upwelling regimes. Comparable results in northern and southern hemispheres suggest the model is general on a global scale.

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Navarrete, Sergio A.*[1] and Evie A. Wieters[1]

Upwelling and shadows: spatially dynamic community regulation and the fuzzy signal of bottom-up factors over meso-scales.

The idea that bottom-up processes can be responsible for considerable variability in the structure and dynamics of benthic communities is gaining support among benthic ecologists. In these systems, there are two primary bottom-up inputs, nutrients and phytoplankton, which enter the benthic community at the basal trophic level, but feed different community pathways and can be spatially de-coupled. Secondary bottom-up processes occur from macroalgae to herbivores and from filter feeders to carnivores. In this conceptual framework, recruitment by itself is not a bottom-up factor. Yet, by controlling the abundance of a trophic level, recruitment variability can dampen, enhance, or completely erase the primary bottom-up inputs and be a determinant factor of variation at higher trophic levels. We investigated the strength of some of these pathways along the coast of central Chile. Results suggest that nutrients and phytoplankton biomass are spatially de-coupled along the coast, with higher nutrient concentration at upwelling centres and high nearshore phytoplankton biomass at areas of upwelling shadows, downstream from upwelling centres. Nutrients produce faster growth rates of some macroalgae: These effects can propagate through the food web in complex ways that involve different pathways and trophic levels. Higher phytoplankton biomass seems to be responsible for slightly higher filter feeder growth rates. However, filter feeder recruitment largely determines available biomass for carnivores and, therefore, phytoplankton inputs do not cascade-up the food web. Human impact on herbivores and carnivores further complicates assessing community responses. Determining the strength of the link between phytoplankton biomass and recruitment of mussels, herbivores and carnivores appears to be critical for further progress.

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Pinkerton, Matt*[1], Philip Boyd[2] and Kenneth Richardson[1]

Ecological observation on appropriate scales: ocean colour remote sensing in the New Zealand coastal zone.

Satellite ocean colour remote sensing has proved valuable in providing regular, synoptic, large-scale measurements of phytoplankton abundance in the upper layers of the open-ocean. Recent work has validated the approach around New Zealand, and linked the large-scale view from space with ecological studies from research vessels. Applying similar ocean colour remote sensing technologies to coastal and shallow waters promises to offer new insights into their ecology, but requires that a number of important issues be addressed. The scales of temporal and spatial variability in coastal waters are typically many times shorter than those of the open ocean, with consequences for the resolution of sensors. The recent launch of a number of new ocean colour remote sensors provides the prospect of a multi-remote-sensor approach to ecological monitoring, combining satellites and aircraft based approaches. The vast increase in data quantity will require a corresponding advance in the sophistication of the management and interrogation of the data.
Material in the water column not of phytoplankton origin, such as inorganic suspended sediment and terrigeneous yellow substance, makes the interpretation of satellite ocean colour measurements complex in the coastal zone. Important recent advances are the development of a coupled atmosphere-ocean model to discriminate water and atmospheric reflectance over turbid waters, and a new generation of interpretive models for optically-complex waters. Novel products being developed to probe ecosystem functioning include primary production rates, total particulate matter concentration, absorption by dissolved coloured organic matter, discrimination between different phytoplankton pigment assemblages, and air-sea gas exchange rates of biogenic gases. It is likely that such models will need to be tuned to local bio-optical and ecological conditions to work accurately. Early work in this direction around New Zealand are encouraging.

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Reed, Dan*[1], Sally Holbrook[1 2] and Carol Blanchette[1]

Differential reproductive responses to environmental fluctuations in three species of marine plants with contrasting demographies.

Reproductive effort is often closely tied to environmental conditions and the availability of resources. Consequently, in temperate zones regional as well as seasonal variation in fecundity is the norm. Surprisingly few studies, however, have examined the extent to which fecundity varies across smaller spatial scales where resource gradients are thought to be small. Here we contrast temporal (intra- and inter-annual) and spatial (among-site, within a region) variation in reproductive effort in three species of marine plants that differ in their reproductive strategies: the giant kelp *Macrocystis pyrifera* is short lived and reproduces year round; the palm kelp *Pterygophora californica*, has an intermediate lifespan and reproduces seasonally; and the surfgrass *Phyllospadix torreyi* is a long-lived clonal plant that flowers seasonally. We found high among-site variation in fecundity for all three species. Reproductive responses to temporal fluctuations in resources differed dramatically among the species, which may reflect species specific differences in demographic traits.

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Scheibling, Robert*[1]

Synergistic interactions among introduced species mediate a phase shift in the rocky subtidal ecosystem off Nova Scotia.

As accidental introductions of non-native species to coastal ecosystems accelerate on a global scale, there is a growing and urgent concern about the potential threats to biodiversity and the integrity of natural marine communities. Along the Atlantic coast of Nova Scotia, Canada, major changes in the abundance and composition of species that make up the community on the rocky seabed have occurred during the last two decades. These "ecosystem phase shifts" are associated with sequential introductions of three non-native species: 1) a pathogenic amoeba (*Parameoba invadens*) that kills off sea urchins (the dominant herbivores), enabling kelps and other seaweeds to thrive; 2) an epiphytic bryozoan (*Membranipora membranacea*) that encrusts kelp fronds, causing severe defoliation of kelp beds; and 3) a green alga (*Codium fragile* spp*. tomentosoides*) that exploits windows of opportunity created by the former species to become established and spread rapaciously. These introduced species appear to have acted synergistically to facilitate transitions between alternative phases of this ecosystem: from sea urchin barrens to kelp beds and, most recently, to what is perhaps the most insidious and persistent phase, *Codium* meadows. I'll examine interactions between native and introduced species that mediate the phase shifts, and discuss the implications of these changes for the structure and functioning of the ecosystem, and the resources we extract from it.

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Schiel, David R.*[1]

When is the demography of key species a major driver of community structure? Comparisons and examples from the intertidal zones of New Zealand and Oregon.

Most models of marine community structure are based on species, particularly filter-feeding invertebrates, whose larvae develop in the plankton and are reliant on complex nearshore processes to reach shore and settle. However, large tracts of New Zealand shores are dominated by seaweeds that have no obligate planktonic phase and whose propagules spend little time in the nearshore water mass. In such cases, highly localised differences in demographic traits of dominant species may assume considerable importance in community structure and recovery from disturbance. The fucalean alga *Hormosira banksii* dominates extensive areas of the mid intertidal zone of semi-protected shores in southern New Zealand. Highly localised differences in reproduction, settlement and density-dependent recruitment have great effects on *Hormosira* populations and overall community structure. There are few macro-grazers present in the algal beds, only an average of 7-10 species per $1m^2$ quadrat and no other perennial species that can displace *Hormosira*. In contrast, in the less exposed shores of Oregon where *Fucus* and *Pelvetiopsis* can be abundant, there are up to 50X the number of grazing invertebrates, double the number of species present and several perennial species that can potentially displace fucalean algae. In these circumstances, demographic processes can have complex interactions with ecological processes. With continuing threats to coastal ecosystems, such as ocean warming, urbanisation and invasive species, understanding the demographic responses of key species will be necessary but not always sufficient to predict community responses.

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Schroeter, Steve*[1], Dan Reed[1], Danielle Toole[1] and David Huang[1]
Experimental studies on factors affecting the recruitment of two structure-forming reef species with contrasting demographies.

Two common assemblages found on subtidal reefs in southern California are lush forests formed by the giant kelp, (*Macrocystis pyrifera*) and a suite of understorey algae, and dense filter-feeding assemblages dominated by the gorgonian coral, *Muricea californica* that are largely devoid of macrophytes. The demographies of the dominant species in each of these two assemblages differ markedly. Giant kelp has a typical generation time of 18 months; a dispersal stage that remains in the plankton for times on the order of hours to days; and has fairly predictable recruitment (major episodes occur about every 1 to 3 years in southern California). *Muricea*, by contrast, is relatively long-lived (average longevity of 50 years); has a dispersal stage that remains in the plankton for about 30 days; and recruits much more sporadically than giant kelp (major episodes occur on a decadal time scale). The intensity and frequency of disturbance, recruitment and subsequent competition are thought to determine which of these assemblage prevails. Construction of a large artificial reef experiment in fall 1999 has provided a rare opportunity to examine some of these ideas by testing the effects of habitat availability and proximity to established populations on the recruitment patterns of these two important reef associated species.

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Steinbeck, John*[1], David Schiel[2] and Mike Foster[3]
Are long-term impact studies long enough?

One problem with many environmental impact studies is the absence of baseline data prior to a disturbance. Another problem is the short duration of these studies relative to the life cycles of many of the organisms potentially impacted. We were fortunate to study the effects of a thermal discharge from a nuclear power generating station in central California that had nine years of pre-operational data and ten years of operational data prior to our assessment in 1995. A BACI analysis that was modified to accommodate the multiple control and impact stations in the original study design was used to assess the impacts of the thermal discharge on intertidal and shallow subtidal algae, invertebrates and fishes. The controversial nature of the project required us to develop a completely transparent approach for data selection, screening, and analysis. Our results support the need for longer-term studies to account for the life cycles of the potentially impacted organisms and oceanographic or other background variation that may interact with the effects of the disturbance affecting the magnitude and spatial scale of the impacts. The need for longer studies is also supported by our observations that the impacts were largely unpredictable and chronic effects from the thermal discharge caused continuing changes in the biological communities many years after the plant began operating.

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Stewart-Oaten, Allan*[1]

Roles for controls: precision and robustness.

One part of assessing local effects of an environmental alteration is to compare a time series of the variable of interest (e.g., estimated abundance of some species) at the Impact site Before the alteration to a time series taken after it. The BACI approach attempts to make this comparison more precise (smaller errors in estimates of effect) and more robust (more accurate estimates of the size of these errors) against large scale natural variation with low frequency but long-lasting effects. It is potentially useful if (1) abundances at the Impact site do experience large fluctuations with long-lasting effects, especially some with low frequency, and (2) it is possible to choose "Control" sites which largely share such fluctuations, so their influence on effect estimates can be substantially removed.
The answers to (1) and (2) are likely to depend on the species, the variable of interest, the site and its surroundings, and other factors, so empirical information from a variety of settings will be helpful. The Channel Islands National Park (CINP) Service has sampled about 80 species at 16 sites in the Santa Barbara Channel Islands annually for the last 20 years. I discuss aspects of these data, such as the relative contributions of sampling error and natural fluctuations to overall variation, the presence of large, low-frequency variation and of long-term or complicated serial correlation, and the ability of sites, or parts of sites, to "track" each other in ways useful for BACI assessment.

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Syms, Craig*[1]

Spatial pattern analysis as a stop-gap approach to dealing with messy impact assessment data: is it really as easy as it sounds?

Environmental impact assessments are often conducted using messy data. Impacts rarely fulfil the conditions required to be treated either as randomised or controlled experiments hence establishing causality is problematic. A common situation confronting the researcher is to establish whether a chronic point source impact has had an effect, in the absence of data prior to the impact, and sometimes even without suitable spatial controls. Analysing spatial patterns of organisms at and around the putative impact site has been suggested as a solution to this problem, however this approach is logically hampered by the asymmetry of pattern and process. Absence of spatial pattern associated with impact implies no effect; but the presence of pattern does not necessarily imply effect. Unfortunately, the problem is even more complex. Correctly measuring and estimating strength of spatial pattern is not a trivial procedure. The value of a sample in space is a combination of 'fixed' components described by location, and two 'random' components - one in which the value depends on other values within some distance range, and the other corresponding to sample error. Researchers are therefore tasked with decomposing one pattern into three components - each with unknown levels of uncertainty about their 'true' value. The appropriate choice of method depends on the hypothesised response, assumptions the researcher is prepared to make about covariation between data, and the amount of data available to estimate the components of spatial pattern. These choices lie along a continuum, illustrated using a hypothesised impact in Monterey Bay, California.

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Underwood, Antony J.*[1]
Analysing potential impacts: complications about spatial scales.

Many impacts have unpredictable spatial extent. For example, flow and dispersion from an outfall can be modelled. Uptake of contaminants to concentration that may affect ecological measures is, however, determined by complex biological process. Modelling will not be precise enough. In many cases, spatial extent of a potential effect is simply not knowable in advance. So, we need sampling designs to deal with hierarchical scales. Univariate, beyond BACI designs are straight-forward to implement and interpret. They will be illustrated. A real example will be considered of impacts (due to a sewage outfall) being very different depending on the spatial scale examined. Multivariate frameworks are much more tricky. An example involving release of acid sulphate soil from a mangrove forest will illustrate the issues and possible solutions.

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Underwood, Antony J.*[1]
Hierarchies, confusion and issues in analyses of spatial patterns in ecology.

Recent renewed interest has been expressed in analyses of spatial patterns. Solutions to many interesting problems require such information. Properties of spatial hierarchies require certain tools to be used. Hierarchical analyses will be discussed here to illustrate how to deal with inappropriate spatial models; analytical systems to bypass issues of different precision at different scales; the non-value of so-called staggered designs and effective ways of transferring estimates of variance to bypass attempts to log-transform zeroes.

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Underwood, Antony J.*[1]
Research agendas for coastal ecological consequences of global warming.

Whatever the rate and amount, must climate modellers agree that global warming is happening. Consequences to coastal habitats seem to be likely as a result of various changes. These are (in no particular order):
· Warmer weather, causing shifts in latitudinal distributions of organisms (?);
· Rising sea levels, causing major loss of habitats where gradients are not uniform across shores;
· Increasing frequencies of storms, causing all sorts of complex changes to ecological processes;
· Increased variance in rainfall (at least in Australia), causing shifts in vertical patterns of distribution around estuaries (?)
Research needs and initiatives to help offset these problems will be briefly discussed, with some practical examples from south-eastern Australian shores.

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Wing, Stephen R.*[1]

Population networks in the New Zealand fjords: an example of source sink structure across an environmental gradient.

Spatial structure of marine populations is a vital determinant of their dynamics. In this example, a study of population structure of the sea urchin *Evechinus chloroticus* across the Doubtful-Thompson Sound complex indicates that inner-fjord subpopulations likely form reproductive sinks and those populations with high gamete production near the fjord entrances likely form larval sources. Large differences in abundance, growth, gonad development and larval settlement were observed at nine sites across the fjord complex. The highest growth rates and gamete production occurred at the entrances of the fjord. Variability in growth among sites likely reflected differences in nutritional history, as indicated by the Aristotle's lantern index and studies of diet. The highest abundance and aggregation of sea urchins occurred at mid-fjord sites which coincided with the highest rates of larval settlement, suggesting limited larval supply elsewhere. These observed spatial patterns in vital rates were used to evaluate the likely influences of spatial heterogeneity in larval production on larval dispersal patterns within the fjord based on particle movements within a validated hydrodynamic model. Each of these analyses indicates that a strong source-sink population structure is the most likely explanation for the patterns observed in this system. As a consequence the dynamics of this population may be particularly sensitive to influences on adult abundance within the source regions. In Fiordland this includes exploitation, habitat conversion and changes in larval transport through changes in the hydrodynamic environment. Examinations of population structure across the 14 fjords in the Fiordland region using direct methods and genetic markers indicate that the same structure observed in Doubtful Sound may apply broadly to the system. These findings have important consequences for our understanding of population structure of meroplanktonic organisms living in the New Zealand fjords and for spatial management and conservation in this system.

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Zimmerman, Richard C.*[1]

Hyperspectral remote sensing of optically shallow waters.

Remote sensing provides an extremely useful tool for spatial analysis of ecosystem processes. The complex and variable nature of coastal waters, however, creates problems for the remote sensing analysis of shallow submerged habitats. A new generation of imaging spectrometers can now deliver the resolution (1 to 3 m spatial, 5 to 15 nm spectral) necessary to study important ecosystem processes in critical nearshore environments across scales of meters to km. The continuous spectral information provided by this new technology permits the application of laboratory based spectroscopic approaches, such as high-order derivatives, to the analysis of remote sensing imagery. We are developing algorithms to identify submerged plant communities and quantify their abundance in optically shallow waters from data sets produced by the airborne imaging spectrometers PHILLS and HyMAP. Effects of depth and suspended and dissolved water column components (e.g. phytoplankton, sediments and coloured dissolved organic matter) on algorithm accuracy are being explored using both numerical simulation and field observations. Strong infrared signals from floating surface canopies may be useful to assess age structure and productivity of giant kelp forests, helping to identify important changes in environmental quality across time and space. We are testing the ability of these algorithms to detect changes in the distribution and productivity of seagrass meadows in the Bahamas and giant kelp forests in California.

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Contributed Papers

Airoldi, Laura*[1]
Sedimentation and community structure on rocky reefs.

Sedimentation is a widespread and increasing process on most rocky reefs. I reviewed the literature on its effects, and found support for the general conclusion that sedimentation is an important ecological factor for reef organisms. Sediments deeply affect the structure and dynamics of reef communities, and increased sedimentation as a consequence of anthropogenic activities can be a threat to their diversity and functioning. Sediments are important agents of stress and disturbance: they cause burial, scour and profound modifications to the characteristics of the bottom surface, and interact with other important physical and biological processes. The ecological effects of sedimentation are complex: they involve both direct outcomes on settlement, recruitment, growth or survival of individual species and indirect outcomes through mediation of competitive and/or predator-prey interactions. Not all species and communities are equally affected by sedimentation, and responses vary over space and time, depending on the characteristics of the depositional environment, life histories and the stage of development of organisms, and in relation to variable physical factors, including hydrodynamics, light intensity and bottom topography. Recent studies have much improved our ability to detect and understand the effects of sedimentation on rocky coast assemblages. However, little is still known about the underlying mechanisms. Overall, generalisations and predictions are hindered by a paucity of quantitative and experimental research, and by the scarce attention devoted to measure the regime of perturbation by sediments and responses of organisms at relevant spatial and temporal scales.

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Anderson, Marti J.*[1] and Angus A. Thompson[2]
Multivariate control charts for ecological and environmental monitoring.

Monitoring ecological assemblages, such as those inhabiting temperate reefs, has become increasingly important, with increasing threats from human disturbances in coastal habitats. Monitoring usually involves sampling from several sites of a similar habitat at regular (or irregular) intervals through time. The purpose of monitoring is to determine where and when an impact may have occurred or, once detected, may still be occurring. Sequential statistical methods, including control charts, as developed for industrial applications, offer some promise in this regard. These provide a way of identifying when a system (e.g. in a factory) is going "out of control," so as to trigger an alarm to stop the system and employ appropriate remedial measures. Such techniques clearly would be useful in the context of ecological monitoring. Traditional control charts, however, cannot be used for many ecological applications because they do not handle multivariate data and individual counts of species abundances do not generally fulfil the necessary statistical assumptions. A distance-based multivariate control chart method is described here, with examples of its use in tropical and temperate reef fish assemblages, that is flexible, as it can be based on any dissimilarity measure of choice, and useful as it does not require strict assumptions regarding variables. It is designed to identify impacts at individual sites as quickly as possible, thus triggering an "alarm bell" in the context of ecological monitoring.

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Barrett, Neville*[1], Graham Edgar[1], Colin Buxton[1] and Alastair Morton[1]
Changes in Tasmanian Marine Protected Areas following a decade of protection.

Tasmania's first 'no-take' MPAs were established a decade ago for conservation purposes. At this time a monitoring program was initiated to document changes occurring in the MPAs and to compare these with changes at external (fished) reference locations. By surveying reef fishes, invertebrates and plants on an annual basis, a comprehensive database has been established allowing some understanding of natural variability at this temporal scale and the extent that fishing, introduced species and range-extensions of habitat modifying species can influence this. Changes within the MPAs over this period indicate that fishing has had a substantial influence on the demographic structure of many species, particularly those targeted by fishers, although the magnitude of change detected depends on the susceptibility of species to capture, the remoteness of protected locations and MPA design. Changes within the remote Maria Island MPA (the largest) relative to reference sites have included increases in the abundance of lobsters and susceptible fish (*Latridopsis forsteri*), increases in the mean size of rock lobsters and a decrease in the abundance of prey species such as urchins and abalone. A 30% decline in the abundance of common urchins within the Maria Island reserve may be the first Tasmanian evidence of cascading ecosystem effects related to protection from fishing, while a strong decline in abalone numbers suggests an inverse relationship between exploited predatory species (presumably lobsters) and abalone. These results show MPAs at the Maria Island scale (7km) can be effective conservation reserves and invaluable reference areas for determining and understanding the effects of fishing in the absence of historical baseline data.

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Behrens, Michael D.*[1] and Kevin D. Lafferty[2]
The kelp forest barrens dichotomy: multivariate description, community patterns, and the effects of reserves.

Kelp forests and echinoderm barrens are alternative community states in temperate near-shore communities. Utilising data from the Channel Islands National Park Service's Kelp Forest Monitoring database, we were able to conduct a discriminant function analysis to describe the continuum between these two states and quantify site/year combinations with respect to their similarity to kelp forests or barrens. We used this measure to determine which species associate with different states. We also tested the effect of no-take reserves on kelp forests, finding that areas inside reserves were more likely to be kelp forests. We suggest that this results from cascading effects of fishing lobsters outside of reserves, which releases herbivores (urchins) from predation. Additionally, using a multivariate analysis of species density patterns, we determined that the community structure within kelp forests differs between areas inside and outside reserves.

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Benedetti-Cecchi, Lisandro*[1]

How can we incorporate tests of hypotheses about changes in the variance of predictor variables in our experiments?

Manipulative experiments are a powerful tool that are largely used by ecologists to establish cause-effect relationships between predictor and response variables. The effect size of a defined process is commonly estimated with reference to differences between means of a response variable across treatments. In many experiments, values of the predictor variable change across replicates within a treatment (e.g. densities of predators in control units), so that an effect size identifies the extent to which changes in the mean intensity of a process affect changes in the mean value of the response variable. In contrast, the extent to which changes in the variance of predictor variables affect biological assemblages has been largely overlooked. In this paper, I seek to identify suitable experimental designs to enable tests of hypotheses on the separate and combined influence of variance and mean intensity of predictor variables. An example is offered where the influence of intensity and temporal variability of desiccation due to aerial exposure were assessed on mid-shore assemblages in the north-west Mediterranean, as part of a study on the impact of climate change. The extension of the procedure to the analysis of spatially variable processes will also be discussed.

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Bers, A. Valeria*[1] and Martin Wahl[1]

Do microstructures of marine organisms influence recruitment of epibionts?

Marine organisms often use multiple strategies for protection against fouling. These may consist of combination of physical, chemical and mechanical mechanisms. Recent studies have shown that microtextured surfaces (1-100 µm) either living or non-living may reduce fouling. In this study we investigate the role of surface microtopography (< 500µm) of different marine invertebrate species, such as crustaceans, echinoderms and bivalves, as a possible contribution to their multiple antifouling strategies. In field experiments, we exposed high resolution epoxy resin replicates of invertebrate surfaces to natural fouling. Abundances of recruits were determined and compared to those on untextured control resin surfaces in order to detect the influence of the microtopography on fouling rates. First results have shown that the surface structure of the European rock crab (*Cancer pagurus*) has repulsive effects on both barnacle and blue mussel larvae. This study contributes to the understanding of the interaction between microtopography of the substratum and larval settlement and emphasises the promising non-toxic antifouling properties of micro-textured surfaces.

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Blanchette, Carol A.*[1] and Steven D. Gaines[1]

Contrasting contributors to nearshore marine community structure around Pt. Conception, California.

Point Conception California is a well-known biogeographic boundary for many marine species. This boundary is coincident with several gradients in the physical environment around the point. Point Conception marks the boundary between two regions with very different circulation patterns. In the northern region, coastal winds are almost always upwelling favourable, but are more variable in winter due to storms. Coastal upwelling brings cold, nutrient-rich waters to the surface resulting in both cold sea surface temperatures along the coast, and high nutrient concentrations. In addition to temperature, however, a steep gradient in wave exposure occurs around Pt. Conception. Sites north of the point are fully exposed to large ocean swell and storms, while sites to the south are relatively protected from heavy wave action. These gradients in the physical environment are reflected in patterns of nearshore community structure around the point. Rocky intertidal communities north of Pt. Conception are dominated by macroalgae, and those south of Pt. Conception are dominated by filter-feeding invertebrates. Recruitment and growth of filter-feeding invertebrates is higher in the region south of Pt. Conception, while macroalgal growth rates are higher at sites north of Pt. Conception. These data suggest that the differences in upwelling intensity around Pt. Conception may ultimately drive these differing community trajectories around the point by favouring macroalgal growth and recruitment in one region, and filter-feeder growth and recruitment south of the point.

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Blockley, David*[1]

The effect of wharves and jetties on the assemblages living on intertidal seawalls in Sydney Harbour.

The fore-shore of Sydney Harbour, like many other coastal cities, has been heavily urbanised. This has seen the introduction of many artificial structures into the marine environment. One of the most common forms of artificial structure in the intertidal zone of Sydney Harbour are seawalls. These are vertical, or near vertical walls constructed mainly of locally occurring sandstone blocks or concrete. The walls generally extend from the low-tidal height to one or two metres above the high-tidal height and replace natural intertidal habitats, such as sandy beaches, mud flats and rocky-shores. Wharves or jetties are commonly associated with the seawalls of Sydney Harbour. These are used for a variety of purposes such as passenger ferries, private boat mooring, commercial shipping and marina access. Although research has been done looking at the intertidal seawalls and pilings associated with wharves as habitats, there has been no work done on the effects that wharves have on the assemblages on seawalls. At Rushcutters Bay, Sydney Harbour, there were several wharves built for the purpose of the Olympic Games that were subsequently removed. This gave the opportunity for experimentation that would otherwise have been technically unfeasible. The results from this experiment and analyses of differences between assemblages and of individual species in wharf and non-wharf habitats will be presented. In addition, the importance of using common managerial practices to aid in ecological research will be discussed.

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Bone, Elisa K.*[1] and Michael J. Keough[1]

Colony fragmentation and colonial integration in three species of encrusting bryozoans.

Modular colonial invertebrates are, due to their sessile nature, vulnerable to processes that damage the colony, including predation and physical disturbance. The resulting colony fragmentation means that growth and reproductive capabilities are not readily predictable by standard measures such as age. Understanding the population dynamics of modular animals requires knowledge of the causes of partial mortality and the nature of colony responses to these processes. An issue of particular concern is whether the fate of damaged colonies is predictable by age or size, or if other measures may be applied. We chose three common encrusting bryozoans and assessed their natural rates of fragmentation, along with colony responses to experimental fragmentation. In addition to considering age and size effects, we sought to determine whether variation in responses relate to the degree of colonial integration in each species, since damage repair requires the translocation of resources from viable areas of the colony to the damaged area. Using scanning electron microscopy, we calculated the number and size of pores and pore plates in the zooid walls. We discuss whether these characteristics are appropriate indicators of colonial integration, relating this to the responses of each species to experimental fragmentation.

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Bracken, Matthew*[1], Bruce A. Menge[1], Melissa M. Foley[1], David R. Schiel[2] and Jane Lubchenco[1]

Variation in benthic-pelagic coupling along productivity gradients.

Quantifying the link between nearshore and intertidal productivity is fundamental to understanding the structure and dynamics of intertidal communities. Because filter-feeding invertebrates assimilate phytoplankton and detritus from the seston, they serve as a mechanism for exchange of materials from pelagic to benthic systems. Using ammonium excretion rates of mussels as a proxy for nitrogen assimilation and metabolism, we demonstrate a link between nearshore organic particulate availability and filter feeders' metabolic and growth rates in New Zealand and Oregon. We exploited spatial and temporal variation in nearshore productivity between sites and more substantial productivity differences between New Zealand and Oregon to address the influence of variation in seston quality and quantity on mussel performance. Within a system, particulate biomass and phytoplankton concentration were positively related, with substantial variation between sites associated with oceanographic differences. However, while total organic particulate availability was similar in New Zealand and Oregon, phytoplankton concentrations were up to two orders of magnitude higher along the Oregon coast. As the total concentration of organic particulates increased, mussels' ammonium excretion rates increased. However, mussels at sites with higher growth rates and higher phytoplankton concentrations exhibited lower ammonium excretion rates. We propose that the efficiency of incorporating ingested nitrogen into new tissue versus its loss as ammonium depends on food quality: the nitrogen in phytoplankton is more easily incorporated into tissue, while the nitrogen in detritus is more readily excreted. We stress the importance of considering both the quality and the quantity of the seston, especially when comparing across systems.

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Broitman, Bernardo R.*[1], Sergio A. Navarrete[3], Carol A. Blanchette[2] and Steven D. Gaines[1 2]

Recruitment dynamics of intertidal invertebrates in the temperate East Pacific.

Several years of coordinated efforts from scientists of PISCO (USA) and ECIM (Chile) have allowed the monthly monitoring of the arrival of mussel and barnacle species along many locations in the West coast of USA and central Chile. The similar oceanographic and biological setting among hemispheres and the extensive spatial domain where monitoring programs have developed provides a unique opportunity to characterise the space-time structuring of larval delivery processes.
Utilizing a geostatistical framework we characterised the dynamics of larval arrival for a number of species and reconstructed the large-scale spatiotemporal pattern utilising ordinary kriging. We found that spatiotemporal patterns of larval arrival are remarkably consistent within hemispheres and appear strongly dependent of the oceanographic setting where monitoring sites are located. Utilizing a space-time statistics from coastal geophysical fields we detected that regions experiencing high recruitment are located in more dynamic oceanographic settings. We also detected very high spatial heterogeneity in larval arrival patterns as sites located short distances away may experience extremely different recruitment regimes despite the regional context where they are embedded.
The interhemispherical comparison suggests that recruitment dynamics are strongly dependent on the oceanographic setting supporting that nearshore transport mechanisms exploited by planktonic larvae may be very similar across hemispheres. The strong geographic component and the characteristic temporal and spatial scales detected provide an explicit framework to study the location, spatial scale and temporal exploitation regime within networks of marine reserves.

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Bulleri, Fabio*[1]

Effects of habitat structure on the development of intertidal epibenthic assemblages at different heights on a shore.

Habitat structure has been shown to be a major determinant of the structure of epibenthic assemblages. In intertidal habitats, cracks and crevices can offer shelter from physical factors, such as desiccation and temperature. The availability of these refuges can determine patterns of abundance and distribution of consumers and, indirectly those of their preys. Alternatively, crevices can represent favourable sites for the recruitment of sessile organisms. Since environmental conditions become more benign moving toward lower levels on the shore, it could be argued that the effects of crevices on surrounding assemblages should decrease in the same directions. Therefore, I proposed that the magnitude of differences between assemblages developing on complex (with crevices) and simple (without crevices) artificial surfaces would be larger at upper than at lower levels on a shore.
Panels with crevices were built by fixing on a PVC sheet six 12 x 12 x 3 cm sandstone plates and leaving a gap of 1.5 cm between each two contiguous plates. Panels without crevices were built mounting a single 24 x 36 x 3 cm sandstone plate on the PVC sheet. Four replicate panels of each complexity were then fixed at each the high and low-shore level. Assemblages were sampled after 3, 6 and 12 months from the start of the experiment and data were analysed by means of multivariate and univariate procedures.

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Burford, Martha O.*[1]

Genetic population structure and year-class formation in two nearshore species of rockfish (*Sebastes*) along the California coast.

Microsatellite genetic markers were used to investigate adult population structure and the structure of a new year-class within *Sebastes mystinus* (blue rockfish). Blue rockfish are non-migratory inhabitants of kelp and rocky reef habitats along the California coast with a pelagic larval and juvenile stage lasting over three months. I tested the hypotheses that both the adult population and the juveniles of the 2000 year-class were genetically homogeneous along the California coast. The adults were genetically homogeneous over large distances (approximately 900km). Analyses of five polymorphic microsatellite loci indicated no significant divergence in allele frequencies in the adult population (FST = -0.0004). In contrast, juvenile allele frequencies were significantly heterogeneous among distant locations (FST = 0.01), but homogeneous among adjacent locations (FST = 0.0001). The effective population size was estimated at approximately 8,042 to 80,416, dependent on assumed mutation rates. Given the ubiquitous nature and high fecundity of this species, the effective population size is probably much less than the actual population size. These results suggest that, despite a genetically homogenous adult population, newly-settled recruits are genetically heterogeneous in time and space along the California coast. I will discuss these results in the context of a continuing sample program, at expanded temporal and spatial scales, for the 2002 and 2001 year classes and contrast these findings with patterns in population structure of the congeneric kelp rockfish (*S. atrovirens*).

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Campbell, Marnie L.*[1 2] and Chad L. Hewitt[1 3]

Invasions coupled with biodiversity: did Elton get it wrong?

One primary tenant of the growing theory of biological invasions is that high diversity systems (communities or assemblages) have an intrinsic resistance to biological invasions. This has been supported both by mathematical models as well as field studies in terrestrial and aquatic systems. However, recent evidence indicates that the mathematical models used, emulate successional assembly systems rather than biological invasions and consequently, the assumptions are based on concepts associated with Island Biogeography Theory rather than introductions. In contrast, field studies appear to have ignored the relevance of scale in their evaluations resulting in either large scale or alternatively, local (fine) scale, evaluations of pattern. Using the encrusting fauna of port communities from around Australia, we evaluate the large (provincial), regional and local scales for linkage between native biodiversity and invasions. Large scale patterns suggest that a latitudinal gradient in both native and introduced species diversity exist, whereby native diversity decreases with increasing distance from the tropics while introduced diversity increases. In contrast, regional and local evaluations demonstrate that invasions are highest in sites and local assemblages where native diversity is highest. This suggests that factors which enhance native biodiversity in space act on invaders as well.

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Chan, Francis*[1], Bruce Menge[1], Karina Nielsen[1], Brian Grantham[1] and Jane Lubchenco[1]

Nutrient use efficiency regulates pelagic production in coastal ecosystems: patterns along the Oregon and New Zealand Coasts.

The primary productivity of marine ecosystems ultimately reflects the supply of nutrients to surface waters and the efficiency with which available nutrients (i.e. nutrient use efficiency, NUE) are used in plant growth. Among nearshore ecosystems, variations in coastal upwelling can result in spatially and temporally heterogeneous patterns in availability of nitrogen (N). In turn, local and meso-scale differences in nearshore productivity can be instrumental in mediating the structure and dynamics of benthic communities. Elevated planktonic production rates in response to the supply of nutrients through coastal upwelling have long been documented. In contrast, the role of NUE in mediating marine productivity, and cross-system variations in marine NUE have remained poorly characterised. We monitored the responses of pelagic primary producers to N-availability in sites along the Oregon and South Island, New Zealand coasts. In these near-shore waters, wide variations in phytoplankton biomass are strongly coupled to variations in NUE. Phytoplankton blooms are characterised by exceptional autotrophic monopolisation of N- pools. Size-fractioned chlorophyll and chemical partitioning of N-pools data suggest that declines in phytoplankton productivity and NUE reflect changes in phytoplankton community structure and increases in the dominance of biologically recalcitrant dissolved organic N in surface waters. Consideration of NUE and the mechanisms that regulate its variation may offer important insights into the controls on marine productivity and carbon and N fluxes to benthic communities.

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Chapman, M. Gee*[1]

Intertidal seawalls as surrogate habitats for rocky intertidal shores.

Intertidal seawalls are very common artificial structures in urbanised estuaries. For example, they make up more than 50 % of intertidal habitats in Sydney Harbour. These seawalls differ from natural rocky shores in many features. They are vertical, rather than gently sloping and, therefore, have a very narrow intertidal area. They also have smoother surfaces, may be composed of different material, such as concrete and lack many intertidal habitats, such as rock pools and deep crevices. Although many algae and invertebrates live on seawalls in Sydney Harbour, previous studies have not evaluated quantitatively these assemblages in comparison to those living on natural shores. This presentation will compare intertidal assemblages on seawalls and natural intertidal shores to test the hypothesis that assemblages differ between these two forms of habitats, with many species absent from or far less common on seawalls. In addition, in order to test the hypothesis that increasing the surface heterogeneity of seawalls, experimental modifications have been made to the manner in which seawalls are repaired by local councils. These modifications and their effects on the flora and fauna living on seawalls are described.

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Chapman, M. Gee*[1]

Using artificial structures and constructed boulder fields to test hypotheses about colonisation of mobile animals to intertidal boulders.

Intertidal boulder fields are not common habitats along the coast off New South Wales. Nevertheless, they are likely to be important for conservation of coastal biodiversity because a number of species that that live under boulders are very rare in other habitats. Many of these species show extremely aggregated patterns of dispersion, with a very large proportion of those present found under relatively few boulders. The factors that cause these strong patterns of overdispersion have not, as yet, been identified. In heavily urbanised areas, boulder fields are frequently disturbed by people foraging for urchins and large gastropods, which may adversely affect populations of this specialised fauna. Artificial "boulder fields" accumulate at the bases of seawalls from slumping of and subsequent repairs to the walls. If the sandstone blocks from degraded seawalls do provide suitable habitat for this fauna, repairs to seawalls may provide additional intertidal habitat if the blocks are not removed during repairs. This presentation discusses colonisation of sandstone blocks and constructed boulder fields by the fauna that usually live under boulders, to test hypotheses about the features of habitat to which this fauna may respond. In addition, the use of constructed boulder fields at the base of seawalls experimentally to increase biodiversity in a very urbanised bay in Sydney Harbour will be described.

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Clements, Kendall D.*[1] and Anthony J.R. Hickey[1]

Ecological speciation in New Zealand triplefin fishes.

The most frequently invoked mechanism of speciation in marine organisms is allopatric speciation. The idea that speciation can be driven by selection in the absence of geographic isolation (i.e. sympatric speciation) was proposed by Darwin, but has been highly contentious. Recently, theoretical and empirical support for sympatric speciation in terrestrial and lacustrine organisms has accumulated rapidly, and methods for its detection are being developed. Demonstration of sympatric speciation is difficult in the sea, where the combination of high dispersal (via larvae) and incomplete geographic barriers often leads to huge ranges for many taxa, and raises the possibility that sympatric distributions were once allopatric.

Triplefins are small, blennioid fishes that are the most abundant component of New Zealand's shallow reef fish fauna. The NZ triplefin fauna is the most diverse in the world with 27 species, all of which are endemic. Our studies on the evolutionary relationships of these fishes show that almost all of the species belong to a single monophyletic group, and therefore the NZ fauna represents a local evolutionary radiation. Most NZ triplefin species have overlapping, sympatric distributions, and our genetic studies on triplefin populations from around New Zealand provide no evidence for the geographic barriers to larval dispersal required for allopatric speciation. The strong species-specific microhabitat preferences of triplefins and their use of demersal nesting sites provide an obvious mechanism for the habitat-assortative mating required by some models of ecological speciation in sympatry. We plan to test whether selection on ecological and physiological characters in the absence of geographic barriers led to the evolution of the NZ triplefin radiation.

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Clynick, Brianna*[1]

The value of marinas and associated structures as habitat for fish.

Marinas and associated structures are common features of waterways around coastal cities. To some extent, these structures appear to provide habitat similar to natural reefs in that many species of fish are common around marinas. Previous studies have, however, found that the numbers of animals and plants in these artificial habitats are different from those associated with natural habitats, which indicates that marinas may be considered novel habitats, quite distinct from natural habitats. It is therefore important to evaluate the effect such habitats have on marine biota and to understand the potential value they have as habitat for fish. Many fish of commercial importance use marinas, yet still little is known as to why such species are attracted to these habitats. Numerous reasons have been put forward in the past, such as increased shelter and availability of food, but questions remain about the distribution of fish within marinas and how this distribution relates to biotic and physical factors. The abundance and diversity of fish found in marinas may be related to the structure and size of the marina, the distribution of invertebrate assemblages growing on the structures and in the surrounding sediment and the proximity of natural habitats. Investigating these factors will help to determine if such artificial habitats may potentially mitigate the loss of natural fish habitats.

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Cole, Russell G.*[1], Niki K. Alcock[1], Glen Carbines[2], Rob Stewart[3] and Neil L. Andrew[3]

Links between habitat and fish assemblage structure in central New Zealand.

The local distribution of biogenic habitats is thought to influence the abundance of reef fishes in many parts of the world. Studies investigating those associations in New Zealand stem mainly from Northeastern New Zealand. We surveyed fish and habitat in Bay of Plenty, western Cook Strait, and Stewart Island in 2001-02. An initial search for pattern undertaken using logistic regression, linear regression, and regression trees revealed linkages between the occurrences and abundances of fishes and several features of habitat, in all three regions. Where species occurred in more than one region, the habitat features associated with the presence or abundance of a species were usually consistent. A second phase, in which canopy-forming seaweeds were cleared from replicate 10 x 10 m areas at D'Urville Island western Cook Strait, provided further evidence of the role that large canopy-forming seaweeds can play in structuring nearshore reef habitats. Temporal fluctuations in habitat may have important consequences for local fish populations.

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Coleman, Melinda A.*[1] and Susan H. Brawley[1]

Population genetic structure of *Fucus distichus* from high shore rockpools and its correlation with dispersal of gametes.

Patterns of genetic structure among fragmented populations of a species are important in understanding ecological processes such as dispersal and speciation. A useful model for such studies is *Fucus distichus*, a seaweed predominantly localised to high intertidal rockpools (10 to 20cm deep) in the Northwest Atlantic. This monecious alga can reproduce both through selfing and outcrossing. Earlier studies have proposed that the occurrence of selfing and subsequent genetic structure of *F. distichus* will be high at the scale of rockpools. This is because gamete release occurs at low tide during neap tidal series when pools are isolated from bulk seawater. We are using molecular markers to test the hypothesis that individuals within a single rockpool are genetically distinct from individuals in other pools. Individuals were collected from 5 rockpools within a 50 m stretch of shore at five replicate locations (up to 200 km apart) on the coast of Maine, (USA). Initial results with a microsatellite motif (L38 CAG) that is polymorphic in *F. vesiculosus* and *F. serratus* found *F. distichus* to be polymorphic at this locus. More loci are being tested to determine spatial patterns of genetic structure among rockpools. Since patterns in the genetic structure of organisms can often be correlated with scale of dispersion of propagules, we further hypothesise that dispersal of *F. distichus* zygotes among pools will be low and zygotes will tend to settle in the pools from which they originated. Hypotheses such as this are being tested through ongoing demographic, dispersal and genetic studies.

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Coleman, Melinda A.*[1]

Effects of ephemeral algae on coralline recruits in intertidal and subtidal habitats.

Coralline algae are an abundant and conspicuous component of intertidal and shallow subtidal algal turfs and are among the first type of algae to recruit into these assemblages. Initial experiments found the size and abundance of coralline recruits on recruitment plates to be negatively correlated with the percentage cover of ephemerals at each of three times. Cover of ephemeral algae was, however, also correlated with habitat (greater covers in intertidal than in subtidal habitats). These experiments evaluate the model that the cover of ephemerals negatively affects the sizes and abundances of corallines. It was predicted that the sizes and abundance of corallines would be greater where the cover of ephemerals is reduced, relative to where it is great. This hypothesis was tested in a field experiment that manipulated the cover of ephemerals in intertidal and in subtidal habitats (thus, unconfounding habitat from cover of ephemerals). It was found that in intertidal and in subtidal habitats coralline recruits were more abundant and grew larger where there was a great cover of ephemeral algae. In addition, in intertidal habitats, a great cover of ephemeral algae decreased mortality of coralline algal recruits by up to 65%. Thus, particularly in intertidal habitats, ephemeral algae have marked positive effects on the growth and survival of coralline recruits. These results are discussed in terms of their implications for models of succession.

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Coleman, Ross*[1]
Why do limpets clump?

Animals frequently choose to live in groups and the reasons for this have long been the subject of debate. There are obvious advantages. Group living should increase reproductive success, particularly important in free-spawning sessile invertebrates that predominate in marine systems. Reduction in predation risk through dilution, increased vigilance and associated predator avoidance has been the focus of attention, especially for highly mobile prey e.g. fish shoaling and bird flocking. Grouping may also reduce risk or stresses from the physical environment. These relatively different explanations have rarely been tested across the same species. Limpets are fundamental in rocky shore ecology, so therefore aggregation behaviours may have consequences for rocky shore assemblages. Here I discuss results from experimental studies testing hypotheses about (1) limpets detecting attacks on members of an aggregation and so modifying availability to predators and (2) desiccation responses on limpet aggregation behaviours. These studies seem to indicate that in any one situation, small scale local effects are always more important than desiccation and predator awareness per se.

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Connell, Sean D.*[1]
Suppression and exclusion of taxa from the assembly of alternate states of habitat.

Strong canopy-understorey associations form readily recognisable patterns that are repeated with great fidelity across Australia's temperate reefs. Our experiments have shown that canopies place strong constraints on the presence and abundance of taxa so that only particular subsets of species (e.g. encrusting algae) coexist as canopy-understorey. I will present experimental results from South Australia that separate the negative and positive roles of physical conditions (sedimentation x shade) modified by marine forests (canopy-forming kelp *Ecklonia radiata*) on the origin and maintenance of understorey and non-understorey algae. Negative and positive affects acted in synergy to actively facilitate the assembly of one habitat-state by suppressing the presence, growth and persistence of species that represent the alternate habitat-state. Furthermore, we established that understorey invertebrates that encrust rock also represent biased subsets of species from a local pool capable of colonisation. My recent experiments revealed that a reduction of light intensity and accumulation of sediment by canopies acted to facilitate recruitment, but physical abrasion by the canopy acted as a negative force to overpower these positive effects. Negative effects acted exclusively to exclude particular sets of invertebrates as understorey. The asymmetric strength of negative effects not only explains the enigma of exclusion of particular subsets of invertebrates, but also indicates that canopy- understorey coexistence reflects a more even match between positive and negative effects.

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Connell, Sean D.*[1]
Density-dependent growth and survival is more than just competition.

Understanding the relative effects of predation and competition in fish is made difficult because predators are attracted to abundant prey and competing prey reduce growth and survival of prey. The density-dependent effects of foraging (predation) and acquisition of over crowded resources (competition) need to be separated. This separation is important because some important and basic predictions about the roles of competition and predation overlap. Models of intraspecific competition predict that an increase in the density of prey results in a decline in growth and survivorship. If predators are attracted to larger numbers of prey and prey suffer slower rates of growth under heavier predation risk, however, then experiments that manipulate densities of prey to test the effects of competition maybe confounded by the effects of predators and competitors on growth. Hence, density-dependent growth and mortality cannot be unambiguously ascribed to the effects of predation or competition. Clarification of these issues could assist progress towards the conceptual understanding of the processes that may limit (e.g. recruitment-limitation) or regulate (e.g. competition v. predation) extensive spatial and temporal variation in the diversity and abundances of marine fishes and invertebrates.
I will present evidence from tropical and temperate reefs that highlight this need. Some of the more novel data will focus on South Australian reefs where I compare prey (magpie morwong *Cheilodactylus nigripes*) feeding in the presence and absence of the piscivorous New Zealand fur seal *Arctocephalus forsteri*.

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Crowe, Tasman P.*[1 2]
Mussels, pollution and biodiversity on UK rocky shores.

Human activities are causing a reduction in global biodiversity, but the relationship between localised anthropogenic impacts and marine biodiversity is poorly understood. Mussels (*Mytilus spp*.) maintain coastal biodiversity in many parts of the world by providing habitat for fauna and flora. Mussels persist in many polluted environments, but population structure, and hence the structure of the habitat they provide, can be affected by a range of environmental factors.
In this study, I tested the hypotheses that communities of macrofauna associated with mussels would differ in sites exposed to chronic urban/industrial pollution compared to relatively unpolluted controls and would exhibit reduced diversity. I also tested relationships between community structure and aspects of the mussel populations and the habitat they provided. Research was done at six rocky shores on the west coast of the UK. The diversity and structure of communities of macrofauna among mussels were found to be closely related to Scope For Growth (SFG - an integrated measure of stress in mussels) and to the concentration of Unresolved Complex Mixtures of hydrocarbons (UCM) in mussel tissues. A relationship between SFG and diversity of rocky shore communities has not previously been demonstrated. The findings suggest that SFG may be a valuable indicator of community-level impacts caused by chronic pollution. Small-scale variation in community structure also appeared to be related to the structure of habitat provided by mussel beds and the abundance of associated sediments.

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Denny, Chris M.*[1], Trevor J. Willis[1] and Russ C. Babcock[1]
Marine reserves protect targeted fish species.

Following the implementation of full marine reserve status at the Poor Knights in 1998, baited underwater video found that heavily targeted species showed significant increases in abundance relative to control sites. Snapper, *Pagrus auratus* and tarakihi, *Nemadactylus acropterus* were 12 ± 0.9 and 1.9 ± 0.7 times more abundant, respectively. Porae, *N. douglasii* took longer to show an increase and are now 4.1 ± 0.9 more abundant. The abundance of tarakihi decreased following the initial increase, but is still higher than pre-reserve status. Underwater visual census also showed an increase in abundance of snapper, porae, koheru, *Decapterus koheru* as well as the pink maomao, *Caprodon longimanus* and golden snapper *Centroberyx affinis*. Furthermore, large fish are becoming increasingly common at the Poor Knights with fish over the minimum legal size rare at the control sites. Seasonal trends were apparent for many species with tarakihi and porae numbers highest in spring (Sept/Oct) and snapper numbers highest in autumn (April/May). Data collected thus far has clearly demonstrated the effectiveness of the Poor Knights Marine Reserve in increasing the number and size of targeted fish species. The increase in snapper density in particular has been rapid, resulting from immigrating adult fish rather than from recruitment, and it is not yet clear whether snapper numbers have stabilised. Species relying on larval recruitment (pink maomao) may take longer to recover.

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Dunmore, Robyn A.*[1], David I. Taylor[2] and David R. Schiel[2]
Small scale variation in reproduction, dispersal, and early stage survival of large brown intertidal seaweeds produces large scale differences in their distribution and abundance.

Factors affecting the early life stages of marine organisms have received increasing attention because differences in survival of these stages can set the distribution and abundance patterns of adult populations. Successful recruitment to an adult population is a function of reproductive output and periodicity, dispersal and settlement patterns, and early life stage survival. We studied several species of perennial, habitat-forming seaweeds at Kaikoura, New Zealand and Oregon, U.S.A. to determine what limits their recruitment. We found that small differences in the demography of species can have large-scale consequences for their distribution and abundance. Reproduction varied from opportunistic, year-round activity to restricted annual peaks. Dispersal was locally variable around adult populations and some species may have restricted propagule dispersal on a larger scale. The resistance of the algae to physical and biological factors influencing their early survival also varied among species.

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Dunstan, Piers K.*[1] and Craig R. Johnson[1]

Relationships between stability, species richness and invasibility depend on species-specific size-dependent mortality in a marine epibenthic community.

Despite widespread acceptance of the spatial structure of ecosystems and the spatial nature of processes acting within them, there are relatively few examples of spatial models of specific systems. Here we investigate the spatial dynamics of a temperate marine epibenthic community in Tasmania with an individual-based spatial model of this community. The model is used to examine how spatial processes influence invasion resistance, stability, interactions among species and the growth rates of individuals. The model communities show emergent patterns of community structure, species diversity and evenness, species-specific size frequency distributions, and patterns of invasibility and stability that are similar to the natural community on which the model is based.
The invasibility of the community is strongly correlated with the stability of cover and thus with the availability of free space. However, the patterns of stability are strongly dependent on patch size. In small patches, community stability is positively correlated with species richness. In larger patches this pattern changes and community stability is negatively correlated with species richness. These changes are the result of species-specific differences in the relationship between colony size and the probability of mortality. Because larger colonies have a lower probability of mortality, when colonies attain large sizes and dominate space, reducing diversity, total cover is more stable and the community more resistant to invasion. These results suggest a broader continuum of relationships between stability, invasibility and richness that are strongly dependent on the exact relationship between individual size and mortality for each species in the community.

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Dürr, Simone*[1], Martin Wahl[1] and Andrew R. Davis[2]

Are conditions at early development important for the later assemblage?

We investigated the question if a change in wall height and/or grazer density (the sea urchin *Centrostephanus rodgersii*) would lead to a change in the structure of a subtidal rocky reef assemblage in South-eastern Australia. This could show us if early development conditions are important for the later structure of an assemblage and by that the significance of early recruitment for the later assemblage. For this purpose we attached unglazed ceramic tiles on three tall (> 4 m) and three small (< 2 m) vertical rock walls. Each wall was then split in half and urchin density was manipulated to high or low density for each half wall. After 22 months tiles were either transferred to a different combination of wall height and/or urchin density or left at the same factor combination. Photos of the assemblages on the tiles were taken prior to and one month after transfer. Statistical analysis of percent cover of species, total cover, species numbers and diversity was done with a change-over analysis. Results showed no carry-over effects from the earlier factors. But there were transfer effects. We conclude that conditions at early development of the assemblage were not as important for the structure of the later assemblage as later influences in our experiment.

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Edwards, Matthew S.*[1]

Factors regulating the southern range limit of giant kelp in the North Pacific Ocean.

The giant kelp (*Macrocystis pyrifera*) occurs from central California, USA to the central Baja California, Mexico. While its northern range limit relatively stable, set primarily by hydrodynamic forces and competition with the more wave-resistant bull kelp (*Nereocystis leutkeana*), its southern limit is highly dynamic, varying over a ~120 kilometre range during the past 20 years. Specifically, prior to the 1982/83 ENSO, the southern range limit occurred at Punta San Hipólito, BCS while following this ENSO, the southern range moved northward ~50 km to Punta San Roque, at the north end of Bahía Asunción, BCS. This range limit then remained stable until the 1997/98 ENSO when it again moved northward ~70 kilometres to Bahia Tortugas. However, unlike following the 1982/83 ENSO, this relocation persisted for only two years, with giant kelp recognising Punta San Roque in late 1999. Then, in late 2001, giant kelp recolonised Punta San Hipólito after approximately 20 years of absence, again setting the southern range limit at its pre-1982/83 ENSO location. I have investigated the physical and biological factors responsible for setting the southern range limit of giant kelp in the Northeast Pacific over the past seven years through both observational and experimental procedures. The primary factors responsible for setting this limit are availability of suitable substrate, elevated sea temperatures and the corresponding decreases in nutrients, and competition with the subsurface kelp *Eisenia arboraea*. The relative importance of the factors however, is highly spatially and temporally variable.

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Egli, Daniel P.*[1]

Ultrasonic tracking reveals multiple behavioural modes of snapper in a marine reserve: implications for conservation and fisheries management.

The potential benefits of marine reserves include increased abundance and size of animals within them, increased recruitment and maintenance of genetic diversity. Hence, marine reserves can be conservation and fisheries management tools simultaneously. Models of interactions between marine reserves and non-reserve areas have generally made simplistic assumptions about fish behaviour. Consequently there is a need for better information on fish behaviour at spatial scales relevant to models of reserves. Automated ultrasonic tracking of marine fish, applied in this study, offers the potential to continuously track individuals for periods up to several years within the study area. Snapper (*Pagrus auratus*) were surgically implanted with coded ultrasonic transmitters to monitor their movement within the Cape Rodney to Okakari Point marine reserve in NE New Zealand from October 2001 to present. The range of movement patterns observed includes some fish being resident for the entire tracking period, while others were more mobile. Some mobile fish left the array permanently and others have returned after varying periods. Nearly all fish showed some level of site fidelity for varying periods of the time they were tracked. Fish activity peaked in the summer, and the highest densities of fish were also recorded during this time. Relative fish density on reefs in the marine reserve varied by over 200% between summer and winter probably related seasonal migrations. Larger fish were also more active than smaller fish, travelling greater distances over the same periods of time and therefore more likely to cross reserve boundaries. Results suggest that snapper have more than one mode of behaviour, and that patterns of habitat utilisation vary between fish and also seasonally. Such complex range of behaviours may be a key component for achieving desirable outcomes for both conservation and fisheries.

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Fairweather, Peter G.*[1]

How far up? Extent of impinging upon rocky intertidal reefs by the Bonney Coast upwelling.

Upwelling off western Victoria and eastern South Australia has recently been implicated in attracting globally significant aggregations of blue whales feed over the continental shelf. Since then, attention has focussed upon this spatially and temporally variable upwelling. I asked to what extent upwelled water impinges upon nearshore coastal ecosystems, in particular rocky intertidal habitats. Could upwelling explain features of the biotic communities there? Nine sites over 250 km of this coastline have been monitored from 1998; these span the inside, outside and at the edge of the core upwelling field. Upwelling events were assessed by referring to satellite images of seas surface temperature and ocean colour (chlorophyll). Temperature loggers placed into intertidal rock pools were used to track water temperatures. Periodic water samples were analysed for nutrient (N, P, Si) and chlorophyll concentrations. Various methods were used to describe the floral and faunal assemblages quantitatively and qualitatively. Even when upwelling was strong on the shelf, pulses of very cold water were only brief and sporadic. Nutrients were elevated against open coast background levels but much less than for estuarine outflows or sewage outfalls. The, the likely effect on the rocky intertidal seems much less than might be predicted from overseas studies. Communities were dominated by coralline algal turfs with occasional blooms of chlorophytes, had very few sessile animals. Animal biomass was dominated by grazers and a scavenging snail *Cominella lineolata* that may act as a sink for production. These findings will be related to more general models of top-down versus bottom-up interactions.

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Feary, David A.*[1] and Kendall D. Clements[2]

Habitat use by triplefin species (Family Tripterygiidae) on rocky reefs in New Zealand.

Habitat use of thirteen species of rocky reef triplefins (F. Tripterygiidae) was investigated at twenty-six coastal and offshore locations in Northeastern New Zealand. Within these locations nineteen broad scale habitats and fifteen fine scale habitats were surveyed. In terms of broad scale habitat use, four triplefin species, *Bellapiscis lesleyae*, *Cryptichthys jojettae*, *Notoclinops yaldwyni* and *Ruanoho decemdigitatus*, were mainly distributed in shallow habitats from 0-5m. Within these shallow habitats these four triplefin species were all distributed in areas of high cover, provided by both topographical features and stands of large macroalgae. Three triplefin species, *Forsterygion flavonigrum*, *F. malcolmi* and *N. caerulepunctus*, were all predominantly distributed in broad scale habitats deeper than 10-15m, irrespective of broad scale habitat characteristics. Seven triplefin species, *N. segmentatus*, *F. lapillum*, *R. whero*, *F. varium*, *Karalepis stewarti* and *Obliquichthys maryannae*, used a wide variety of broad scale habitats, and were found throughout the reef irrespective of both depth and broad scale habitat characteristics. In terms of fine scale habitat use, although differences between species were distinguished, the majority of study species were distributed in a small number of distinct fine scale habitats. In terms of nesting sites the majority of study species encountered laid nests in microhabitats that were well sheltered from predation and physical disturbance despite being found in a variety of microhabitats throughout the year.

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Ferguson, Adrian*[1] and Andy Davis[1]

Invertebrates with attitude: spicule armament and defence in temperate reef sponges.

Sponges are ubiquitous members of marine benthic communities and represent a potentially valuable food source for many predatory species, yet they have few natural predators. An in situ method was used to assess the deterrent effects of siliceous spicules and whole sponge skeleton, which were hypothesised to act as a physical defence in temperate reef sponges. Natural concentrations of spicules and skeleton from six species of sponges were incorporated into artificial diets, which were similar in nutritional quality to the sponge tissues. These were offered to the sea urchin *Centrostephanus rodgersii* in a feeding choice experiment using control disks containing no spicules. Spicules from four species, *Pronax sp*., *Clathria pyramida*, *Chondrilla australiensis* and *Chondrilla sp*. caused reduced feeding by *C. rodgersii.* Spicules from a fifth species, *Callyspongia sp*., and intact skeleton, isolated from *Cacospongia sp*., failed to deter *C. rodgersii.* Thus, the morphology of the skeleton may be an important factor influencing the likelihood of physical defence against urchin feeding. This is the first study to demonstrate that sponge spicules, when incorporated into an artificial diet of similar nutritional quality to sponge tissues, serve an antipredatory function.

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Fowler-Walker, Meegan J.*[1] and Sean D. Connell[1]

Does the structure of marine forests predict understorey assemblages of algae across temperate Australia?

Description of spatial pattern is a vital step towards understanding ecological generality and predictability. One of Australia's most widespread canopy-forming algae is *Ecklonia radiata*, and therefore provides an excellent opportunity to test for broad scale generalities about the structure of these forests and their predictability of associated biota. I tested for relationships between the morphology of *Ecklonia radiata* and understorey assemblages of algae between different types of forest (monospecific v. mixed). This was done over multiple spatial scales spanning much of the longitudinal range of *Ecklonia radiata* in temperate Australia. The results of this research may provide the basis of predictive relationships between canopy-forming algae and understorey assemblages. This information will also be used to focus tests of hypotheses that identify causal relationships between morphology and the composition and abundance of understorey algae.

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Freeman, Debbie J.*[1]

Population dynamics and predation effects of spiny lobsters (*Jasus edwardsii*) in two East Coast New Zealand marine reserves.

Populations of spiny lobsters (*Jasus edwardsii*) have been monitored within and outside two east coast New Zealand no-take marine reserves since their establishment in 1997 and 1999. Within the two reserves, the rate of increase in lobster density, as well as the rate of increase in the average size of lobsters, is significantly higher than has been recorded for other New Zealand marine protected areas. In addition, differences in the structure of the lobster populations between sites have been detected, which may have implications for the reproductive output of the populations.
If the observed trends within the two marine reserves continue, there may be implications not only for the productivity of east coast lobster populations, but also for the structure of both the intertidal and subtidal communities of which they are a component. Predation by lobsters on invertebrates such as urchins and molluscs has been demonstrated in other studies to have a role in structuring reef communities. The potential effects of large increases in lobster biomass within east coast New Zealand marine communities are discussed and preliminary results of lobster feeding ecology research presented.

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Gillanders, Bronwyn M.*[1]

Determining the spatial extent of connectivity between juvenile and adult fish populations.

Understanding connectivity among populations of marine organisms is central to studies of population dynamics, management of fishery stocks, designation of marine protected areas and determining whether populations are open or closed. Juvenile snapper (*Pagrus auratus*, Sparidae) were collected from a number of estuaries and their otoliths analysed to determine the concentrations of chemical elements. Differences in elemental composition of juveniles were found among estuaries or groups of estuaries suggesting that the nursery or recruitment estuary of adult fish could be determined. Adult fish from the commercial fishery were then collected and fish with birth years matching the juvenile fish selected for microchemical analysis to determine their recruitment estuary. Juvenile fish from different regions could be distinguished with a high degree of accuracy. Using the juvenile signatures 2-year old adult fish caught as part of the snapper fishery in the Sydney region were assigned to their recruitment estuaries. Most (89%) adult fish caught as part of the snapper fishery originated from local estuaries. These results suggest that adults on reefs outside estuaries in the Sydney region have come from the estuaries closest to them with little transfer from other estuaries. Whether similar patterns are found for other regions and age classes will be discussed. Results suggest that populations of snapper may be self-sustaining or relatively closed and this may have implications for the management of the fishery.

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Goldstien, Sharyn*[1]
Bridging the gap: molecular ecology of larval dispersal.

Many intertidal invertebrates are semi-sessile with limited adult dispersal that can restrict the commerce between populations. Understanding larval dispersal, therefore, is an important part of explaining biogeography, gene flow and recovery of populations. This is particularly relevant for co-existing or closely related species showing similar demographic characteristics and competitive ability, yet exhibiting different biogeographic distributions.
The unique oceanographic characteristics of New Zealand coastal waters offer an ideal environment for testing larval dispersal across putative dispersal barriers created by merging water masses and disturbed flows. Here I combine molecular and ecological techniques to trap and track larvae of New Zealand limpet species from the genera *Siphonaria* and *Cellana*. It is expected that larval supply and genetic population structure will vary within and between these genera according to both reproductive strategy and physical dispersal barriers. Allozyme electrophoresis and mitochondrial DNA analysis will show the genetic population structure and phylogeography of the limpets, which will then be linked to the perceived dispersal potential and larval supply.

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Goodsell, Paris J.*[1] and Sean D. Connell[1]
Local and regional patterns of diversity in response to habitat heterogeneity.

Understanding patterns of biodiversity at local through to regional scales is surely an ambition of ecology and conservation biology. Environmental decisions require the support of information about where biodiversity is at maximum and whether patterns of diversity are consistent at small and large scales. Animal diversity is strongly influenced by the structure of their habitat (composition, morphology, spatial arrangement) hence we need to understand how diversity responds to variation in habitat structure over many spatial scales.
This paper examines patterns of invertebrate diversity associated with different types of algal forests through local to regional scales in temperate Australia. Algal forests of kelps (*Ecklonia radiata*) and Fucales (*Sargassum spp*. and *Cystophora spp.*) form dominant habitat along the southern coastline of Australia. Previous research has shown that heterogeneity in Australian algal forests is common, and this has consequences for invertebrate diversity. How general is this result? Using the diverse assemblages of invertebrates associated with Ecklonia radiata holdfasts, I tested whether diversity differed among monospecific and mixed species algal forests over nested hierarchical spatial scales.

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Griffiths, Shane P.*[1], Andrew R. Davis[1] and Ron J. West[1]

Influence of habitat complexity on fish assemblages in temperate Australian intertidal rockpools.

Habitat complexity in temperate Australian intertidal rockpools was manipulated to assess the effects on fish assemblages. Four experimental treatments were assessed: addition of algae and rocks, removing rocks and algae, removing rocks but adding algae, adding rocks but removing algae, and controls (unmanipulated). Algal cover was simulated using artificial seagrass units (ASUs). Numbers of species and individuals and species composition only differed in the removal of both rocks and algae treatment. The same pattern was evident for the four most abundant species. Reversing the substratum complexity treatments resulted in the reverse effect as in the first manipulations. Rockpool fishes do not discriminate between different habitat types so long as some shelter is available, but the amount of substratum rock cover may be the most attractive shelter since most species are benthic. Their lack of habitat specificity may be due to many rockpool fishes only utilising rockpools as temporary low tide refuges. Although rockpools are shallow tidally isolated habitats for fish, they are easily accessible by terrestrial predators (i.e. birds) and stranded subtidal piscivores. Therefore, fish may select rockpools with adequate shelter where predators may have difficulty of access.

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Habeeb, Rebecca L.*[1], Craig R. Johnson[1], Simon Wotherspoon[2], Jessica Trebilco[1] and Piers K. Dunstan[1]

Robustness of characteristic length scale estimates of marine systems.

The scale at which an ecosystem is viewed largely influences the patterns and therefore the underlying processes that are detected. In determining the most appropriate scale at which to examine the dynamic of an ecological system, a crucial question is whether a natural or "characteristic" scale exists. Current theories define the characteristic length scale (CLS) as the scale at which the ratio of determinism to noise in the system's dynamics is maximised. Recent studies (Keeling et al. 1997; Pascual & Levin 1999) used attractor reconstruction from nonlinear time series analysis to determine the CLS of dynamical model systems. However, the utility of any CLS relies on the robustness of the measure, including its sensitivity to the methods used in the reconstruction process. In this study, we compare the robustness of these two recently developed methods to estimate CLSs. We used the COMPETE software to run spatial multispecies models of varying complexity, and applied these techniques to estimate the CLS of each system. Sensitivity of the CLS was examined with respect to changes in species identity, system complexity, initial conditions, and in the parameters used in attractor reconstruction such as the time delay and embedding dimension. The Pascual & Levin measure was more robust than that of Keeling et al to changes in reconstruction parameters. However, both methods are sensitive to the choice of species used in the analysis of more complex model systems. Overall, the approach of Pascual & Levin (1999) appears to be a potentially useful approach to estimating system-level CLSs. We modify and develop this method further in another paper in this symposium (see Trebilco et al.).

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Halpern, Benjamin S.*[1]
The impact of marine reserves: a synthesis of global evidence.

I reviewed the biological response (change in density, biomass, organism size, and diversity) within reserves for 80 different reserves around the world to address the following questions: 1) do reserves work? 2) does reserve size matter? 3) how rapidly do reserve effects occur? 4) how long do reserve effects last? 5) does reserve performance differ between temperate and tropical reserves? and 6) does habitat type affect reserve performance? On average, density doubled, biomass tripled, and organism size increased by approximately a third. Furthermore, species diversity was on average 23% higher inside reserves compared to control sites. Results were the same for both temperate and tropical reserves and for reserves containing different habitat types, although only 4% of reserves protected habitats other than rocky or coral reefs. The relative impact of reserves was equal across all reserve sizes, although this translates into marked absolute differences between small and large reserves. Finally, the higher values of density, biomass, etc. were reached rapidly (1-3yr) and persisted for decades. The overall success of marine reserves demonstrated here suggests that reserves should be used in marine conservation and resource management efforts.

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Halpern, Benjamin S.*[1]
Juvenile habitat as a limiting resource.

Although the juvenile stage of a species' life and the habitat this stage uses (e.g., nursery habitats) are factors widely considered to be crucial for the maintenance of many marine species, little research has focused on determining if and how juvenile resources control adult population size. Here I present research in which I use hermit crabs as a model species to demonstrate when and to what degree the availability of resources at the juvenile stage limits population size. Through the use of modelling, lab, and field experiments I show that when recruitment limitation is not severe, the availability of juvenile habitat (in this case empty snail shells) can dramatically control the ultimate population size. The degree of this bottleneck at the juvenile stage depends in part on the amount of time spent in the juvenile stage relative to the adult lifespan and the amount of juvenile habitat relative to the amount of adult habitat. Results from this work provide guidance on how to protect and manage species that use different habitats throughout their lives, particularly through the use of habitat-based management efforts such as marine reserves.

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Harley, Christopher D.G.*[1]

Abiotic stress and predation interact to create a regional scale gradient in species richness.

Large scale patterns in species richness have been the focus of a substantial body of ecological research. However, the mechanisms underlying these patterns remain hotly debated. In this study, I investigated the underlying causes of a regional scale gradient in species richness in the Northwest Straits, which separate Washington State, USA, from British Columbia, Canada. In the Northwest Straits, a west-to-east decline in intertidal invertebrate species richness is correlated with decreasing wave action, and with increasing insolation, air temperature, substrate temperature, and mid-day aerial exposure. The upper limits of sessile taxa are strongly, negatively correlated with increasing stress from west to east. By comparison, lower limits, set by sea star (*Pisaster ochraceus*) predation, are independent of the horizontal stress gradient. As a result, the vertical range occupied by sessile species decreases from west to east, to the point where many species are "squeezed" out of the system at eastern sites. Experimental *Pisaster* exclusions at the eastern terminus of the Northwest Straits allowed sessile species (mussels and barnacles) that were otherwise restricted to western sites to dominate the available space. Because these sessile species provide favourable habitat for smaller invertebrates, *Pisaster* exclusions resulted in a doubling of local species richness. Thus, the differential impact of the horizontal environmental gradient on the vertical distributions of consumers and prey creates dramatic differences in species richness and assemblage structure at the regional scale.

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Hickey, Anthony J.R.[1], Shane Lavery[1], C. Scott Baker[1] and Kendall D. Clements*[1]

Molecular tools for reef ecology: from larval recruitment to invasive species.

Larval recruitment studies often lack the ability adequately to resolve species identifications. New Zealand's diverse and closely related assemblage of triplefin fishes (Family Tripterygiidae) dominate the ichthyoplankton in coastal New Zealand waters in winter and spring. However, triplefins are difficult or impossible to identify to species level using standard morphological criteria. We used a fragment of the hypervariable mitochondrial control region (D-Loop) sequenced from a reference collection of adult specimens to enable us to identify to species 84 triplefin larvae collected on four nights from light traps in the Hauraki Gulf. From the 84 larvae sequenced we identified 73 unique haplotypes from 6 species. Despite this low species diversity (there are 26 species of triplefin in New Zealand), intraspecific genetic diversity was surprisingly high. Genetic diversity of the larval *F. varium* collected from this single location on 4 nights over 39 days exceeded the total diversity of 154 adult *F. varium* collected from 9 locations around New Zealand for a separate phylogeographic study.
We also used control region sequences to investigate the origins of three cryptogenic triplefin species from two Australian harbours: Forsterygion lapillum from Port Phillip Bay, Melbourne, and *F. varium* and Grahamina gymnota from the Derwent Estuary, Hobart. All three species nest within haplotypes from New Zealand waters, showing that *G. gymnota* is not an Australian endemic as previously thought. Furthermore, *F. varium* and *G. gymnota* show low genetic diversities consistent with those expected for founding populations (introduced species). Our data provide further support that these species are invasive.

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Hill, Andrew F.*[1] and Neil L. Andrew[1]

Mapping subtidal habitats using acoustic and photographic techniques.

The coastal marine environment is a valuable economic, recreational and cultural resource which is coming under threat from numerous anthropogenic sources. To be effective, resource managers require information on the habitat structures present in coastal areas under their jurisdiction. Collecting such information over broad spatial scales while maintaining an ecologically relevant resolution is a difficult problem. Sidescan sonar in conjunction with textural analysis techniques offers the potential to provide such information quickly and cost effectively.
Three increasingly complex environments of interest to resource managers were chosen to test the ability of these techniques to discriminate habitat type: mussel reefs formed beneath mussel farms, bryozoan thickets and subtidal rocky reefs. Both the mussel reefs and bryozoan thickets were located on soft sediments and provided a strong acoustic return against a weak background signal. Groundtruthing video footage confirmed that areas of thicket and reef were accurately discriminated by these techniques. The subtidal rocky reef environment exhibited far greater structural diversity. The two principal habitat types on the rocky reefs (dense stands of macro-algae and algal turf/kina barrens) provided strong backscattered signals and variations in their acoustic signature were subtle and essentially invisible to the naked eye. A mosaic of patches was discerned using the textural analysis process and the accuracy of habitat classification, when compared to groundtruthed data, was 78-88%.

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Hirst, Alastair J.*[1]

Interactions between diversity, composition and morphology of subtidal algae influence epifaunal diversity by mediating faunal abundance.

The role of diversity in ecological communities and its contribution to ecosystem function has recently become a major focus of ecological research, motivated by growing concerns over loss of biodiversity. To date, research has focussed primarily on the relationship between plant diversity and productivity, within typically terrestrial grassland systems. However, plants also function as sources of habitat, refuge and food for a range of small mobile animals. In contrast to terrestrial plant communities, marine benthic plant assemblages are grazed by fewer species, but nonetheless support diverse associate (epifaunal) assemblages, particularly amongst the peracarid crustacean fauna (amphipods, isopods etc.). Southern Australian temperate reefs are renowned for their high macroalgal diversity, yet the relationship between algal and faunal diversity within these communities remains largely unresolved. In this study crustacean epifauna were sampled from two distinct subtidal algal assemblages (locations) using 0.06m^2 quadrats. Faunal abundance and species richness were significantly correlated with algal species richness at one location, but not the other. Following rarefaction, faunal species richness was no longer correlated with algal richness, indicating that this relationship was primarily driven by variation in faunal abundance; and indeed faunal species richness and abundance are highly correlated. Algal species with the highest morphological complexity had the greatest effect on faunal abundance (and diversity), despite representing only 12% of the total algal biomass. Thus the diversity gradient observed among these samples was manifested through interactions between algal species richness, composition (combination of species present) and morphology within naturally occurring assemblages. The results of this study indicate there is no "magic effect" of species number per se, other than those that arise from specific interactions between algal species.

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Hofmann, Gretchen E.*[1] and Mary A. Sewell[2]

Stress along environmental gradients: indicators of physiological stress in the purple sea urchin *Strongylocentrotus purpuratus* in an intertidal to subtidal gradient.

A significant challenge for the marine ecology community is to make informed predictions about how environmental change will impact natural populations. One key component of this undertaking is to understand the impact of the physical environment on organismal performance. To begin to understand the biological consequences of environmental temperature, we examined indicators of physiological stress in a marine invertebrate living across an intertidal to subtidal gradient. Our study organism, the sea urchin *Strongylocentrotus purpuratus*, is found in intertidal tidepools and subtidal rocky reefs of the exposed west coast of North America. Individuals that occurred 10-20 meters from each other were exposed to different temperature regimes as a result of emersion of the intertidal zone during low tide. Temperature records from a datalogger in a tidepool showed regular daily changes in temperature associated with the tidal cycle, reaching a peak of 18.42 °C; roughly 6 °C warmer than the subtidal. Using biochemical indices of thermal damage to proteins, we compared the status of proteins in isolated tube feet from urchins living in the relatively thermally-stable subtidal to those living in thermally-variable tidepools. Biochemical analysis revealed that levels of ubiquitinated proteins and Hsp70, and the threshold induction temperatures for the heat shock response were significantly different in sea urchins collected from the tidepools as compared to the adjacent subtidal. These data indicate that there are physiological differences between sea urchins living in intertidal and subtidal locations, and that thermal history has an impact on physiological performance in these organisms.

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Hurd, Catriona L.*[1], Steven Wing[2], Christopher Hepburn[1], James Holborow[2] and Russell Frew [3]

Seasonal mass-transport limited growth of the giant kelp *Macrocystis pyrifera*.

Rates of nutrient transport to seaweeds, and hence seaweed growth and production rates, are thought to be reduced in habitats where seawater flows are slow (< 6 cm s-1), but to date there is little evidence supporting this hypothesis. We examined the influence of hydrodynamic environment on the blade and stipe growth rates of *Macrocystis pyrifera* at eight sites in Paterson Inlet, Stewart Island, New Zealand, each season during 2002. Seawater velocity estimated from gypsum dissolution blocks and S4 current meters varied between sites. Seawater nitrate concentrations varied seasonally, but concentrations of nitrate and ammonium did not vary between sites. In winter, *M. pyrifera* growth was light-limited and water motion had no effect on growth rates. In summer, growth was nitrogen-limited but because inorganic nitrate concentrations in seawater were low at all sites (<1 μM), water motion had no influence on *M. pyrifera* growth rates. In late summer (February-March), however, there was a significant correlation between water motion and blade and stipe growth rates, with rates at wave-exposed sites being 6-fold greater at than those at wave-sheltered sites. Furthermore, the C:N ratio of *M. pyrifera* blades during late summer was inversely related to seawater velocity. We suggest that water motion influences the growth rates of *M. pyrifera* only at specific times of year; when growth is N-limited (C:N >20) but inorganic N is available in the water column.

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Irving, Andrew D.*[1] and Sean D. Connell[1]
Direct and indirect effects of subtidal forests on mobile invertebrates.

Separating direct from indirect effects is seldom attempted in ecology, particularly in the context of a broad spatial pattern. Mobile invertebrates inhabiting understorey algae provide an excellent opportunity to test the direct and indirect effects of canopy-forming algae (*Ecklonia radiata*) on subtidal assemblages of invertebrates because canopies can have both direct effects on invertebrates and the habitats they occupy and indirect effects through the modification of their habitat. I tested for differences in the structure of assemblages of invertebrates inhabiting articulated coralline algae and any associated differences in percentage cover and composition of these habitats in the presence and absence of canopy-forming algae across temperate Australia. Large differences in the composition and abundance of mobile invertebrates and their habitat were detected between the presence and absence of canopy-forming algae across Australia. The results provide the basis of experiments currently being done in South Australia that separate the direct and indirect effects of canopy-forming algae on assemblages of mobile invertebrates.

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Johnson, Mark P.*[1], Matthew Mosley[2], Mick Hanley[3] and Stephen J. Hawkins[4]
Spatial scales and temporal synchrony of populations on rough and smooth surfaces.

We investigated the spatial synchrony of population dynamics by repeatedly mapping areas on rocky shores. This approach allowed us to address questions of turnover that are left unanswered by 'snapshot' spatial surveys. For example, local processes may generate spatial pattern due to differential post settlement mortality, but if most variation in larval supply is actually temporal (interannual), populations may vary in synchrony across an entire region. Spatial scaling analyses in this study were based on a series of 4 x 4 metre quadrats on different shores. Each quadrat was divided into a grid of 0.01 m^2 sub-quadrats ('cells'). Densities of mobile organisms were recorded for each cell, with a code used to classify the sessile species. Quadrats were surveyed repeatedly every six months for 4 years. Population synchrony was examined at different scales within quadrats and between shores. We predicted that habitat heterogeneity on rougher surfaces would create refuges, altering the scales of population synchrony. Initial analyses do not support this prediction. Spatiotemporal structure differed between species, reflecting the scales of individual mobility.

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Johnston, Emma L.*[1]

Competition modifies the response of organisms to toxic disturbances.

Field experiments conducted on marine epifaunal assemblages have revealed that pulse chemical disturbances from copper decrease the densities of dominant space occupiers such as ascidians and colonial bryozoans, while increasing the densities of serpulid polychaetes. By manipulating both competition and pollution disturbance we confirmed initial interpretations of an indirect effect of the toxicant mediated through competition for space. Only one species of serpulid polychaete is deemed sensitive to frequent (monthly) direct exposures to copper pulses in the field. Our results show that the interaction between a pollution disturbance and competition for a limiting resource modifies the response of organisms to a toxicant. Further studies showed the impacts of transient pollution events to be pulse or press, depending on the rate of settlement and growth of the previously dominant organisms. Monitoring and detection of impacts from unplanned pollution events therefore requires a rapid (within weeks) response accompanied by ongoing monitoring of recovery at a fine temporal scale. Such results could not be predicted from conventional laboratory based toxicity tests and they suggest that small-scale ecotoxicological field tests can be a useful tool in predicting the impacts of pollution events in complex systems.

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Kim, Jeong Ha*[1]

Introducing Korean coastal habitats and current ecological research.

Coastal environmental problems and ecological works in Korea have not been well known to marine ecologists outside the country. The Korean peninsula is under the influence of the warm Kuroshio current and the cold North Korean current, exhibiting the diversity of subtropical and temperate marine organisms such as subtropical fishes, soft and hard corals, sea grasses, and kelps. Although this natural and geographical settings support a high biodiversity of marine organisms, there are severe anthropogenic environmental problems in the near shore habitats that threaten biodiversity, mainly due to heavily populated coastal areas, overloading aquaculture systems, overexploitation of edible species, etc. In this talk, I will particularly introduce problems of green tide and barren grounds in Korea with presenting some of the data from on-going ecological work. These include 1) competition and herbivory in *Ulva* dominated intertidals, 2) effects of *Ulva* mats on soft-bottom benthic fauna, 3) ecological status of crustose coralline-dominated subtidals and *Ecklonia* beds.

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Kinlan, Brian P.*[1]

Spatial and temporal variation of kelp forest habitat structure in the Northeast Pacific.

Habitat-forming species such as kelps and corals often differ from associated benthic species in resource requirements, sources of disturbance, and dispersal ability. These differences in life history can cause habitat to vary at spatial and temporal scales that differ from the "optimal" scale that would promote maximum abundance of any particular associate species. As a result, the spatiotemporal dynamics of habitat can exert important effects on benthic community structure and composition. To quantify the spatial and temporal dynamics of giant kelp (*Macrocystis pyrifera*), a key habitat-former in the NE Pacific, I analysed a 32-year monthly time series of estimated canopy biomass covering ~1500 km of coastline (7º of latitude) and digital maps of annual maximum canopy cover. Canopy biomass varied at dominant periods of 12 months, 3-7 y, 12-14 y and >20 y, and spatial scales ranging from mesoscale (~50 km) to regional (~250 km). Digital canopy maps revealed that changes in biomass were associated with shifts in the spatial structure of the kelp habitat. Patch size and inter-patch distance distributions varied with canopy biomass in a non-linear, but predictable relationship at local (0.1-10 km), mesoscale (10-100 km), and regional (100-1000 km) scales. The spatiotemporal dynamics of kelp habitat were also related to geographic region (Central vs. Southern vs. Baja California), and long-term mean size of kelp beds. Larger kelp beds exhibited less short-term variation and greater patch coherence than smaller beds. Long-term monitoring data suggest these differences in habitat structure have important consequences for community dynamics.

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Krenz, Christopher*[1], Maxine L. Chaney[1] and Wayne R. Wood[1]

Does spatial variation in barnacle and mussel recruitment affect rocky intertidal community dynamics?

Variation in recruitment of new individuals into marine populations can have important effects on interactions between species, because those interactions are based in part on population sizes. Recruitment of barnacles and mussels to the rocky intertidal zone varies dramatically along a 600km section of the U.S. west coast. Barnacle and mussel recruitment is one to two orders of magnitude
higher at sites along the Oregon coast than at sites along the northern California coast. We conducted a combination of experimental and observational studies at two high recruitment sites in Oregon and two low recruitment sites in California to test the prediction that the strength of interspecific species interactions are correlated with rate of recruitment. At the high barnacle and mussel recruitment sites in Oregon, where recruitment is saturating, there was intense competition for space. Predation by whelks on mussels decreased the intensity of, but did not eliminate, competition between mussels and barnacles. In contrast, there was little competition for space at the low barnacle and mussel recruitment sites in California. Predation by whelks on mussels in California had no effect on the outcome of competition between mussels and barnacles, because of the lack of competition for space. Overall, the strength of interspecific interactions was positively correlated with recruitment regime. This is strong evidence in support of the hypothesis that recruitment rates have important effects on community dynamics.

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Lafferty, Kevin D.*[1]
Trophic cascades alter density thresholds for urchin disease.

To investigate what happens when a trophic cascade pushes a host population over a host-threshold density, I analysed a 20 yr data set of kelp forest communities at 16 sites. Historically, lobsters, and perhaps other predators, kept urchin populations at low levels and kelp forests developed in a community-level trophic cascade. Where the main predators were fished, the cascade switched such that urchin populations increased to the extent that they overgrazed algae and starvation limited population growth. In 1992, an urchin-specific bacterial disease entered the area which already had urchin densities well exceeding the host-threshold density for epidemics. Epidemics were more probable and led to higher mortality in dense urchin populations such that disease acted as a density-dependent mortality source. Epidemics did not reduce urchin populations to the extent that predators did and, therefore, did not substitute for predators in the historical cascade. These results indicate how predation can alter disease dynamics by altering host density in ways that favour or impair disease transmission.

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Langlois, Timothy J.*[1], Marti J. Anderson[1] and Russell C. Babcock[1]
Reef associated predators influence adjacent soft sediment communities.

Reef associated predators have been hypothesised to influence adjacent soft-sediment communities. Their effects were examined by comparing soft-sediment assemblages along gradients of snapper and rock lobster density, both inside and outside marine reserves. Sampling was conducted at three reserve locations at each of four sites inside and outside of reserves. At each site assemblages were sampled at increasing distances from the reef edge to test the hypothesis that predators will forage only to a certain distance from the reef habitat. Replicate (n=6) 0.5m^2 samples were excavated and passed over a 4mm mesh sieve to obtain fauna and concomitant sediment characteristics were measured. Concurrent estimates of rock lobster (*Jasus edwardsii*) and snapper (*Pagrus auratus*) densities were made at each site. Increased densities of these reef associated predators at each location coincided with decreases in certain bivalves. At sites of high reef associated predator density for one location, decreased densities of *Scalpomactra scalpellum* were found, whilst other locations exhibited a decrease in density of *Dosinia subrosea* and *Myadora striata*. The greatest decreases in soft-sediment fauna were found near the reef edge (2-5m), compared to assemblages 15-30m away from the reef edge. Although the soft-sediment assemblages differed between locations, the patterns suggest that reef associated predators influence adjacent soft-sediment communities. This large-scale mensurative study has shown that in fished areas concomitant effects exist in addition to the decreased densities of exploited species.

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MacDiarmid, Alison B.*[1], Rod Bertelsen[2] and Mark J. Butler IV[3]

Does removal of large males in fished populations of two species of spiny lobsters, *Jasus edwardsii* and *Panulirus argus*, reduce brood size in females?

Fishing may not only decreases abundance and mean individual size, through the removal of larger individuals but also skew the population sex ratio when one sex is exploited more than the other. This is the case in New Zealand, southern Tasmania and South Africa, where males make up 80-100% of the landed catch of *Jasus* species. Recent laboratory experiments indicate that female fertilisation success and subsequent brood size may become limited because of size dependent sperm production in males. Only large males provide enough sperm to fertilise the entire clutch produced by large females. To determine if the fishery had depressed female brood size by this mechanism we compared the population abundance and structure, and female clutch-size in fished and protected populations of *J. edwardsii* in New Zealand and *Panulirus argus* in the US. Although the action of the fishery for *J. edwardsii* had shifted the operational sex ratio strongly towards females there was no difference in brood size among localities. The male biased fishery in New Zealand has continued and there is now evidence of unmated females in some populations. The ratio of females to males at which this phenomenon occurs is unknown but must be higher than observed in this study

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Mackie, Joshua*[1 2], Michael Keough[1] and Leslie Christidis[2]

Phylogeography of the bryozoan *Mucropetraliella ellerii*: the effect of Pleistocene cycles on genetic differentiation in south-eastern Australia.

Phylogeographic (COI) structure was examined in *Mucropetraliella ellerii*, a bryozoan that occurs in diverse habitats on the south-eastern Australian shelf. Geological evidence suggests a land bridge occurs in the area of Bass Strait at glacial maxima. The evolutionary influence of Pleistocene disturbance is puzzling - quantitative surveys of species distributions have not shown the presence of a major zone of species turnover. The genetic structure of *M. ellerii* is dominated by a sequence divergence 13.5% in the area of the Ninety Mile Beach in Victoria. This break separates southern Australian including Tasmanian populations from variation on the east coast, and is consistent in position with allozyme genetic breaks in other clonal organisms. Analysis of the signal of population growth and amount of variation within both phylogroups reveals very different demographic histories. A recent population bottleneck appears to have occurred on the east coast. In contrast, genetic structure of the southern phylogroup reflects the accumulated effects of multiple historical cycles of population expansion, possibly from multiple refuges. Demonstration of a mode of 'incipient' speciation that is consistent with Bass Strait isolation suggests that the definition of biogeographic regions using species-level surveys is hindered by insensitivity of morphological taxonomy to Pleistocene-age divergences.

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McConnico, Laurie A.*[1]

Ecology and reproductive phenology of *Alaria marginata* along the Big Sur coast: the population dynamics of an exposed kelp, exposed.

Recent surveys show that the large (to >5m long) kelp, *Alaria marginata* dominates much of the exposed mid to low rocky intertidal shore along the Big Sur coast of California, at densities of up to 500/m2. Experimental clearings and controls were established in July 2001 at two sites to assess timing of recruitment and plant survivorship. Plants were collected monthly to determine population growth and reproduction. Results show that the plant is an annual. Sporophyte recruitment occurred primarily on geniculate corallines and residual *Alaria* holdfasts in early spring. Maximum growth rates were estimated at 1.6m/mo in April and averaged 0.67m/mo over the entire growing season (February-July). Sorus development began as early as April, peaked in late summer/early fall and decreased as adult plants were tattered or ripped from substrate by winter surf. However, spore release was generally minimal except between October and January and appeared to be stimulated by high water motion. Survivorship of plants beyond one year was rare (<1% in natural stands). The persistence of this annual, intertidal kelp appears to be related to specific patterns of recruitment, growth and reproduction.

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Mei, Junxue*[1]

Novel adaptations for survival of *Polysiphonia adamsiae* and *Polysiphonia strictissima* in Southern New Zealand.

Polysiphonia adamsiae and *Polysiphonia strictissima* form obvious patches in the intertidal zone around New Zealand, blooming in winter and spring and then disappearing in summer. Understanding the life cycles of these species gives us insight into how they survive through summer and how they are adapted to live in harsh environments.
To answer these questions, the tetraspores and carpospores of the two species were collected and cultured in different temperatures until they grew into juvenile gametophytes and sporophytes. It appeared that the two species could complete their *Polysiphonia*-type life history as expected, under the conditions we tested. However, *P. adamsiae* and *P. strictissima* also succeeded at reproducing vegetatively. The apex cells of *P. adamsiae* stopped dividing and producing new branches when the plants bore well-developed tetrasporangia and cystocarps. After these mature plants were cut into fragments, the apex cells of the fragments produced new cells and branches and each fragment developed into a whole plant. More importantly, those fragments survived under conditions which spores and sporelings of the same species could not. The prostrate stems were also reproductive and could survive in the temperature as high as 20 ºC. Therefore we suspect that fragments and prostrate stems play important roles in the success of this species.
In the late stage of the life cycle, *P. strictissima* was also able to grow entire plants from its apex cells. These new plants began as a prostrate stem, then developed holdfasts and main stems and grew into a new group of plants. Fragments of these plants were also able to reproduce in that fashion. We believe these structures are more resistant to sedimentation and grazing than sporelings. It also appears that vegetative reproduction in these species is more successful than sexual and asexual reproduction. These novel reproduction strategies may be what allows them to bloom annually each winter and be more resistant to grazing and sedimentation.

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Nielsen, Karina J.*[1], Bruce A. Menge[1], Brian A. Grantham[1] and Jane Lubchenco[1]
Macrophytes, phytoplankton, and upwelling: light limitation in the intertidal zone?

In lakes, estuaries and coastal seas, anthropogenic nutrient loading is associated with phytoplankton blooms. There is also a strong association between phytoplankton induced light attenuation and reduction in the depth distribution and abundance of macrophytes in these systems. In temperate upwelling ecosystems, phytoplankton blooms are associated with oceanographic factors that influence nutrient supply, stratification and water residence times. Variation in nutrient supply can also influence the abundance of macrophytes. However on Oregon's coast, spatial variation in macrophyte abundance cannot be explained solely by variation in nutrient supply. We made continuous in situ measurements of chlorophyll fluorescence and light attenuation in the intertidal zone at four sites during spring and summer 2001. As expected, we found sharp light attenuation to the benthos at sites when chl-a fluorescence was high. Long-term monitoring of chl-a concentrations in the surf zone documents that differences among sites are persistent and can be as high as that observed in eutrophic lakes and estuaries. The light saturation parameter (Ek) for several common intertidal macrophytes (calculated from in situ rapid light curves made with a pulse amplitude modulation fluorometer), along with published values of the irradiance needed to saturate their growth rates, suggest that underwater light levels may limit macrophyte growth where phytoplankton blooms are common and persistent. We hypothesise that correlation between upwelling dynamics and macrophyte abundance patterns on rocky shores are mechanistically linked to both water transparency and nutrient supply.

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Pederson, Hugh*[1] and Craig R. Johnson[1]
Effects of fishing lobsters on the population dynamics of the sea urchin *Heliocidaris erythrogramma* on the east coast of Tasmania.

We examined whether fishing of rock lobster (Jasus edwardsii) and fish predators on rocky reefs in Tasmania could account for population increases of the sea urchin Heliocidaris erythrogramma to the point of overgrazing of macroalgae to form 'urchin barrens'. Large-scale surveys (over >100 km of coastline) of abundances of urchins and putative predators revealed a significant negative relationship between urchins and lobster abundance, but not between urchins and demersal fishes. At smaller scales, both large lobsters and demersal fish are significantly more abundant inside no-take marine reserves than in equivalent adjacent habitat subject to fishing. These observations are consistent with results of small-scale experiments in which the rate of urchin mortality was ca. 23 times greater inside two marine reserves than in adjacent exploited habitats. Caging experiments also showed that predation by rock lobsters on sea urchins is highly size-specific. Juvenile lobsters are not capable of predating urchins with test diameter (TD) > 60 mm, while medium-sized lobsters preyed on urchins up to 80 mm TD, and large urchins >81 mm TD were only at significant risk of predation mortality by large lobsters. Demersal fish were notably less important predators of urchins between 40-100 mm TD than were rock lobsters. In tethering experiments inside reserves, juvenile urchins were predated more frequently than larger ones. However, when tagged urchins were free to move, mortality of adult urchins was significantly higher than that of juveniles, because juveniles sought shelter in small crevices.
Growth rate parameters and age frequency distributions derived for several distinct urchin populations enabled construction of simple matrix models of population growth. We will report on the application of this model, using empirical estimates of size-specific per capita rates of predation by lobsters on urchins, to assess the effect of exploitation of lobsters in regulating urchin population density.

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People, Julie C.*[1]

City living: the ecology of organisms associated with mussel beds in urban areas.

When in large numbers, mussels attach to the substratum and to each other to form a complex three-dimensional matrix that is referred to as a mussel bed. Mussel beds provide habitat for a diverse assemblage of associated organisms. The diversity of organisms associated with mussel beds has been studied for mussels growing on natural surfaces, including estuarine soft sediments, intertidal and subtidal rocky shores. Mussels also commonly inhabit artificial structures in urban areas such as seawalls, pilings and pontoons. Little work has focused on the diversity of organisms associated with mussel beds on these artificial structures. The associated assemblages of mussel beds were sampled on pontoons, seawalls, pilings and natural rocky reefs. Mussel beds on different structures generally supported different assemblages. Results of a manipulative field experiment done to determine some factors that may contribute to the differences between these structures will be described.

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Petraitis, Peter S.*[1]

Scale-dependent successional changes in experimental clearings.

In 1996, experimental clearings in *Ascophyllum* stands were established to determine if mussel beds and macroalgal stands on protected intertidal shores of New England represent alternative community states. Clearings of 0, 1, 2, 4 and 8 m in diameter were created at 12 sites on Swan's Island Maine. If mussel beds and *Ascophyllum* stands are alternative states, we expected some, but not all, of the larger clearings to colonised by barnacles and mussels, and we predicted small clearings would shown similar patterns of successional change while large clearings would diverge. Here data are presented on the scale-dependent successional changes that have occurred between 1997 and 2002. Data include recruitment, densities, and percent cover of fucoids, mussels and barnacles, and densities of three common gastropods. ANOVAs and MDS show divergent successional changes in large clearings. By 2002, many, but not all, of the 4 and 8 m clearings are dominated by *Fucus*. *Ascophyllum* and mussels remain rare. Patterns of fucoid recruitment are idiosyncratic, which is not unexpected given the short dispersal distance of zygotes, and so *Fucus* cover by 2002 shows large site-specific differences. Barnacle and mussel recruitment are negatively correlated with *Fucus* cover. Gastropod densities and *Fucus* cover show positive correlations. Overall, patterns of barnacle and mussel recruitment suggest larval supplies were important in 1997 and 1998 but by 1999 site-specific effects due to *Fucus* cover dominated. It remains an open question if assemblages are diverging to alternative states or are simply in transition to a common endpoint.

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Phillips, Nicole E.*[1]

Variability in larval condition at settlement: influences on post-settlement performance and patterns in the field.

For organisms with planktonic feeding larvae, variation in food availability during the larval stage influences the condition of larvae as they develop, and may also have longer lasting effects on the performance of juveniles after they settle. To investigate this issue, I first conducted a laboratory experiment on mytilid mussel larvae. I raised larvae at three constant food rations, high, medium and low, then monitored juvenile performance after settlement. Settling larvae from high larval food were larger and had higher lipid content, and juveniles had greater survival and growth than those from lower larval food even after two weeks in the same juvenile environment. The results indicated that juvenile performance was strongly influenced by larval quality at settlement, which in turn was mediated by larval nutrition. Few studies however, have investigated natural variability in larval quality at settlement, and none have attempted to examine several species settling simultaneously. In the second part of my study therefore, at biweekly to monthly intervals from May-September 2001, I collected the terminal larval stages of mytilid mussels and barnacles (*Pollicipes polymerus* and *Cthamalus sp.*) that settled into larval collectors placed in the mid-zone of the intertidal in southern California. There was substantial variability in both size and lipids for all species both within and among cohorts, but these two parameters did not covary. Additionally, there was a significant positive relationship for barnacles between settlement intensity and lipid stores. Implications of these results for recruitment in natural populations and communities will be discussed.

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Raethke, Natalie*[1 2] and John D. Booth[2]

Sociality and conspecific attraction in juvenile *Jasus edwardsii* (Palinuridae).

Small juvenile *Jasus edwardsii* are said to be - like other spiny lobsters - asocial, their small size and cryptic, usually solitary behaviour providing best protection against predators. On the other hand, larger juveniles (more than about 30 mm carapace length (CL)) and the adults are communal, often aggregating for defence in shelters during the day. However, our experiments suggest that all juvenile *J. edwardsii* are gregarious to some extent. Although pueruli displayed no tendency to associate with or avoid brick shelters that contained conspecifics of the same size, all juvenile size groups tested (15-59 mm CL) showed significant attraction to shelters containing lobsters. The cues may be visual, olfactory, and/or auditory.

Further, we investigated the role of olfaction in sociality and shelter choice and whether juvenile *J. edwardsii* are attracted to the odour of a certain size class of conspecific. Test lobsters had the choice between shelters that had previously been occupied by juveniles of the same size group, or by small mature females, or which had been soaked in plain seawater. Both size groups tested were gregarious, but while most small juveniles (20-30 mm CL) chose shelters that had cues of juvenile conspecifics, larger juveniles (40-50 mm CL) were attracted to shelters with lobster cues regardless of the size of the previously occupying lobster. Conspecific odour cues are therefore not exclusively water-borne but are also absorbed by den surfaces. Under laboratory conditions the chemical signals remain attached to concrete blocks for at least 24 hours.

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Readdie, Mark D.*[1]

Shifting zones: how species upper limits can vary vertically on rocky shores.

The distributions of many species on rocky shores are limited to distinct zones. An ingrained paradigm in marine ecology is that the upper limits of these zones are set by physical factors. As these are relatively stable over long time periods, vertical spatial variation in species upper limits should be low. Long term monitoring data from rocky intertidal sites in central California have revealed however, that species zones have shifted considerably over the past decade. At some sites the data reveal a temporal pattern in which the upper limits of barnacles and two mid-intertidal algal species, *Endocladia muricata* and *Silvetia compressa*, have shifted upwards on the shore in a predictable sequence of events. Barnacles (the highest) became colonised by *Endocladia* (the mid-height species), and *Endocladia* became colonised by *Silvetia* (the lowest species). Surprisingly, *Silvetia* recruited as far up as the original barnacle zone. This represented a shift of up to 0.6 vertical meters in the most extreme case. Over the past two years, these upper limits have begun shifting downward again. I propose a conceptual model to explain how upper limits may exhibit vertical variation as a function of both physical and biological factors and indicate the importance of recruitment, disturbance and succession at a site-specific scale.

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Rilov, Gil*[1] and David R. Schiel[1]

Top-down or bottom-up regulation of the New Zealand rocky intertidal community? Hints from mussel population structure and predation experiments.

Rocky intertidal communities vary on both small (same site, sheltered vs. exposed rocks) and large (biogeographical) scales. There is now a growing body of evidence that differences in community structure also occur on the regional meso-scale (1-10s kms). These differences can be driven by meso-scale near-shore oceanographic conditions that affect nutrient and larvae supply (bottom-up effects). Strong bottom-up effects enhance the entire community and have a feedback loop on top-down effects. In New Zealand, it has been suggested that strong upwelling conditions on the west coast enhance top-down predation effects, while on the east coast both effects are very weak and macro predators (seastars and whelks) are rare. We examined the mussel bed communities in several sites on both coasts and found that patterns of mussel distribution and population structure in exposed sites are highly variable both within and between coasts. While most sites in the east coast do seem to have very low numbers of small mussels, we found sites with plenty of recruits, suggesting either high larvae supply or very low predation-or both. We also found many small whelks inside most mussel beds. Finally, we have initial evidence that large mobile predators (probably fish) can have strong and rapid predation effects on small mussels: in the low shore all mussels transplanted were removed within a day in plots unprotected from such predators, while a slower predation pace was evident in the mid shore. We suggest that whelks and (probably) fish are important predators on the east coast, and that predation on small mussels inside and outside mussel patches can play a major role in shaping mussel distribution and populations structure, especially where recruitment is relatively poor or sporadic. We also suggest that communities on exposed rocks can vary dramatically within a scale of hundreds of meters-probably as a result of highly localised oceanographic, biotic and demographic differences.

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Robles, Carlos D.*[1] and Jeff Shima[2]

Alongshore dispersal of the sea star *Pisaster ochraceus* in intertidal landscapes with varying wave exposures and prey availabilities.

Sea stars (*Pisaster ochraceus*) were tagged with passive internal transponders and translocated either between sites of contrasting wave exposes and prey distributions (treatments) or within the same site (controls). Subsequent movements were plotted on GIS landscapes. Alongshore movement rates on a given type of site were the same for treatments and controls. Sea stars on wave exposed sites with prey zones extending to low shore levels diffused slowly from the release points. Sea stars on sheltered sites with sparse high zones of prey diffused an order of magnitude faster. Alongshore movements > 10 m in 24 h are not uncommon. Direct observations by divers revealed that at high tide the sea stars make higher, longer vertical excursions to reach prey concentrations on sheltered shores than they do on wave-exposed shores. We propose that the apparent coupling of the extent of vertical excursions and alongshore dispersal results from alongshore shifts in the relative levels of top-down and bottom-up factors; hydrodynamic effects reduce prey production and allow greater predator foraging on relatively sheltered locations. In this view, sea star movements are one of several mechanisms causing spatially structured equilibria of the vertical distribution of their prey.

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Russell, Roly*[1]

The ecological importance of biological diversity for system functioning and stability: evidence from experiments with intertidal algal assemblages.

Humankind is massively reducing and homogenising global biological diversity. Although we may be able to recognise the ethical consequences of these alterations to biodiversity, we are relatively naive about the ecological consequences of such changes. Some thoughtful research has demonstrated the existence of patterns between species richness and ecosystem functioning - typically a positive relationship between species richness and productivity (for example, Naeem et al., 1994; Tilman et al., 1996; Hector et al., 1999) - but the mechanistic underpinnings of these patterns remain vague. Utilising marine macroalgal assemblages and their oxygen-producing photosynthetic rates as a model system, I was able to investigate some of these mechanisms. I assembled an assortment of algal species in various combinations and levels of species richness in the lab, and then analysed the magnitude and stability of photosynthetic rates of these assemblages. My results indicate that after accounting for the effects of individual species (a.k.a. sampling effects), there remains a significant positive contribution of species richness to overall photosynthetic rate. Thus, having more species increases photosynthetic rates (therefore carbon fixation) per gram of tissue - a mechanism which could underlie the demonstrated positive relationship between species richness and annual productivity (biomass). Likewise, increased species richness is associated with an increase in the stability of photosynthetic rates in these algal assemblages. It is clear that if biological diversity causes an ecosystem to increase efficiency or stability of carbon fixation in a given environment, then we have an ecological obligation to minimise our anthropogenic diminishment and homogenisation of biological diversity.

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Salomon, Anne K.*[1]

Bottoms-up to top-down: linking the role of species interactions and recruitment in structuring temperate intertidal communities.

Our capacity to predict biological patterns and conserve marine ecosystems will rely in part on understanding the biological interactions and physical processes that govern community dynamics. In attempts to determine the relative contribution and interaction between these factors, I conducted local manipulative experiments at a broad regional scale across a gradient of salinity. Settling plates were deployed at 7 intertidal sites, spanning 18 km, within Kachemak Bay, Alaska to assess spatial variation in larval settlement and grazing pressure. Plates surrounded by copper excluded grazers while controls and treatment controls were subject to macroscopic grazers such as *Katharina tunicata*, a strongly interacting herbivore. In the absence of grazers, primary production increased from the head to the mouth of Kachemak bay and varied from 0.001 to 340 grams of dry weight per square meter per year among sites. Barnacle recruitment peaked in the middle of the bay. The gradient in production was largely driven by the appearance of *Alaria marginata*, a highly productive annual kelp which replaced less productive perennial species when grazing pressure was reduced. At the site with the greatest production, grazers facilitated barnacle recruitment via interference or preemptive competition, however, where algal production was low, grazers reduced barnacle recruitment. Grazer densities and composition also varied among sites, in some cases due to shoreline harvest by Alutiiq natives where *Katharina* remains an important traditional subsistence food source. Therefore, factors structuring these rocky intertidal communities include strong top down direct and indirect interactions which vary spatially due to differential larval delivery.

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Samuela, Aletha T.*[1] and T. Alwyn V. Rees[1]

Environmental factors that influence egg release in *Hormosira banksii*.

The effect of environmental conditions on gamete release and fertilisation in temperate marine seaweeds has largely been restricted to studies of northern hemisphere fucoids. Egg release in five contrasting populations of *Hormosira banksii* have been studied. These populations consist of two urban populations in Auckland (Castor Bay and Point Chevalier) and three non-urban populations (Leigh, Whangateau and Scott's landing). Moreover, these populations differ with respect to plant morphology. The temporal patterns of egg release in plants from these populations will be presented. In addition, the effect of other environmental factors (eg. storms) will be discussed.

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Schiel, David R.*[1] and Spencer A. Wood[2]
Sedimentation on coastal reefs affects early post-settlement stages of dominant algae.

Modification of the coastal environment by human activities often leads to an increase in sedimentation of nearshore waters, with potential effects on benthic marine assemblages. We discuss the relationships between levels of sedimentation, wave exposure and benthic organisms on intertidal platforms. We tested several hypotheses concerning whether different levels of sedimentation affected algal zygote attachment and germling survival, whether interactions of grazers and sediments affected germling survival, and how different molluscan grazers affected germlings of various sizes. Levels of sediment and exposure were inversely related across seven sites. Biotic communities were characterised by sediment and exposure. In field tests, sediment had variable effects on the survival of recently settled algal germlings. However, in laboratory-based experiments, even a light dusting of sediment greatly reduced the percentage of *Hormosira banksii* and *Durvillaea antarctica* zygotes that attached to primary substratum. Overall, increased sedimentation, and its interactions with grazers and wave exposure, clearly contributes to the renowned patchiness of recruitment of habitat-forming fucalean algae in intertidal habitats.

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Schreider, Maria J.*[1], Rohani Ambo Rappe[1] and Matthew Anderson[1]
The effect of patch size and proximity to *Zostera* beds on the abundance and diversity of epifauna.

Seagrass beds get fragmented due to various human-induced and natural disturbances. Such fragmentation could potentially affect epifaunal invertebrates associated with seagrasses and consequently the whole ecosystem, because epifaunal crustaceans represent an important link between primary producers and higher level consumers. Many terrestrial studies demonstrated that fragmentation of habitats leads to great reduction in biodiversity as smaller patches of habitat contain smaller numbers of species and individuals per unit area. In seagrass habitats, however, the results are contradictory and may depend on a particular location and/or geographical area. Some studies showed that animals were more abundant on smaller than on the larger patches whereas others reported the opposite.
We used 'small' (50 x 50 cm) and 'large' (200 x 200 cm) patches of artificial seagrass at two sites of Budgevoi Lake (Central Coast of New South Wales, Australia) to test whether the size of a patch or its proximity to the beds of commonly occurring seagrass *Zostera capricorni* would influence abundance and composition of epifauna. Artificial patches were colonised very quickly by large numbers of amphipods and isopods. Overall, there was no difference in abundance or species composition of invertebrates between small and large patches or between patches deployed near and away from *Zostera* beds. Epifaunal abundances, however, varied greatly between experimental sites and were similar to the abundances of animals naturally found on *Zostera* at these sites. The mechanisms influencing abundance and distribution of epifaunal crustaceans are discussed in view of the results.

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Schroeder, Donna M.*[1] and Milton S. Love[1]

Is recreational fishing a low impact activity and compatible with MPAs? A review of evidence from California, USA.

We present and review information regarding recreational angling and exploited reef fish populations in California, USA. A comparison of rockfish assemblages among three differently fished areas (open to all fishing, open only to recreational fishing, and a de facto marine protected area) revealed large differences in fish density, size structure and species composition. The all fishing area harboured the highest density of rockfishes (7303 fish/ha), although the size structure and species composition was dominated by small fishes. The recreational fishing area had the lowest rockfish density (431 fish/ha), and a size structure also dominated by small fishes. The de facto protected area possessed high fish density (5634 fish/ha), but here the size structure and species composition shifted towards larger fishes compared to the two other areas. Two federally listed overfished species, cowcod and bocaccio, had 32-fold and 408-fold higher densities respectively in the de facto reserve compared to densities observed inside the recreational fishing area, and 9-fold and 48-fold higher densities respectively than densities observed in the all fishing area. A comparison of the relative proportion in nearshore reef fish landings between recreational and commercial fisheries revealed that recreational angling was the primary source of fishing mortality for most species. We illustrate the potential damaging effects of mortality associated with catch-and-release programs on long-lived reef fish populations. Based on this information, we recommend that legislators and natural resource managers reject the assumption of recreational fishing to be a low or no impact activity until specific studies can demonstrate otherwise.

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Schroeder, Donna M.*[1], Guy R. Cochrane[2] and Mary S. Fangman[3]

Application of benthic habitat mapping inside marine protected areas using textural analysis of sidescan sonar data.

Mapping seafloor habitat is a fundamental first step in many marine resource management objectives, including estimating the number of fish residing within a network of marine protected areas (MPAs). We employ both habitat and fish survey data to compare how two MPAs may succeed in protecting exploited fishes associated with rocky outcrops in the eastern Santa Barbara Channel (SBC) region, USA. The US Geological Survey collected and groundtruthed sidescan sonar data in depths between 0 to 100m. For each area of interest, we quantified available reef fish habitat by summing the area within polygons drawn around three different substrate types (exposed rock, mixed/low relief rock, and continuous sediment). Estimates of fish density associated with each of these substrate types were obtained from a study conducted over six years at three different sites in the eastern SBC. Seafloor substrate within the 7.2 sq km Big Sycamore Canyon Ecological Reserve (BSCER) consisted entirely of continuous sediment, and thus failed to protect reef fishes. Seafloor substrate within the 0.57 sq km Landing Cove Marine Ecological Reserve contained relatively large amounts of exposed rock or mixed/low relief rock substrate, and therefore protected many more fish than BSCER. A conservative estimate of regional fish populations in the eastern SBC reveals that the two-reserve network protected a negligible fraction of regional fish population. Further regulations may be needed to protected these species from over-exploitation.

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Schroeter, Steve C.*[1], Susan L. Swarbrick[1] and Joseph H. Connell[2]
The role of catastrophes in structuring marine rocky intertidal communities.

The frequency and intensity of disturbance can play a significant role in structuring ecological communities. During a 26-year period of ecological monitoring, we have studied the effects of disturbances on a rocky intertidal boulder community. A catastrophic disturbance occurred in a storm on a single day in the 9th year (March 1983), followed by a 17-year period of low intensity of disturbance similar to that occurring before the catastrophe. Before and after the 1983 catastrophe, the pattern of community structure was strongly determined by small scale disturbances resulting from different rates of boulder-overturning. The result was a predictable pattern of community structure that was correlated with the average size of boulders. The catastrophe in 1983 resulted in almost complete local extinction of algae and invertebrates. Initial re-colonisation followed within months, with the entire habitat becoming dominated sessile tube worm (*Phragmatopoma californica*), that was present, but relatively rare, preceding the catastrophe. Recovery to the pre-catastrophe state of community structure varied as a function of the area and intensity of disturbance and the successional stage of species in the community. In some parts of the boulder field recovery was not achieved until 17 years after the catastrophe. Our study clarifies the roles of tidal elevation, microhabitat, species characteristics and the area and intensity of disturbance on the process of post-catastrophe recovery.

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Shears, Nick T.*[1] and Russell C. Babcock[1]
Marine reserves and the generality of the predator-urchin-kelp paradigm in Northeastern New Zealand.

Phase-shifts from macroalgal forests to coralline-dominated urchin barrens have been linked to over-fishing of sea urchin predators in many temperate marine ecosystems. The reverse transition from barrens to algal forest in New Zealand's oldest marine reserve is consistent with the hypothesis that predators have a top-down role in structuring benthic communities. This predator-urchin-kelp trophic cascade, and its generality, was tested using a combination of experimental and descriptive studies over a range of spatial and temporal scales, within multiple reserve and non-reserve locations, in Northeastern New Zealand. Clear contrasts in macroalgal and urchin populations were found between the two oldest reserves and their adjacent coastlines, with macroalgal biomass being more than 20 times higher at reserve sites, and the abundance of exposed sea urchins being 2 times higher at non-reserve sites. Both reserves support higher abundances of commercially targeted urchin predators, and the chance of predation on tethered urchins was found to be more than 7 times higher at reserve sites. While these patterns are consistent with a trophic cascade, they are not generalisable to the other reserves examined in Northeastern New Zealand. The importance of sea urchins in structuring algal assemblages was found to vary across environmental gradients in Northeastern New Zealand. At both the most sheltered, and the most exposed locations sampled, the role of urchins in regulating algal assemblages was limited, potentially by bottom-up processes.
Subsequently, contrasting community types between reserve and non-reserve locations did not occur under these circumstances. Furthermore, variation in environmental conditions across relatively small regional scales (<10 km) had the potential to confound direct comparisons between reserve and non-reserve sites.

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Shima, Jeffrey S.*[1]

Cryptic density dependence: effects of spatiotemporal covariation in settlement intensity and quality in reef fish.

The importance and strength of density dependence continues to engender debate because of its central importance to population dynamics and regulation. Using results from a model reef fish system, I show how confounding effects of site quality can mask strong effects of density dependence. In particular, I explore spatio-temporal variation and covariation among (1) densities of newly settled reef fish (*Thalassoma hardwicke*), (2) environmental characteristics, and (3) the strength of density-dependent mortality. Environmental features of patch reefs were spatially and temporally variable and influenced density-dependent survival. Higher quality sites (i.e., reefs possessing features yielding greater numbers of recruits at any given settlement level) received greater settlement, and this relationship masked the operation of density dependence when variation in quality among sites (or times) was not distinguished (a common approach in many observational studies of density dependence). I present complimentary results from another model reef fish system (*Paralabrax clathratus*) that examines the relationships between larval quality and recruitment success. Together, these studies illustrate how spatio-temporal covariation in settlement density and site- or larval quality can obscure patterns of density dependence at larger scales, contributing to a phenomenon termed *cryptic density dependence*. Acknowledging patterns and consequences of covariance may alter the way we study population dynamics, especially of marine organisms where the link between processes that affect larval quality, settlement and post-settlement survival remains relatively poorly understood.

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Spalding, Heather L.*[1]

Deep-water macroalgae, light, and the space-time continuum: temporal and spatial patterns in central California.

The deep-water macroalgal assemblage was described at 14 sites off the central California coast during 1999 and 2000 from SCUBA and ROV sampling. Macroalgae typically formed 3 broadly overlapping zones usually characterised by one or a few visually dominant taxa: (1) the upper "Pleurophycus zone" (30-45 m) of stipitate kelps and *Desmarestia spp*. with a high % cover of corallines, low cover of uncalcified red algae, and rare green algae, (2) a middle "Maripelta zone" (40-55 m) with other uncalcified red algae and infrequent corallines and green algae, and (3) a zone (55-75 m) of infrequent patches of nongeniculate coralline algae. The abundances and lower depth limits of perennial macroalgae were similar between years, while annual species were more variable between years. Year-round profiles of water column irradiance revealed unexpectedly clear water with an average K0 of 0.11om-1. The low % surface irradiance found at the average lower macroalgal depth limits in this study (0.56% for brown algae, 0.12% for uncalcified red algae, and 0.01% for nongeniculate coralline algae), and lack of large grazers, suggest that light controls the lower distributional limits. The ubiquitous distribution, perennial nature, and similar lower depth limits of deep-water macroalgal assemblages at all sites suggest that these assemblages are a common, persistent part of the benthic biota in this region.

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Steller, Diana L.*[1]

Contributions of rhodolith beds to a commercial scallop fishery: the importance of reefs that rock and roll.

Rhodolith beds are biogenically derived, structurally complex habitats, formed by dense collections of unattached branching coralline red algae. World-wide, they support diverse communities in areas that are otherwise dominated by soft-benthos. While rhodolith beds are known to support more complex communities that surrounding soft sediments, little is known about the consequences of this habitat heterogeneity to commercially important species. In the Gulf of California in north Pacific Mexico, beds dominated by the rhodolith *Lithophyllum margaritae* are common coastal habitat in bays and channels. In some locations the distribution of this fragile substrata overlaps with commercially harvested areas for the scallop *Argopecten ventricosus*. Seasonal coastal surveys indicated that motile adult scallops were distributed at higher densities in rhodolith beds relative to sand substratum. Pre- and post-settlement processes were examined in both habitat types to establish the stage at which this pattern was initiated. Larval supply and settlement onto artificial substrates did not differ between habitats. However, settlement was higher on both live and rhodolith-derived substrates than fine grain sediments. These initial settlement patterns were reinforced by post-settlement processes. Predator densities, predation rates and scallop movement rates were higher on sand flats. Thus, rhodolith beds may act both as nursery habitat and as a predation refuge. This study demonstrated that rhodoliths can enhance scallop populations by affecting a combination of pre- and post-settlement processes and indicates that local biogenic habitat heterogeneity might be an important source of variation in the abundances of species that otherwise occupy less heterogeneous habitat.

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Stevens, Craig L.*[1], Murray J. Smith[1], David R. Schiel[2], Spencer A. Wood[3] and Iain T. MacDonald[4]

The fluid mechanics of propagule transport in the rocky intertidal zone.

Waves and currents have a significant influence on life in the rocky intertidal zone. This influence occurs at a number of scales, from large-scale ocean current transport down to flow at the scale of early life-phases of biota. Here we use both direct observation and laboratory experimentation to examine the linkages between macroalgal survival and physical processes in the rocky intertidal zone. Specifically we are considering *Durvillaea antarctica*. The work focuses on three scales. The largest scale encompasses coastal currents and open-ocean waves. These processes are transformed through interaction with the reef topography to create a near-shore turbulent environment that controls intertidal transport. The turbulent flow influences motion at small scales comparable to the size of the early life stage of *Durvillaea antarctica*.

We first determine the transformation of waves from the open ocean to the reef system by examining wave spectrum attenuation. As the waves arrive onshore acoustic velocimeters are used to provide a direct measurement of the velocities generated near the substrate onshore. These velocities define the hydrodynamic habitat that controls the attachment/detachment processes that occur right at the substrate. These high-resolution observations are placed in an ecological context using correlative multi-parameter monitoring.

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Stewart, Romola*[1] and Hugh Possingham[1]

The opportunity cost of ad hoc marine reserve system design: an example from South Australia.

The rationale for using computational techniques for the selection of marine reserve systems is in their ability to rapidly treat large datasets, deliver near optimal solutions and readily incorporate new information to generate solutions that satisfy criteria under a range of different circumstances. These factors distinguish them from evaluation and scoring techniques, which to date, are more commonly used for reserve selection.
Using South Australia as a case study, we investigate the process of reserve system identification and design using the computational tool 'Marxan'. We commence with (1) the definition of goals, (2) collation and review of data, (3) set targets and decision rules, (4) identification of reserve system solutions, and (5) evaluate the efficiency and effectiveness of our solutions. Our aim was to compare marine reserve systems that retain South Australia's existing marine reserves with reserve systems that are free to either ignore or incorporate them. This serves to examine the performance of ad hoc marine reserve design decisions. We use a new interpretation of irreplaceability to identify sites selected more than could be expected from chance alone. This is measured by comparing the observed selection frequency for an individual planning unit with a predicted selection frequency distribution. Knowing which sites make a valuable contribution to efficient marine reserve system design allows us to determine how well South Australia's existing reserves contribute to achieving reservation goals at different representation targets. Existing marine reserves that fail to contribute to efficient marine reserve systems constitute 'opportunity costs'.
We found that despite spanning less than 4% of South Australian state waters, locking-in the existing ad hoc marine reserves presented considerable opportunity costs. Even with representation targets set at 50%, more than half of South Australia's existing marine reserves were selected randomly or less in efficient marine reserve systems. Hence, ad hoc marine reserve systems are likely to be inefficient and may compromise effective conservation of marine biodiversity.

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Taylor, Richard B.*[1] and Peter D. Steinberg[1]

Mesograzer specialisation on seaweeds: a test of current theory using Australasian temperate rocky reef systems.

Mesograzers, small herbivores that use individual seaweeds as both a living site and a food source, are predicted by M. E. Hay and J. E. Duffy et al. to inhabit and consume seaweeds that are chemically defended against larger grazers such as sea urchins and fishes. Support for this hypothesis has come from several studies done on the temperate east coast of North America and in some tropical regions, but the present study is the first community-level test, and the first done in a typical kelp-dominated temperate system (the rocky reefs of Southeast Australia and Northeast New Zealand). Results from both regions were similar. Larger grazers (three species of fishes, four gastropods, and three sea urchins) varied widely in diet breadth, but most often preferred to eat nutritionally superior green algae of the family Ulvales and the red alga *Pterocladia capillacea*, all of which were restricted to the high intertidal. Most of the mesograzers surveyed (seven amphipods, three isopods, a gastropod, and a sea urchin) preferred to eat the seaweed species that they inhabited in the field, many of which were less palatable to larger grazers. While these results conformed to Hay and Duffy et al.'s theory, community-level mesograzer distribution patterns did not, as neither abundance nor species richness tended to be higher on host seaweeds that were unpalatable to larger grazers. We argue that spatial refuges on Australasian rocky reefs enable palatable seaweeds to persist in the face of herbivory by larger grazers, and thus lowers the selective pressure on mesograzers to inhabit unpalatable species.

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Taylor, David I.*[1], Robyn A. Dunmore[2] and David R. Schiel[1]

A hemispheric comparison of grazing and growth of habitat-forming algae across exposure gradients.

Several models of intertidal community structure suggest that the relative importance of processes like grazing changes over gradients of environmental stress along intertidal shores. A commonly used proxy for environmental stress has been that of 'wave exposure'. Tests of such models have often been done using mussel and barnacle assemblages but do these models apply for habitat-forming seaweeds? We tested the relative importance of grazing in determining survival of related habitat-forming algae across wave exposure gradients in southern New Zealand and Oregon.
Fucoid algae can dominate the intertidal biomass in lower and mid tidal zones in New Zealand and in the mid and upper tidal zones in Oregon. We measured the effect of grazing and wave action on early benthic life-stages (germlings) that are critical to establishment of algal populations and are most likely to be vulnerable to invertebrate grazers. We transplanted germlings (c.150µm) of *Hormosira banksii* and *Durvillaea antarctica* in New Zealand and *Pelvetiopsis limitata* and *Fucus gardneri* in Oregon across wave exposure gradients and reduced the effects of grazers using fences. The grazing effect on germling survival was often small (less than 5 percent within the first 7 days) but varied considerably and accounted for up to 38% of mortality at sheltered and exposed sites in one experiment. Overall, germling survival was low, usually less than 20% after 14 days, even in fenced treatments. Growth differed considerably between species within 14 days with *Durvillaea* growing up to three times faster than the other species.
In another set of experiments fish grazing by *Odax pullus* was found to constrain the distribution of juvenile stages of *Durvillaea* across wave exposures. Our results suggest that for early life stages of at least some habitat-forming algae environmental factors and grazing do not change in importance across wave exposure gradients.

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Thompson, Glen A.*[1] and David R. Schiel[1]

Mechanisms of invasion: facilitation and inhibition of the invasive alga, *Undaria pinnatifida*, in New Zealand.

Marine invasive species are a major nuisance world wide and can expand dramatically in non-native habitats. Initial invasion occurs via transport across national borders, often through shipping, but expansion from these initial hot-spots can be through a variety of mechanisms. However, any expansion must involve interactions with native biota. Here we discuss the localised invasion of the laminarian alga, *Undaria pinnatifida* at sites in Southern New Zealand. *Undaria* is a large annual kelp native to Japan, southern Korea and China that was first discovered in New Zealand in 1987. Since its arrival it has invaded many areas of the lower North Island, and much of the South Island. It occurs mainly subtidally in its native areas, but in New Zealand it occupies mainly the intertidal zone where it has to compete for space with native algal species such as coralline turfs and the fucalean seaweed *Carpophyllum maschalocarpum*. We show experimentally that *Undaria* recruited better to turf areas than into bare space, suggesting a facilitation mechanism. In contrast, other experiments showed that the canopy of *C. maschalocarpum* inhibited the recruitment of *Undaria*, probably by abrading the recruits with its fronds. Areas cleared of canopies were invaded by *Undaria* within months. Over time the size of a clearance influenced the type of algae dominating space, with *C. maschalocarpum* eventually dominating small (25 cm^2) clearances and *Undaria* the bigger ones (625 cm^2 and 2500 cm^2).

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Thompson, Richard C.*[1], Steve J. Hawkins[2] and Trevor A. Norton[3]
Pattern and process in benthic biofilms: the relative importance of physical forcing and biological interaction.

Biofilms play a key role in marine ecosystems and provide a tractable system for investigating the relative roles of physico-chemical forcing and biological interactions in regulating intertidal communities. Patterns of microbial biomass were described over a 4-year period on rocky shores on the Isle of Man. Photosynthetic biomass and the abundance of diatoms were greater during winter than summer. Seasonal patterns for cyanobacteria varied among tidal levels: abundance being greater on the upper shore during winter and on the lower shore during summer. Photosynthetic biomass was negatively correlated with insolation stress and air temperature but was not related to sea temperature, planktonic chlorophyll, nutrients, or grazing.
Field experiments to investigate processes generating these patterns showed that reducing insolation stress by shading caused a 50% increase in microbial biomass and a five-fold increase in the abundance of diatoms and macroalgal germlings. Reducing grazing had a similar effect on microbial biomass, but there were no effects of reducing desiccation or increasing nutrients.
Limpets were the principal grazers on these shores. Their feeding intensity also had a distinct seasonal pattern being positively correlated with temperature, but not microbial abundance. Hence, although it is widely recognised that grazing has an important role regulating the succession of algae on rocky shores, the present study has demonstrated that physico-chemical limiting factors and stressors are also important in controlling seasonal patterns of micro and macro algal abundance. The data also indicate that during the summertime grazers respond to patterns in microalgal abundance rather than generate them.

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Thomsen, Mads*[1] and Karen McGlathery[1]
***Codium fragile* - an invasive species in Hog Island Bay, Virginia, US.**

Codium fragile is an introduced and invasive species on the US Atlantic coast. *Codium* was introduced in New York in the 1950's and has spread north and south to Maine and the Carolinas respectively. No data have been presented on *Codium* from Virginia. We report data on distribution, recruitment and growth of *Codium* in Hog Island Bay (HIB), a soft-bottom lagoon with sparse and scattered oyster reefs. Today, *Codium* is the 3rd most abundant macroalgae in HIB, only superseded by *Gracilaria tikvahiea* and *Ulva lactuca* (27 surveys during a 4 year period). It has a late summer biomass peak but is present year-round attached to unconsolidated shells and as drift weed. Drifting *Codium* is mainly observed in late summer when its size and thus drag peaks. Recruitment onto artificial substrate (200 building bricks, 20*10 cm, 1.5 years incubation time) is relatively high and the *Codium* thallus can cover a brick completely in 1 year. However, the vertical band of successful recruitment in HIB is very narrow, being limited by desiccation at high elevations and sediment cover at low elevations. Tissue growth rates follow a pattern similar to recruitment with high growth in the shallow subtidal at mid lagoon sites. We conclude that *Codium* is highly successful in HIB, but only under a specific subset of environmental and spatio-temporal conditions (shallow subtidal, hard substrate, spring-summer and low sedimentation).

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Trebilco, Jessica*[1], Craig R. Johnson[1], Simon Wotherspoon[2], Rebecca L. Habeeb[1] and Piers K. Dunstan[1]

Techniques to estimate characteristic length scales of real marine systems.

The choice of appropriate spatial scales for observing, conserving and managing ecological systems are pervading questions in applied ecological research. Determining the characteristic length scale (CLS) of ecological systems is likely to provide valuable information towards answering these questions. The CLS is the scale at which the ratio of deterministic signal to noise in the system's dynamics is maximised, i.e. the scale that captures the meaningful signal of the system's deterministic dynamic. Recent methods for identifying CLSs are attractive because they accommodate the complex non-linear behaviours that occur in ecological systems. However, these methods require long temporal data series and so are unrealistic for most natural systems.
We develop and assess two alternatives to using long time series data for estimating CLSs. The first requires data from only three or four consecutive landscapes, but from several different places in space. The second approach uses spatial data from only a single point in time. We trial these techniques using model systems that are more complex than those used by previous authors and which may provide a broader test for how CLSs might perform with real data sets. Results indicate that our short time series approach to estimating CLSs is robust, with several advantages over those requiring long time series. It has strong potential for application to natural systems. Combining estimates of CLSs based on system dynamics with more conventional analyses for identifying scales of spatial pattern formation may be an optimal approach to defining

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Underwood, Antony J.*[1]

"Preference" in ecological analyses: a much mis-used term!

Many authors have described preferences by animals for components of habitat or microhabitat, when all that is known is greater density in these microhabitats than elsewhere. Other authors have described preferences by predators for some components of available prey - when all that is described is a confused experimental analysis of consumption of more of the apparently "preferred" prey than of other species. Both issues share the lack of logic that makes ecology such a muddle. In this paper, I describe the issues, the logical structure of relevant and coherent models and hypotheses and new advances in thinking and analysis (in collaboration with Drs M.G. Chapman, T. Crowe, C. Olabarria and Professor K.R. Clarke) to illustrate better ways forward in these different areas of ecology.

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Valentine, Joe*[1] and Craig R. Johnson[1]

Establishment of dense stands of the introduced kelp *Undaria pinnatifida* in Tasmania depends on disturbance to native algal assemblages.

Despite high rates of occurrence of non-indigenous organisms in the marine environment, few studies have critically examined mechanisms underpinning the invasion process. We used manipulative experiments to examine the invasion dynamics of the Asian kelp *Undaria pinnatifida* at two sites on the east coast of Tasmania. Disturbance to reduce cover of the native algal canopy was found to be a critical stage in the establishment of *U. pinnatifida*, while the presence of a stable canopy of native algae inhibited sporophyte development. In the first season of sporophyte growth following canopy disturbance, *U. pinnatifida* recruited at high densities (up to 19 plants per m^2) while remaining rare or absent in unmanipulated plots. This result suggests that *U. pinnatifida* gametophytes occur throughout these native algal beds, but do not develop into visible sporophytes while the canopy is intact. The timing of disturbance was also an important factor. *U. pinnatifida* recruited in higher densities in plots where the native canopy was removed just prior to the sporophyte growth season (winter 2000), compared to plots where the canopy was removed 6 months earlier during the period of spore release (spring 1999). In the second year following canopy removal, *U. pinnatifida* abundance declined significantly, associated with a substantial recovery of native canopy-forming species. We recorded similar responses of *U. pinnatifida* in areas where native macroalgae were removed by natural phenomena. From a management perspective, where disturbance is linked to anthropogenic activity, managing the disturbance is likely to prove a more practical and cost-effective option that targeting the plant directly.

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Wahl, Martin*[1 9], Markus Molis[1], Andy Davis[4], Sergey Dobretsov[2], Simone Dürr[4], Josefin Johansson[7], Jeff Kinley[4], David Kirugara[5], Matthias Langer[6], Heike Lotze[3], Martin Thiel[6], Boris Worm[3] and Dafna Zeevi[8]

Impact of natural UV-radiation on shallow marine hard-bottom assemblages: a global approach.

In identical experimental approaches, the impact of ambient UVA and UVB radiation was assessed in 13 regions around the globe spanning 134 latitudinal degrees: Antarctica (66°S), Australia (34°S), Brazil (25°S), Canada (44°N), Chile (30°S), China (22°N), Germany (54°N), Israel (30°N), Kenya (4°S), Namibia (27°S), Norway (68°N), Philippines (8°N) and Scotland (57°N). The experiments consisted of exposing ceramic tiles to natural marine colonisation (in situ) at 4 cm water depth under different light treatments created by cut-off filters (full solar spectrum (FS), FS without UVB and FS without UVA and UVB). The response variables monitored over several months were wet weight, total cover, species richness, and Shannon diversity. Here we concentrate on the latter. Some experiments had to be dropped due to natural hazards. The results of the remaining sites are presented.
Surprisingly, UV effects on the community level were generally weak and varied strongly within and among sites. While both diversity-enhancing and diversity-decreasing effects were observed, UV radiation more often decreased benthic diversity. Remarkably, the effects of UV radiation in most instances were of transient nature. They reach their maximum diversity-reducing strengths at an early or intermediate stage in succession and vanish when the communities matured. The gradual disappearance of negative UV effects in most sites coincided with the enhanced growth of one or more apparently UV resistant species which increasingly protected other species in the community from radiation. The identity of the UV resistant species varied among regions but in most instances belonged to fast growing red or green algae. Concluding, while UV radiation has negative effects on numerous species, communities seem to have a buffering capacity which gradually compensates UV effects. Actual ambient UV-levels may not be expected to have lasting effects on marine benthic communities. Further increases in ambient UV levels may, however, challenge the observed buffering capacity at the community level.

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Webster, Michael S.*[1], Bruce A. Menge[1] and Jane Lubchenco[1]
Effects of regional variation in recruitment and community structure on intertidal fishes.

Understanding the factors that drive population and community dynamics is particularly challenging in systems that are connected via propagule dispersal because the rate of arrival of new individuals is both notoriously unpredictable and potentially critical in determining future dynamics. Furthermore, patterns of propagule settlement can be fundamentally modified by post-settlement interactions. Thus both settlement rates and post-settlement processes jointly determine future population and community structure. We investigated how variation in both the recruitment of juveniles and local community structure affected the demography of intertidal fishes in two oceanographically distinct regions in Oregon. Observations over three years indicated persistent regional differences in the abundance of intertidal fishes. Measurements of variation in tidepool fish recruitment suggest similar rates of delivery among oceanographic regions. By factorially manipulating the presence and absence of dominant sessile organisms in tidepools, we tested whether differences in tidepool communities were responsible for regional variation in the abundance and species composition of tidepool fishes. We found little evidence that tidepool community structure affected adult intertidal fishes. In contrast, newly recruited fish may recruit disproportionately to pools with low cover of mussels. These results suggest that interactions between habitat type and juvenile fishes partly determine adult population structure. Ultimately these interactions may arise from regional differences in oceanography that influence intertidal communities of sessile invertebrates.

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Wellenreuther, Maren*[1] and Sean D. Connell[2]
Response of predators to prey abundance: separating the effects of prey density and patch size.

Studies of predator-prey dynamics tend to use three different categories of abundance: prey density, prey-number and patch size. This study demonstrates that these different notions of prey abundance can have profoundly different effects on predatory responses, partially explaining why generalisations about the form of predatory responses to varying abundances of prey have been slow. We tested the relative and combined effects of prey density and patch size on the functional response of a predatory reef fish (*Cheilodactylus nigripes*) to their invertebrate prey. Fish attacked prey at a greater rate and for longer time in large than small patches of prey, but large patches had naturally greater densities of prey. We isolated the effects of patch size and prey density by reducing the density of prey in larger patches to equal that of small patches; thereby controlling for prey density. We found that the intensity at which fish attacked prey (combination of attack rate and duration) was primarily a response to prey density rather than the size of patch they occupied. However, there was evidence that fish spent more time foraging in larger than smaller patches independent of prey density; presumably because of the greater total number of prey available. These results suggest that greater awareness is needed when describing and reviewing the effects of density dependent processes. Understanding these differences may improve our ability to generalise about to form of responses of predators (both numerical and functional) to varying abundances of prey in natural habitats.

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Whitmer, Allison C.*[1]

Genetic analysis of population growth in an intertidal alga, *Postelsia palmaeformis*, using microsatellite markers.

The early stages of population growth can occur either through the recruitment of propagules originating primarily from within the population, or from propagules originating outside the population. The former will increase the probability of inbreeding. This will be particularly the case if there were few colonisers or if only a fraction of the founders successfully reproduce in the following years. In order to investigate the mode of early population growth in an intertidal alga, *Postelsia palmaeformis*, microsatellite markers were employed to examine the genetic variability and composition of individuals in isolated stands over time. Analysis of microsatellite genotypes of individuals over 2 years suggested that reproduction occurred primarily from within the stand and supports the hypothesis of short-range (< 5.0 m) dispersal. Data also suggested that successful self-fertilisation allows single individuals to found new populations. These data support a prediction that a model of isolation-by-distance would describe the genetic structure of large populations, which is supported by preliminary data on allele distribution in a large stand of *Postelsia*.

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Wood, Spencer A.*[1], David R. Schiel[2], Murray J. Smith[3] and Craig L. Stevens[3]

How early life stages of seaweeds attach and survive in wave-dominated environments.

Early life stages of attached organisms must not only arrive to shore but stick to it and remain attached. These processes are only beginning to be understood for habitat-forming seaweeds. In New Zealand, several fucalean species dominate the intertidal zone on rocky reefs across all wave climates. Here, we use laboratory experiments to test hypotheses about the ability of early life stages of some species to stick to hard substrata in varying flow velocities and to remain attached after initial settlement, and we attempt to validate this work in field-based experiments. Three species (*Durvillaea antarctica*, *D. willana* and *Hormosira banksii*) showed differing abilities to stick to substrata but succeeded mostly at lower velocities. In flume tests of the ability of settlers to remain attached, there was a simple fall-off of numbers remaining attached across flow velocities. However, once initial settlers detached there was almost 100% survival of the remaining germlings during repeated tests across the same velocities, demonstrating a difference of attachment within a species. Older germlings (up to a week post-settlement) had greater survival. Field experiments showed a complex relationship between germling survival and wave climate, but were confounded by a number of other factors.

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Zemke-White, W. Lindsey*[1] and Kendall D. Clements[1]

Long term temporal changes in kelp abundance.

Abundance of *Ecklonia radiata* in Southeast Bay and Northwest Bay at the Three Kings Islands, New Zealand was determined in the early 1980s, in the early 1990s and in 2002. The diet of the endemic herbivorous fish, *Odax cyanoallix* was examined in 1993 and 2002. *E. radiata* was rare in the 1980s, abundant in the 1990s and rare in 2002. This affected the diet composition of *O. cyanoallix*; in Southeast Bay *E. radiata* comprised 84.09% ± 3.83SE of the diet of these fish in 1993, and 6.84% ± 3.87SE in 2002. Possible causes of the variation in *E. radiata* abundance are discussed.

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Poster Presentations

Airoldi, Laura*[1], Francesca Bacchiocchi[1] and Marco Abbiati[1]
Effects of artificial structures on the distribution of rocky reef assemblages.

Artificial structures are a common and increasing feature of many urbanised sandy coastal areas. Despite the resulting increase of rocky habitats, which in some areas can affect over half of the natural shoreline, little is known about how marine organisms respond to the addition of artificial structures. The evaluation of the effects of artificial structures on the regional distribution and diversity of rocky reef assemblages is in progress along the Italian shores of the North Adriatic Sea, where natural reefs are rare and over 60% of the coastline is characterised by the presence of artificial structures, mainly hard structures for defence and stabilisation of shores. The composition, abundance and distribution of intertidal and subtidal assemblages associated to defence structures and natural reefs were analysed along about 400 km of coasts. Sampling covered several spatial scales: (1) 10s to 100s of kilometres (distance among locations), (2) 10s to 100s of meters (distance among defence works within each location) and (3) 1 to 10s of meters (distance among replicate plots within each defence work). Differences in the composition and structure of assemblages were observed between defence structures and natural reefs. Such differences were particularly notable for intertidal assemblages, while they weakened in the subtidal. In areas where no natural hard substrata occurred, assemblages on defence structures were generally characterised by low species richness and spatial dominance by mussels and green ephemeral algae. Major differences in the composition of species were observed among locations, reflecting both a geographic trend of increasing species richness from North to South and a trend of decreasing richness at greater distances of the structures from natural reefs. Overall results suggest that artificial structures may act by changing the patterns of distribution of locally abundant species rather than by increasing species diversity.

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Bassett, Daniel*[1] and John Montgomery[1]
The ecology and behaviour of nocturnal marine predatory fish.

Despite the importance of nocturnal predatory fish in temperate marine ecosystems there is little knowledge available on this guild. This study aims to research three fundamental areas into the ecology of nocturnal predatory fish giving an overall 'picture' of how fish within this guild function and interact. Through the use of infrared video bait stations the population ecology of the nocturnal predatory guild will be investigated within the Leigh marine reserve. This will determine what fish are nocturnal and in which habitats they are abundant. The movement, foraging and activity patterns of the Yellow moray eel, *Gymnothorax prasinus*, will be studied long-term through the use of acoustic tags giving an insight into the actual behaviour of a major nocturnal predator in situ. The ability to detect a hydrodynamic trail using the mechanosensory lateral line will be explored further enhancing our knowledge of non-visual feeding strategies in fish. The entire study will not only provide an insight into the ecology and behaviour of nocturnal predators but will also demonstrate how species tend to function in other non-visual environments such as the Deep-Sea and Antarctica.

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Bell, Andrew H.*[1]

Evaluation of a technique for the *in situ* determination of the ultraplankton contribution to the nutrition of oysters.

The ultraplankton (planktonic cells <5µm) are the most abundant potential food source for suspension feeding bivalves and the least studied. While laboratory studies have suggested that the ultraplankton may be unavailable to suspension feeders (due to the theoretical mechanical efficiencies of the filter mechanisms) in situ measurements are few. This lack is primarily due to the technical difficulties of examining this small size fraction in a meaningful manner.
Utilising a simple clearance rate equation we devised an in situ sampling technique to assess the ultraplankton retention in pacific oysters. Inhalant and exhalent water samples were collected by syringe, frozen and analysed for particle composition and size using flow cytometry. Flow cytometric analysis using fluorescence from the photopigments and DNA stain SYBR Green I, allowed efficient identification and enumeration of the ultraplankton populations. By comparison of samples it was possible to determine retention. The use of flow cytometry to monitor the microecology of plankton has the potential to substantially enhance our knowledge of primary productivity and the contribution of various water column components to energy flow in the aquatic ecosystem.

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Carbines, Glen*[1]

The impact of oyster dredging on blue cod in New Zealand.

Little is known about the potential impact of dredging on the growth and abundance of demersal fishes. Observations of blue cod (*Parapercis colias*) and oyster (*Ostrea chilensis*) fishing patterns indicate that dredging by the oyster fishery reduced localised catches and changed fishing patterns of blue cod fishers in Foveaux Strait, southern New Zealand. An analysis of the diet and growth of blue cod from undisturbed biogenic reefs and reefs modified by oyster dredging further showed that diet complexity and growth of juvenile blue cod are reduced by dredging for oysters. However, stabilising dredged habitat with fresh processed oyster shells shows promising signs of regeneration of blue cod populations in only a few years. Towed underwater videos will be used to confirm the impact of dredging on habitat complexity and numbers of blue cod.

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Carless, Sarah[1], Richard Stillman[2], Pete Cotton[1] and Ross Coleman*[1]
Human disturbance and Oystercatcher behaviour on rocky shores.

An experimental investigation into the effect of varying intensities of disturbance on the individual foraging behaviour of Oystercatchers on rocky shores has been undertaken in Southwest England. Controlled disturbance events, incorporating the novel application of a model dog, provided valuable results for developing further hypotheses about bird foraging behaviours under conditions of disturbance stress.

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Cole, Russell G.*[1], Craig Syms[1], Tim Haggitt[1] and Russell C. Babcock[1]
Scales of distribution, abundance, and mortality of kelp *Ecklonia radiata* in Northeastern New Zealand.

Kelp *Ecklonia radiata* is one of the dominant habitat-forming seaweeds in New Zealand's subtidal. Its populations are patchy in shallow areas, and those in deeper areas undergo intermittent "dieback" events. We assessed the spatial scales of kelp distribution, abundance, and dieback in several sampling programmes over a 10-year period. Analysis of patterns of abundance in two depth-stratified hierarchical sampling designs indicated greater variance among replicate quadrats than among sites, when pooled across depth strata. That pattern was maintained for individual depth strata, except for two year*depth combinations where among-site variability was high. Analysis of kelp forest distributions from a habitat map indicated characteristic distribution scales between 20 and 80 m at four sites. Two quadrat sampling programmes with different grains provided conflicting results. One detected no statistically significant scales, whereas the other found variability in kelp abundance at a scale of about 10 m. Finescale mapping of individual stipes indicated that patterns of distribution at scales between 0 and 1.5 m varied among replicate quadrats. These surveys emphasise the variability of kelp distribution and abundance scales, and raise questions regarding sampling approaches suitable for detecting them.
Experimental clearances of 2x2, 5x5, and 10x10 m were obviated by a dieback event of much greater spatial extent. The spatial pattern of dieback did not have a detectable characteristic scale when sampled in a 50 x 100 m grid. Subsequent dieback-induced clearances have been rapidly replaced by kelp recruitment in several events over the last 10 years. It appears that *Ecklonia*'*s* fecundity and the—presumed—existence of a spore bank render it immune to clearances even at scales of km, and there are no alternative colonists able to form a canopy on reefs below 10 m in Northeastern New Zealand.

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Cox, Serena L.*[1] and Danielle J Johnston[2]

Developmental changes in the structure and function of mouthparts of phyllosoma larvae.

Concern for the sustainability of spiny lobster fisheries has created significant interest in their aquaculture however, attempts to culture them from egg to puerulus have been largely unsuccessful, hampered by provision of unsuitable diets during the phyllosoma larval phase. Therefore, complete documentation of species-specific feeding behaviour is vital for understanding feeding biology and quantifying developmental shifts in diet. This information can be used to indicate possible changes in dietary preference and ingestive capabilities, which are key considerations when formulating artificial diets for culture.
This research explored the morphology, structure and function of mouthparts in cultured *Sagmariasus* (formerly *Jasus*) *verreauxi* phyllosoma (instars 1-13) using SEM analysis. Video analysis was used to determine ontogenetic changes in processing ability, mastication and ingestion during development. Based on increasing complexity of setation structure and robustness of the mouthparts and improved ability to capture, manipulate and externally process prey, we suggest early instar phyllosoma would benefit from a diet comprising softer prey items, whereas later-instar phyllosomas are better equipped to deal with larger, fleshier prey. We propose that formulated feeds must suit mouthpart development and that texture, size and composition may need to be altered for each developmental stage.

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Cranfield, H.J.*[1], K.P. Michael[1], G. Carbines[2], D.P. Gordon[1], B. Manighetti[1], A. Dunn[1] and A.A. Rowden[2]

Effects of 135 years of oyster (*Ostrea chilensis*) fishing on the benthic habitat, associated macrofaunal assemblages, and sediments of Foveaux Strait, southern New Zealand.

We demonstrate historical changes in biogenic reefs in relation to fishing by synthesising data from fishers', institutional fishing records, side-scan imagery, and geological and biological surveys. The seafloor of Foveaux Strait once consisted of biogenic reefs, each hundreds of metres wide and many kilometres long, aligned with the tide, and separated by similarly wide swaths of relict pebble-gravel sediment. The macrofauna of biogenic reefs was dominated by bryozoa (over 200 species) and bivalve molluscs (over 60 species). Oysters were localised on the reef habitat, which was also important for blue cod, *Parapercis colias*. Much of the epifauna of the biogenic reefs was removed by dredging and oysters rapidly became locally depleted. Biogenic reefs were important in the formation of biogenic sediments as well as in the recruitment, growth, and survival of both oysters and blue cod. The expansion of relict pebble gravel seafloor as sediments of biogenic reefs were eroded (probably hundreds of millions m^3), is directly related to the expansion of the area of Foveaux Strait being fished as oyster beds were serially depleted. Mytilid bivalves and pyurid tunicates are identified as early colonisers of regenerating biogenic reefs, these organisms help to stabilise the sea bed enabling the accumulation of fine sediments. Regeneration and enhancement of biogenic habitats and the concomitant rebuilding of oyster and blue cod populations, suggest habitat enhancement and rotational fishing are important mitigation tools for sustainable management.

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Etchemendy, Sheri M.*[1], Maria T. Kavanaugh[1], Gary W. Allison[2], Spencer A. Wood[3], Carl Schoch[4], Bruce A. Menge[1] and Jane Lubchenco[1]

Assessment of community structure and diversity of intertidal rocky shores at local, regional, and latitudinal scales.

Evaluation of the impacts of natural and human-caused change on ecological communities in marine coastal environments has long been stymied by the lack of systematic information on historic patterns of distribution and abundance. To plug this gap in knowledge, we are documenting the patterns of diversity and abundance of intertidal organisms on rocky shores of California, Oregon and Washington as part of the PISCO (Partnership for Interdisciplinary Studies of Coastal Oceans) project. We use a nested sampling scheme that allows us to perform cross-scale comparisons from latitudinal (100's of kilometres) to individual 0.25m2 quadrat scales. We estimate the abundance of macroscopic organisms as percent cover and density counts of mobile invertebrates. Estimates are made within quadrats along transects (very high, high, mid and low zones) at each site. Each year we sample a total of 144 transects across 48 wave-exposed sites nested within 16 major study areas spread evenly from Cape Flattery in Washington to San Diego, California. The ~250 taxa recorded in the database (mostly invertebrates and algae) represent species or composite groups across 14 phyla representing a wide variety of life-history stages, functional groups, and commonness/rarity levels. Along with abundance data, we record many physical measurements of these areas including aspect, slope, and elevation. In addition to our core project we also obtain some supplementary data including mussel bed heights, mussel bed depths, and belt transects. These observations are made to further aid our core data set in determining species abundances of particularly large or patchy species and structure of certain habitats. The data are organised in a relational database and a web-based taxonomic database is also maintained as an identification and teaching tool.

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Foley, Melissa M.*[1], Jacqueline A. Pamplin[1] and Bruce A. Menge[1]

Effect of limpets on the recruitment of barnacles on natural and artificial surfaces.

Community structure in rocky intertidal areas can be shaped by patterns of recruitment of major space occupying species. Once settled, the overall influence of these recruits can be impacted by various factors such as biological disturbance (e.g., limpet bulldozing), substratum properties, algal abrasion, and heat stress. In this study we focused on the effects of limpet bulldozing and substratum properties on recruitment of two intertidal barnacle species, *Balanus glandula* and *Chthamalus dalli* on the central Oregon coast. To test the effect of substratum on barnacle recruitment we used two types of surfaces, natural (bare rock) and artificial (saf-t-walk covered PVC plates). Limpet effects were tested using anti-fouling paint to exclude them from both types of settlement plots. Results showed that limpets had a strong effect at all sites for metamorphs of both species. Settlement of cyprids was not affected by limpets. Recruitment (reflected by metamorphs) and settlement (reflected by cyprids) to the artificial surfaces greatly exceeded that on bare rock. Hence, both limpet bulldozing and substrate surface can be important determinants of initial barnacle abundance, and thus may influence rocky intertidal community structure. Our results suggest caution in making inferences from studies of recruitment that employ either artificial or natural surfaces. The higher recruitment on artificial surfaces, the variable patterns and lower densities on bare rock, and the strong limpet effect suggest that full understanding of the process of recruitment should rest on evaluation of settlement and recruitment patterns obtained under all the conditions tested in this study. Additional issues for future work include examining the differing thermal properties of substrates and how this interacts with limpet and substratum rugosity effects.

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Freidenburg, Tess L.*[1] and Bruce A. Menge[1]

The effects of regional variation in coastal upwelling on recruitment and growth of intertidal invertebrates.

Recent studies in marine systems have pointed to the importance of understanding how links between adjacent ecosystems can influence community structure. Along the U.S. West Coast, coastal upwelling can affect both phytoplankton production and the delivery of larvae to adult habitats. From 1998-2000, we investigated how regional variation in upwelling regimes affected phytoplankton concentration, recruitment rates of barnacles and mussels, and growth rates of mussels along the Oregon coast. The central Oregon coast is characterised by intermittent upwelling during spring and summer while on the southern Oregon coast, upwelling is more persistent. Within the central Oregon coast, nearshore circulation patterns are further influenced by the width and bathymetry of the continental shelf. Our results suggest that large-scale regional differences in upwelling between the central and southern coasts are likely responsible for observed macroscale variation in recruitment and growth rates of intertidal invertebrates. However, at the mesoscale, comparisons between regions within the central Oregon coast did not reveal consistent patterns of recruitment and growth rates, although significant variation occurred among sites. This result contrasts prior work that showed clear between-region differences on the central Oregon coast. We conclude that during 1998-2000, between-site sources of variability had a greater influence on recruitment and growth rates than regional differences in ocean circulation within the central coast. Further study is needed to determine the cause of the differences between pre-1998 and 1998-2000 patterns.

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Guerry, Anne D.*[1]

RNA to DNA ratios and the physiological status of *Mytilus trossulus*: A laboratory examination of food supply, temporal variability, and growth rates.

There is growing interest in understanding the links between the physiology and ecology of intertidal organisms. Biochemical indicators of physiological status allow for the investigation of organismal responses to environmental change at finer temporal scales than traditional ecological methods. However, before using such biochemical indicators in field studies, it is important to understand how they relate to environmental conditions and observed responses of whole organisms. In a laboratory study using the mussel *Mytilus trossulus*, I examined the variability of the ratio of RNA to DNA (an index of protein synthetic capacity) and the relationship between RNA:DNA and shell growth. Using a complete randomised-block design, I examined three treatments: 1) Fed: filtered seawater plus a constant supply of phytoplankton, 2) Food-deprived: filtered seawater only, and 3) Pulsed food: food deprived for seven days, fed for seven days, and food-deprived for seven days. Nine mussels per treatment were measured and dissected each day. I determined RNA:DNA from adductor muscles using ethidium bromide fluorescence. Mussels in the fed treatment grew faster than those in the food-deprived treatment (t-test, $p=0.042$). Although overall mussel growth rates decreased throughout the 21-day experiment, the only significant negative correlation between growth and day of the experiment was for starved mussels ($r=-0.269$, $p=0.005$). RNA:DNA ranged from 0.5 to 4.8, significantly less than we see in the field (0.5 to16 for *M. californianus*). For mussels assayed to date ($n = 67$), there was a trend toward slightly higher RNA:DNA in fed vs. food-deprived mussels for each day of the experiment.

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Harley, Christopher D.G.*[1] and Brian S.T. Helmuth[2]
Local and regional scale effects of emersion time, thermal stress, and absolute vs. effective shore level on patterns of intertidal zonation.

Rocky intertidal ecosystems are often characterised by marked zonation patterns in which species replace one another along the vertical gradient of emersion time. Yet, we still do not fully understand the reasons that zonation patterns shift in space and time, making it difficult to 1) compare ecological patterns and processes across sites, and 2) predict the ecological outcomes of changing climate. Here, we explore the ability of Effective Shore Level (ESL), a metric that incorporates the effects of wave splash, to describe the relationship between uninterrupted emersion time and the zonation patterns of two ecologically important species - the mussel *Mytilus californianus* and the barnacle *Balanus glandula* - in Washington State, USA. At the local scale (10s to 100s of m), the upper limits of both species are closely related to ESL, regardless of substrate aspect or temperature. At larger spatial scales (10s to 100s of km), the upper limit of *Balanus* is related to ESL at cool sites, but not at hotter sites. Thus, although ESL explains most of the local-scale variation in zonation at cool sites, other factors (temperature, desiccation) likely become important as spatial scale increases to incorporate warmer sites. Our results emphasise that an understanding of where and when specific ecological factors are limiting is crucial for our ability to explain and predict large-scale biological patterns in space and time.

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Honma, Lawrence O.*[1] and Michael S. Foster[2]
Long-term variation in a Southern California kelp forest.

Variation in large kelps and invertebrates in a giant kelp forest near San Onofre, CA was assessed over 22 years (1978-2000) based on abundance estimates of large kelps and invertebrates in six stations within the forest. Giant kelp (*Macrocystis pyrifera*) density was cyclic, with large peaks in 1981 and 1992. Recruitment occurred approximately every three years. The understory kelp *Pterygophora californica* and red and purple sea urchins (*Strongylocentrotus spp.*) were abundant at the beginning of the study, but declined to near extinction at most stations in 1980 - 85. *Pterygophora* abundance increased beginning in 1986, but declined to near zero by 1997. *Strongylocentrotus spp*. abundance began to increase in 1990, and has remained high but variable since 1996. Bat stars (*Asterina miniata*) declined to near extinction by 1983 and have remained rare. The white sea urchin (*Lytechinus anamesus*), increased in 1982-4 and then declined to near zero by 1990. Dramatic declines in giant kelp abundance were associated with warm water/low nutrients in 1981-4 and 1997-8, and increases with cooler water in 1990. Variation in kelp abundance among stations appears to be negatively associated with sand cover and sea urchin abundance. These data and historical records indicating that entire kelp forests in the San Onofre region can be buried by sand suggest that temporal variation in this kelp forest is largely driven by variation in the physical environment.

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Kavanaugh, Maria T.*[1], Gary W. Allison[2], Sheri M. Etchemendy[1], Carl Schoch[3], Spencer A. Wood[4], Bruce A. Menge[1] and Jane Lubchenco[1]

Community structure and diversity: evaluating biotic interactions and oceanographic effects on Pacific rocky intertidal communities using a large-scale, data-intensive survey.

A major hindrance in understanding how marine communities respond to larger-scale perturbations has been a lack of information of natural patterns at appropriate scales. Most survey results are limited in spatial and/or temporal scope to one or a few sites and sample dates. To overcome these limitations the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) has been quantifying community structure of rocky intertidal communities along the US west coast from Cape Flattery, WA to San Diego, CA since 1999. The project employs a spatially nested design that provides geographically dense sampling within 16 areas. Abundance data are collected on both invertebrates and macrophytes at four standardised elevations.

In addition to its use for monitoring community changes, the extensive surveys lend themselves well to exploring a number of ecological questions. For example, are local experimental results relevant at larger spatial scales? Are patterns of herbivore/ macroalgal diversity consistent over space? And, what are the community responses to physical and/or oceanographic signals at different scales? Initial explorations of the effects on algal diversity suggest that, though physical components (e.g. sand, latitude, substratum rugosity) have a dominant role in shaping lower intertidal communities, biological components (such as herbivory, predation, spatial competition) may have a more dominant role in shaping mid zone communities. Thus, coupling the intense biological sampling with appropriate physical measurements has provided unique perspectives not possible with a less spatially explicit protocol. Furthermore, integration of this dataset with results from small scale experiments, recruitment monitoring and large-scale climate observations are likely to yield further insights into the forces, both biotic and abiotic, that shape temperate intertidal communities.

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Lilley, Stacie A.*[1] and David R. Schiel[2]

Deletion of habitat-forming species and the consequences to community biodiversity in New Zealand rocky shore ecosystems.

Marine intertidal habitats tend to be defined by their dominant, structural species. These habitat-forming species increase spatial complexity and alter local environmental conditions, often facilitating a more diversified assemblage of plants and animals. Removal of these dominant species, therefore, has the potential to result in pronounced changes in local diversity. The mid-shore of wave protected rocky shores in New Zealand are typically dominated by the fucoid alga *Hormosira banksii*. *H. banksii* individuals were removed from three $3m^2$ areas at two intertidal platforms in the South Island of New Zealand in late winter 2002. Monitoring of the understory 2, 4, 8 and 16 weeks (to date) following canopy removal was completed to assess any secondary extinctions and recruitment that followed removal of *H. banksii*. Although changes to the understory (e.g. bleaching and blackening of species) occurred within two weeks of removal, no significant change in the total number of species or the community composition occurred until four months following removal. In comparison to control plots (in which *H. banksii* was not removed) at two months, the canopy removal plots had a decrease in abundance and in the number of molluscan grazer species and a dense cover of ephemeral algae. At four months after removal the total number of species in the canopy removal plots was significantly lower than in the control plots. Monitoring will continue along with further experimentation to examine the mechanisms through which *H. banksii* promotes increased diversity.

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McBride, Graham*[1] and Russell G. Cole[2]

Implementing the precautionary principle with inequivalence tests: it costs….

Tests of “point-null” hypotheses are the primary statistical tool of ecologists at present, yet they have many shortcomings that are poorly understood. One alternative is tests of interval hypotheses, i.e., equivalence tests, which are required for drug evaluations by US FDA. These are of two kinds; tests of equivalence (“proof of hazard”) and tests of inequivalence (“proof of safety”). Rejection of the equivalence hypothesis demonstrates an important difference between populations. More interestingly, rejection of the inequivalence hypothesis allows proof of environmental safety, and directly admits the conclusion that there is no difference of concern. We demonstrate the application of interval tests to an assessment of dredge spoil disposal in Taranaki. Although we could not demonstrate safety for the abundances or composition of intertidal or subtidal rocky reef organisms, there was no proof of hazard either. Calculations of sample size suggest that far greater sample sizes than normally used will be required to maximise utility of the interval tests. Equivalence tests offer an important opportunity to examine realistic hypotheses, and enhance environmental impact assessments.

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Moore, Pippa J.*[1 2], Richard C. Thompson[1] and Steve J. Hawkins[2]
The role of biotic interactions in mediating species responses to climate change.

It is generally acknowledged that the distribution of many species will alter in response to changes in our climate. However predictions for the extent of these shifts are generally based on anticipated changes in temperature alone. Here we use the rocky intertidal as a model system to investigate how the balance of northern and southern species may also be influenced by biological interactions.
In northern Europe the abundance of many intertidal organisms is influenced by the presence of large fucoid algae which provide a refuge, from desiccation and temperature. These macroalgae are replaced by smaller turf forming algae in southern Europe which offer little refuge. The effects of macroalgal cover on the relative abundance of northern and southern species of limpets was examined on shores in south-west Britain. These two limpet species have a key role in structuring semi-exposed shores of the NE Atlantic and it is important to understand changes in their abundance in relation to climate change.
Results show that the southern/Lusitanian limpet *Patella depressa* does not aggregate under *Fucus* patches with significantly higher proportions of *P. depressa* found outside *Fucus* while the abundance of *P. depressa* increases with decreasing *Fucus* cover. In contrast it has been demonstrated that the northern/boreal limpet *P. vulgata* aggregates under *Fucus* patches. The results of manipulative field experiments are presented which describe the responses of the two limpet species to the loss of *Fucus* and discusses the extent to which this may affect their distribution in response to climate change.

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Naylor, Larissa A.[1] and Stephen J. Hawkins*[2]
Possible responses of *Sabellaria alveolata* (Linné) populations under different scenarios of climate change in Great Britain.

Sabellaria alveolata (Linné) are currently a rare, but locally abundant, species that build reef colonies in intertidal and subtidal areas of western Britain. Historically, *S. alveolata* populations in Britain occupy the northern extent of their European distribution; they typically have only one spawning period compared with two in more southerly locales such as Brittany; intertidal populations have been sensitive to periods of extreme cold weather, such as the die-back of lower eulittoral reefs which occurred during the winter of 1962-1963. Since the winter of 1963, the populations of *S. alveolata* have been steadily increasing. For example, individual worms were found to be settling and establishing reef communities in the lower mideulittoral zone in south Wales, UK. *S. alveolata* require a range of conditions for successful settlement and growth, including moderately exposed wave conditions, near continuous water turbulence, a local sediment supply (> 63um - 2 mm on the Wentworth Scale) and a firm substrata. Given the range of climate change scenarios for Great Britain, including increased temperatures, such as ambient air temperatures causing warmer winters and warming of coastal seas, increased storm activity, sea level rise and possible shifts in wave climate, there is a large likelihood that the populations of *S. alveolata* will undergo considerable spatial change. This paper examines the possible effects of changes climatic conditions, using recent analyses of climate change such as the IPPC TAR report, the UKCIP02 scenarios and scientific papers, on *S. alveolata* reef populations in Southwestern Britain.

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Nielsen, Karina J.*[1], Francis Chan[1], Brian A. Grantham[1], David Fox[2], Mark Amend[2], Renee Davis-Born[1], Jane Lubchenco[1] and Bruce A. Menge[1]

Unusual die-off off Oregon's Coast associated with a persistent low-oxygen zone.

In Summer 2002, we observed an unusual die-off of marine organisms including lingcod, rockfish, sculpins, wolf eels, octopuses, worms, and skates along the Oregon coast. On July 10, Oregon Department of Fish and Wildlife scientists conducting an underwater video survey near Cape Perpetua saw only dead fish and invertebrates on a previously well populated rocky reef. Shortly thereafter, commercial crabbers pulled up crab-pots with dead rockfish, crabs, and other invertebrates. Scientists from Oregon State University's (OSU) College of Oceanic and Atmospheric Sciences also measured unusually low-oxygen water extending at least 9.3 km offshore. Following these reports, researchers from the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) at OSU investigated the cause(s) of this die-off during three research cruises. We found a layer of very low-oxygen (<2 mg/l, or "hypoxic") water 10-20 m thick along the ocean bottom, and as shallow as 8 m. We estimate the hypoxic zone covered > 672 km2, persisted for at least 33 days, and is the probable cause of the die-off. These observations, plus data from PISCO nearshore moorings, suggest that upwelling of unusually cold, salty, and low-oxygen water is the primary reason for this hypoxic event. Oxygen levels may have been further depleted by the normal oxygen-consuming decomposition of phytoplankton. This is the first documentation of a hypoxic zone die-off in shallow waters off the Oregon coast. The ecological consequences of this event, reasons for its appearance and persistence, and the potential for its recurrence are the subjects of ongoing research.

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Multiple ecological roles of brominated secondary metabolites from the red alga *Asparagopsis armata*.

Marine red algae are chemically rich producing secondary metabolites that deter herbivores, fouling organisms, and other natural enemies. We tested the role of secondary metabolites from the red alga *Asparagopsis armata* in both herbivore deterrence and microbial colonisation. *A. armata* has specialised cellular structures where secondary metabolites, including bromoform and dibromoacetic acid, are stored . These metabolites were quantified in the plant by GC-MS. The role of these chemicals in plant defence was tested using a novel technique by removing bromide ions from growth media. This produced plants that contain brominated metabolites (Br(+) plants) and those that do not (Br(-) plants). This allowed us to test whole plant palatability of *A. armata* against a range of herbivores and also examine whether these metabolites are involved in the regulation of bacterial biofilms at the plant surface. In feeding experiments with the common amphipod, *Hyale sp.*, Br(-) plants were consumed at a significantly higher rate than plants with brominated metabolites (Br(+) plants). Furthermore, bacterial counts on Br(+) plants were significantly lower than on Br(-) plants. These results demonstrate that *A. armata* produces brominated secondary metabolites that are active in both herbivore deterrence and the regulation microbial communities.

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Richards, Daniel V.*[1]

Black abalone, *Haliotis cracherodii*, struggling for survival at the California Channel Islands.

The surviving number of *Haliotis cracherodii* in southern California remains at a level of less than one percent of the 1985 population. Once important spatial components of the rocky intertidal community, black abalone succumbed to Withering Syndrome, a lethal, contagious disease that wiped out over 90% of the population between 1985 and the early 1990s yet exploitation of the resource continued legally until 1991. Still susceptible to the disease, survivors may be too dispersed for effective reproduction and recruitment is very low. Worms, algae, and mussels now cover rocks once dominated by black abalone. At the warmer water islands, Anacapa and Santa Barbara, black abalone are extremely rare. At the cooler water islands, San Miguel and Santa Rosa, we do find small numbers of young abalone, providing some hope. The continued survival of this species is precarious. The National Marine fisheries Service has added black abalone to the candidate species list for possible listing under the federal Endangered Species Act.

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Russell, Bayden D.*[1] and Bronwyn M. Gillanders[1]

The effect of habitat size and isolation on diversity of macrofauna.

Theory predicts that both habitat size and habitat isolation will affect faunal diversity within habitats. Faunal diversity in habitats is predicted to resemble that of neighbouring habitats more closely when the habitats are closer together and larger in size. On a subtidal reef at West Island, South Australia, we experimentally manipulated size and distance between artificial habitats to test this prediction. We compared assemblages of macroinvertebrates among experimental habitats in an orthogonal combination encompassing two sizes of habitat and two levels of isolation. Such comparisons may be used to test hypotheses derived from models about the spatial arrangement of Marine Protected Areas (MPAs).

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Smith, K. Allison*[1] and Russell C. Babcock[1]

The effects of marine reserves on juvenile *Jasus edwardsii* survival.

New Zealand has been establishing and maintaining “no-take” marine reserves since 1975. These unfished reefs are helping scientists understand more about the functioning of reef communities and providing insights into the management of unprotected coastline. Among changes that have been observed are increased abundances of top predators, expansion of kelp forest into former “urchin barrens” habitats, and increased predation on sea urchins. However, little is known about the direct or indirect effects of marine reserves on recruitment of juveniles, particularly the commercially important red rock lobster, *Jasus edwardsii*. The increased abundances of top fish predators could lead to increased predation on juvenile *J. edwardsii* decreasing the overall number of lobsters reaching legal size in marine reserves. However, the extended range of kelp forest may simultaneously reduced mortality by creating more protective habitat. Since it is hoped that marine reserves will help replenish stocks of lobsters in fished areas through migration, increased predation may inhibit this function of marine reserves. Juvenile *J. edwardsii* were tethered inside and outside marine reserves and with and without kelp cover to determine predation pressure. Lab experiments were also conducted to determine the effects of predators on juvenile *J. edwardsii* behaviour. The interaction of predation and habitat change may determine the effects of marine reserves on juvenile *Jasus edwardsii* survival.

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Stewart, Megan J.*[1]

Experimental transplants to investigate the effect of habitat change on adult cockles.

The abundance of cockles (*Austrovenus stutchburyi*) has declined at several beaches in urban Auckland. Despite a ban on harvesting at some beaches, there has been no return of populations to anywhere near historical densities. With the harvesting factor removed, this points towards other factors, such as habitat change associated with urban development. In order to investigate the effect of changes in sediment type and contaminant levels on adult cockles, a series of experimental transplants were conducted. Cockles were collected from the relatively clean Whangateau Harbour, north of Auckland, and transplanted to four sites along a pollution gradient in the Tamaki Estuary. Sediment analysis shows a clear gradient in heavy metal and PAH contamination, with lowest levels in Whangateau and increasing to much higher levels in the upper Tamaki. Sediment organics and particle size were also analysed. Four seasonal transplants of cockles (90 days each) and a medium term transplant (360 days) were conducted. Survival up to 60 days was relatively high, but after 90 days there was a marked difference in survival among sites, which is even more evident in the medium term experiment. Cockles in the seasonal transplants were sampled at 15, 30, 60 and 90 days for a range of physiological indicators.

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Walker, Jarrod W.*[1] and Russell C. Babcock[1]
The effects of sedimentation on the survivorship of juvenile sea urchins.

During 1999-2002, algal communities at 30 subtidal rocky reef sites within inner the Hauraki Gulf, Northeastern New Zealand, were surveyed. These reefs are subjected to high levels of sedimentation. Thus are dominated by the fucalean brown seaweeds *Carpophyllum maschalocarpum* and *C. flexuosum*, along with a number of subtidal grazers. The most notable herbivore is the sea urchin, *Evechinus chloroticus*. Sea urchins are capable of maintaining areas of substratum, devoid of large brown algae (called urchin barrens) on reefs exposed to wave action but this 'urchin barren' habitat has not been observed on the sheltered reefs of the inner Hauraki Gulf. Densities of sea urchins found at these sheltered reef sites were low and very few juveniles were found. In contrast a survey of more exposed reefs in the outer Hauraki Gulf revealed widespread urchin barrens habitat containing high densities of urchins and high proportions of juveniles. The aim of our study is to determine the potential role of sedimentation in producing the broad-scale differences between sheltered and exposed reefs. We will present experiments designed to assess the effects of sedimentation on the survivorship of juvenile urchins on sheltered reefs within the inner Hauraki Gulf.

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Wernberg, Thomas*[1] and Gary A. Kendrick[1]
The effect of clearing size and wave exposure on initiation of alternative states in West Australian kelp beds.

Beds of *Ecklonia radiata* are a dominant feature of temperate reefs in Western Australia. These kelp beds can be described by an 'alternative states' model as a mosaic of kelp patches and gaps, which are usually dominated by *Sargassum spp*. or foliose red algae. In a recent review of experimental approaches to investigating alternative states in communities Petraitis and Latham (Ecology 1999 80(2):429-442) emphasised the importance of distinguishing between processes initiating and processes maintaining alternative states. Contrary to many other kelp-dominated systems grazing does not seem to play a significant role in structuring kelp assemblages in Western Australia. Physical disturbances in the form of winter storms are the major forcing agent, creating gaps in the dominant kelp canopy. Studies have shown that *E. radiata* control kelp bed assemblage structure by modifying the surrounding physical environment. It has however also been shown that physical environment and turf algae in gaps may control *E. radiata* distribution. Consequently, there is now good evidence for mechanisms maintaining alternative states in West Australian kelp beds. Petraitis and Latham also emphasised the importance of spatial scale in alternative state initiation, i.e. the presence of disturbance size thresholds in changes from one state to another. This idea is implicitly included in most alternative states models, but it remains largely untested experimentally. We tested the hypothesis that there is a threshold level of disturbance (gap size) above which gaps will persist and that this threshold is lower in more stressful environments (higher wave exposure) are presented. Clearings ranging in size from 0 - 200 m2, covering the size-range of naturally occurring gaps, were made in kelp beds on exposed and sheltered reefs and kelp recruitment monitored for 19 months. After 19 months only small (2 m diameter) clearings on in-shore reefs had recovered to pre-clearing kelp densities. There was no evidence of large (> 4 m diameter) clearings being re-colonised from the edges towards the centres, and we conclude that the experiment supports the proposed hypothesis.

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The importance of trophic status in testing community saturation patterns across multiple local and regional scales.

Plots of local species richness versus regional species richness have provided a foundation for attempts at understanding the influence of regional-scale processes on local species richness. Here, we present an analysis of local species richness of rocky intertidal communities on the west coast of the U.S.A., emphasising the importance of scale, habitat type, and taxonomic resolution. The concept of saturation of ecological communities - an upper limit to species richness imposed by local ecological interactions - theoretically should be most evident by analysis of local richness of functionally similar species across a range of regional species pool sizes. Our analysis of an enormous empirical dataset, encompassing various trophic levels and functional types, indicates that saturation is not a common feature of all intertidal communities. Nonetheless, there are certain situations where saturation is evident. For example, subdividing intertidal communities into such broad groups as 'algae' and 'invertebrates' uncovers saturation patterns unobserved when all species are lumped, especially in the high intertidal. Likewise, dividing invertebrates into broadly defined feeding-guilds leads to more wide-spread saturation patterns encompassing larger local scales. These results challenge the evidently growing consensus that saturation is not a common feature of biological communities, and caution against the application of such tests to data that are a) not grouped in ecologically relevant ways, and b) are not taken at appropriate scales for the ecological interactions of interest.

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