

Celebrating 25 years of temperate reef science

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Introduction

In January 2014, 25 years after its inception (Table 1), 196 delegates from 24 countries descended on Perth for the 10th International Temperate Reefs Symposium (ITRS). For 5 days, temperate reef scientists ranging from students to senior professors, submerged themselves in presentations, passionate discussions and networking.

Temperate reefs are hard-bottom marine ecosystems found in cool waters between the tropics and the poles. Temperate reef ecosystems are diverse, spanning supralittoral lichen-encrusted boulders to sponge gardens on rocky outcrops in the deep oceans. They comprise extensive rocky platforms and small boulder islands in soft-sediment habitats, and biogenic surfaces such as consolidated piles of oyster shells to man-made structures including groynes and pylons. These reefs are inhabited by a plethora of unique, weird and wonderful seaweeds, invertebrates and fishes, all interacting in complex ways with their environment and each other. Unravelling the patterns and processes that drive these ecosystems is the calling of the temperate reef ecologist.

Temperate reefs are not just esoteric constructs of academic acclaim – they are important marine ecosystems that contribute goods and services worth billions of dollars through biodiversity, coastal protection, and activities such as tourism, and recreational and commercial fishing (Bennett *et al.* 2016). Indeed, our intimate connection with temperate reefs is as old as humankind itself. Some believe early humans evolved along the rocky coasts of southern Africa, where a rich diet of mussels, limpets and other marine organisms provided the omega-3 fatty acids and trace elements required for brain function and development (Compton 2011). Temperate reefs have also played an important role in the biogeography of humans, as early colonisers of the America's followed the 'kelp highway', sustained by the bounty provided by reefs along the Pacific rim (Erlandson *et al.* 2007). In more recent times, temperate reefs have been at the centre of many scientific discoveries, and the development of our understanding of the living world, as the cradle and test-bed for many ecological theories (Petraitis and Latham 1999; Underwood 2000; Menge *et al.* 2009; Hawkins *et al.* 2016) although, perhaps not always duly recognised by the non-marine scientific community (Menge *et al.* 2009; Thomsen and Wernberg 2014).

Of immediate concern, though, the temperate reefs we are passionate about, faces ever increasing pressures from expanding human populations and activities. Urbanisation, fishing, invasive species and climate change are threatening the

fundamental functioning and ecological integrity of temperate reefs across scales, latitudes and biogeographical regions (Fraschetti *et al.* 2001; Steneck *et al.* 2002; Connell 2007; Wernberg *et al.* 2011; Smale *et al.* 2013). Understanding the impacts of these pressures is complicated by the fact that many temperate reefs are intrinsically dynamic, experiencing substantial natural environmental and biological fluctuations over decades, seasons, days and tidal cycles (e.g. Reed *et al.* 2016; Wahl *et al.* 2016). Understanding of the interplay between natural and human processes across local to global scales is critical to our ability to predict, detect, and mitigate adverse ecological change.

Never before has it been so critical to place temperate reefs front and centre in our public conscience and nowhere is this more pertinent and urgent than in Australia, where almost 70% of the population live within 50 km of a temperate coastline (Bennett *et al.* 2016), and where reefs have experienced dramatic degradation and habitat loss (Coleman *et al.* 2008; Connell *et al.* 2008; Johnson *et al.* 2011; Wernberg *et al.* 2013; Alleway and Connell 2015). However, it is not all bad news. As we are increasingly understanding the many facets of habitat-species interactions (Thomsen *et al.* 2010) we also find ways to minimise impacts through less destructive harvesting (Stagnol *et al.* 2016) and habitat protection (Olds *et al.* 2014), as well as new management procedures (Shiel and Howard-Williams 2016), and we discover new opportunities for ecological engineering, reclaiming and maximising the ecological value of man-made structures increasingly encroaching on our coastlines (e.g. Evans *et al.* 2016; Firth *et al.* 2016).

Importantly, the seed of science does not grow in a vacuum. For quarter of a century, the International Temperate Reefs Symposium has been a cauldron, forging the new ideas, international collaborations and professional friendships that are at the core of successfully and efficiently meeting the challenges faced by temperate reefs and other marine ecosystems. The 10th ITRS is a milestone in temperate reef science well worth a celebration!

The International Temperate Reefs Symposium

The *International Temperate Reefs Symposium* (ITRS) is a conference for marine scientists with a focus on temperate hard-bottom habitats. The scope is broad and captures natural rocky reefs, man-made structures, and biogenic surfaces. Ecology is the key focus, but the meeting also caters for other scientific disciplines of relevance to temperate reef biology from biogeochemistry, genetics, oceanography and remote sensing to

Table 1. Overview of the first 10 and the 2 future ITRS meetings

Prof. Tony Underwood, the only person to have attended all 10 meetings to date, helped populate this table

ITRS	Date	Host(s) and venue	Country
1	July 1989	Mick Keough, Gerry Quinn and Peter Fairweather, The University of Melbourne, Melbourne	Australia
2	January 1992	David Schiel, Bob Creese, Chris Battershill, Geoff Jones and Alison McDiarmid, The University of Auckland, Auckland	New Zealand
3	February 1995	Tony Underwood and Gee Chapman, The University of Sydney, Sydney	Australia
4	July 1997	Juan Carlos Castilla and Patricio Ojeda, Pontificia Universidad Católica de Chile, Santiago	Chile
5	February 2001	George Branch, The University of Cape Town, Cape Town	South Africa
6	January 2003	David Schiel, The University of Canterbury, Christchurch	New Zealand
7	June 2006	Dan Reed, Carol Blanchette, Ali Witmer, and Steve Gaines, The University of California, Santa Barbara	USA
8	January 2008	Sean Connell and Bayden Russell, The University of Adelaide, Adelaide	Australia
9	June 2011	Steve Hawkins, Richard Thompson and Louise Firth, The University of Plymouth, Plymouth	UK
10	January 2014	Thomas Wernberg and Gary Kendrick, The University of Western Australia, Perth	Australia
11	June 2016	Lisandro Benedetti-Cecchi and Fabio Bulleri, The University of Pisa, Pisa	Italy
12	2018?	Gray Williams, The University of Hong Kong, Hong Kong	Hong Kong

Table 2. Guiding principles of the International Temperate Reefs Symposium as discussed by the informal ‘ITRS council’ during the 10th ITRS in Perth

In attendance or contributing to the list: Tony Underwood, Gee Chapman, Steve Hawkins, David Schiel, Mike Foster, Gray Williams, Sean Connell, Bayden Russell, Lisandro Benedetti-Cecchi, Fabio Bulleri, Dan Reed, Christopher McQuaid and Thomas Wernberg

Guiding principles of the ITRS...

- The ITRS is run by active and enthusiastic marine ecologists, and is not a society *per se*. ITRS matters are dealt with by the informal ‘ITRS Council’, composed of past and known future hosts active in the ITRS community and other stalwarts of long-standing in ITRS.
- The ITRS is principally concerned with the ecology of temperate hard-bottom marine habitats; its aim is to exchange scientific information and ideas about temperate reefs at the international level, with an emphasis on the presentation of completed or nearly completed research. The symposium encourages critical discussion of topical issues and ideas.
- The ITRS is held at ~3-year intervals and should, if possible, alternate between Australasia and elsewhere. Succession planning is an organic process of volunteering, consultation and discussion.
- The ITRS should be hosted by a research group which has shown a long-term commitment and engagement in the ITRS community.
- The ITRS should retain, as much as possible, a ‘workshop’ atmosphere, with appropriate plenaries, discussion groups and social activities, and not become ‘just another conference’. It should be a priority to keep registration costs down to facilitate student and postdoc participation (there is no tradition for using expensive conference organisers).
- To facilitate consistency and continuity, it is customary to have immediate past and future hosts serve on a scientific reference and planning group for new meetings.
- Occasionally, the ITRS presents an ‘Award in Recognition of Lifelong Service and Contributions to Temperate Marine Ecology’ (Fig. 2). It is expected that awardees have been active in ITRS over several meetings and have achieved high international standing in the scientific community. Awardees are nominated by senior colleagues and agreed on following broad consultation among other senior members of the ITRS community, especially the ‘ITRS Council’. An engraved plaque is awarded, modelled on previous awards, with wording consistent with previous awards and with the logo of the ITRS conference where it is presented (Fig. 2).

biogeography and management, not to mention all their inter-sections. Since its inception 25 years ago, the ITRS has grown steadily and is now arguably the biggest meeting of relevance to those with a dedicated focus on temperate marine ecology and associated disciplines.

The first 25 years of temperate reefs symposia have enjoyed the strong-spirited mentorship of those who originally instigated the meeting. However, as the original stalwarts are passing on the baton to the next generation, maintaining the strong momentum of temperate reef science into the future is increasingly in new hands. To facilitate this process, discussions in Perth resulted in a set of broadly agreed guiding principles for future meetings (Table 2). These are not meant to be prescriptive, but rather an explicit reflection on the intentions of the original meeting and the tradition that has emerged.

The ITRS originated in Australia in the late 1980s (Table 1). Born out of frustration with the heavy dominance of the coral reef agenda in research and funding, leading Australasian marine ecologists at the time instigated the ITRS as a platform to showcase outstanding temperate reef science (A. J. Underwood, pers. comm.). Taking turns at hosting each other’s research groups under informal conditions, the emphasis was to provide a forum for critical discussion of topical ideas and research in temperate reef ecology. As interest and attendance grew, it was agreed that meetings should alternate between Australasia and ‘somewhere else’. The first two meetings outside Australasia were respectively in Chile and South Africa, but eventually the Northern Hemisphere was also included and this pattern of alternation has now become a tradition (Table 1). Given its roots, the temperate reef community remains in

agreement that maintaining a strong Australasian and Southern Hemisphere connection into the future is important, as well as ensuring a broad geographic representation (Table 2).

The informal beginnings of the ITRS remain deeply imprinted in the ethos of present day meetings. Unlike the premier meetings of many other disciplines, the ITRS is not controlled by the rigid structures of a formal society, but is driven by the passion and enthusiasm of active temperate reef researchers. To this end, a core principle has always been that the ITRS is hosted by a research group(s), who invites the community to experience their local setting with minimal interference from expensive professional conference organisers. ITRS meetings have therefore always had a strong local flavour: maintaining this, and avoiding the ITRS turning into 'just another sleek conference', invokes strong feelings in the ITRS community. Keeping registration costs down to facilitate broad participation has also always been a priority, as has providing ample opportunities for all participants to interact in informal gatherings (Table 2).

In lieu of a formal society, succession planning and other ITRS business is an organic process centred on an informal 'ITRS council', made up of all past and known future meeting hosts active within the ITRS community, and a few other stalwarts. The primary mechanism for recruiting future hosts is 'volunteering' by and of colleagues with a high scientific standing and long history of active participation in the ITRS community including attendance at several previous ITRS meetings (Table 2).

The ITRS has a strong tradition for acknowledging outstanding students and honouring distinguished colleagues. Most meetings present awards for the best student presentations (Fig. 1) and it has been customary to invite plenaries from within the ITRS community. Several formats have been employed to honour long-time engagement and contributions. For example, at the 2nd ITRS in Auckland, a special colloquium was organised in honour of Prof. Joe Connell, and at the 8th ITRS in Adelaide Prof. Tony Underwood was invited to give an honorary afternoon seminar and speech during dinner. This tradition was carried on at the 10th ITRS in Perth, with casual (i.e. refreshments provided), late afternoon reflective plenaries by Prof. Steve Hawkins and Prof. David Schiel. As a pinnacle of peer recognition, the ITRS *occasionally* presents an award for outstanding achievement, consistent contribution and engagement in the temperate reefs community (Table 2). The nomination for an ITRS Award is a peer-driven process, and to date this honour has been bestowed on six members of the ITRS community (Fig. 2):

- 2003 Prof. Michael S. Foster, Moss Landing Marine Laboratories, United States of America.
- 2006 Prof. Antony J. Underwood, University of Melbourne, Australia.
- 2006 Prof. George M. Branch, University of Cape Town, South Africa.
- 2006 Prof. Joseph H. Connell, University of California Santa Barbara, United States of America.
- 2011 Prof. Stephen J. Hawkins, Southampton University, United Kingdom.
- 2014 Prof. David R. Schiel, University of Canterbury, New Zealand.

The 10th ITRS at UWA

The 10th International Temperate Reefs Symposium convened at the University of Western Australia (UWA) in Perth within the unique, heritage listed surrounds of Western Australia's oldest university campus. Located on the banks of the Swan River, the Temperate Reefs community acknowledge the traditional owners of the land hosting the ITRS, the Nyoongar People, and also pay our respect to their Elders both past and present, and extend that respect to other indigenous Australians.

Perth was the perfect location to celebrate the 25-year milestone in temperate marine science – few places in the world have such natural biodiversity, resources and human activities juxtaposed in such a rapidly growing intellectual and economic environment, and science is at the core of navigating these diverse interests. Pertinently, the overarching theme for the symposium was '*Ecological Transitions*', a theme intended to explore diverse spatial, temporal, environmental and biotic transitions in temperate reef ecosystems while recognising that a key challenge for the future is linking mechanistic ecology with approaches that address global questions.

The symposium was opened by Prof. Paul Johnson, Vice-Chancellor for UWA, and Prof. Lyn Beazley, Science Ambassador and Chief Scientist for Western Australia. Prof. Len Collard of the Nyoongar people welcomed everyone to his country and demonstrated traditional didgeridoo playing, with notable on-stage participation from Prof. Peter Petraitis (University of Pennsylvania), Prof. Lisandro Benedetti-Cecchi (University of Pisa) and Dr Gil Rilov (Israel Oceanographic and Limnological Research).

The 10th ITRS was attended by 196 delegates from 24 different countries (Fig. 1). With a scientific program sporting 145 oral presentations and 49 posters, as far as it has been possible to ascertain, this makes the 10th ITRS the biggest to date! The total of 194 presentations for 196 attendees this is an impressive testimony to the active participation of all delegates, and a strong indicator of the enthusiasm with which the temperate reefs community engages in scientific discussions. A full program and abstracts will remain available at <http://10itrs.org/> for some time.

Four morning plenaries provided profound insights on key topics within the overall theme. Prof. Dan Reed (University of California Santa Barbara) spoke about the importance of long-term monitoring in kelp forests, Prof. Peter Petraitis used catastrophe theory to explain multiple stable states in marine systems, whereas Prof. Martin Wahl (GEOMAR) spoke about biologically relevant scales of observation and experimentation in climate studies and Dr Alistair Hobday (CSIRO) provided insightful information on the types of knowledge managers need from scientists to address issues of climate change. Two casual light-hearted afternoon plenaries provided a platform for Prof. Steve Hawkins and Prof. Dave Schiel to reflect on the journey of temperate reef ecology, ecologists and the ITRS. Most of these plenary talks are presented as papers in this special issue. The general level of all presentations was very high. The judging panel had some tough deliberations but eventually settled on well deserving winners for the student prizes (Fig. 1).

The symposium also provided opportunities for broader participation through the public forum '*Forgotten coast: the*



Fig. 1. Group photo of all delegates attending the 10th International Temperate Reefs Symposium at the University of Western Australia (top) and student prize winners and runners up (bottom). From left to right: Rebecca Neumann, University of New South Wales (winner, best student oral presentation), Daniel Okamoto, University of California, Santa Barbara (honourable mention, student oral presentations), Ben Harvey, Aberystwyth University (honourable mention, student oral presentations), Rhiannon L. Rognstad, University of South Carolina (honourable mention, student poster presentations), Clarissa Fraser, the University of Sydney (honourable mention, student poster presentations) and Aline Sbizzera Martinez, The University of Sydney (winner, best student poster).

state and future of Australia's temperate reefs'. Here an expert panel consisting of Prof. Craig Johnson (University of Tasmania), Prof. Sean Connell (University of Adelaide), Dr Elvira Poloczanska (CSIRO), Dr Alistair Hobday (CSIRO) and Assoc. Prof. Thomas Wernberg (University of Western Australia) highlighted the beauty and uniqueness of Australia's temperate reef ecosystems and discussed their socio-economic importance and the threats and future challenges faced by these ecosystems.

The forum was attended by ~250 people and a recording was later broadcast on ABC Radio National as part of their 'Big Ideas' program.

The presentation program was balanced by interactive activities such as the poster session and social sports, where delegates kept engaged with hotdogs, pizza and scientific discussions facilitated by 'Snail Ale' and 'Wheat Pointer' – beers handcrafted for the occasion by the Degrees Brewer at

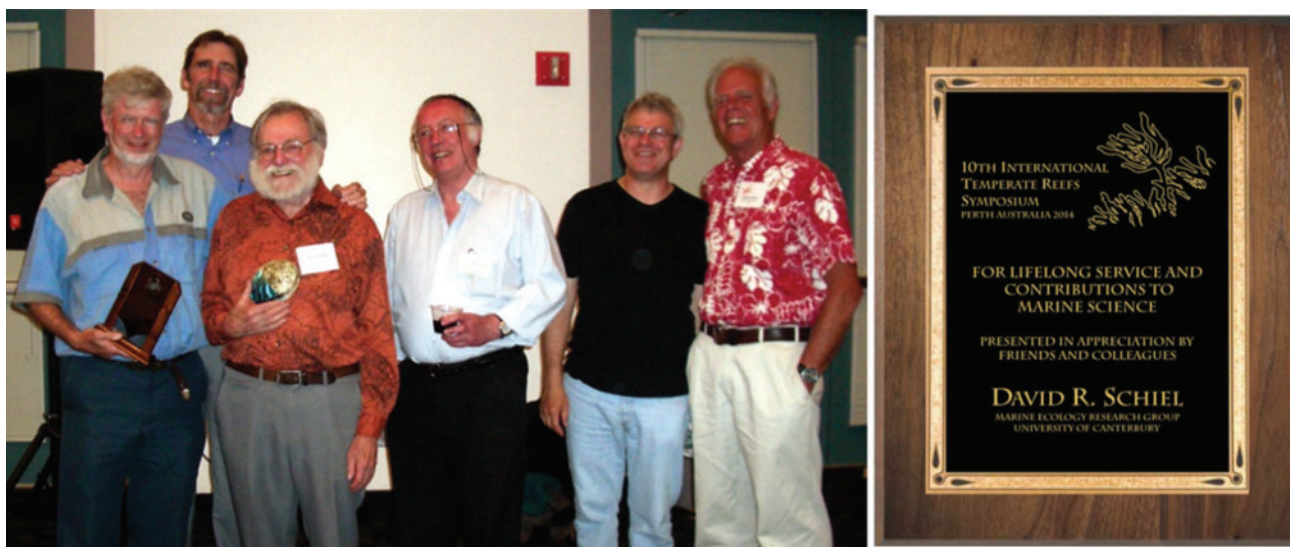


Fig. 2. Honouring distinguished colleagues. Recipients of the ITRS award (from left to right: George Branch (2006, 7th ITRS), David Schiel (2014, 10th ITRS), Joe Connell (2006, 7th ITRS), Tony Underwood (2006, 7th ITRS), Steve Hawkins (2011, 11th ITRS) and Mike Foster (2003, 6th ITRS) (photo taken at the 7th ITRS in Santa Barbara and supplied by D. R. Schiel). Right, the plaque presented to David Schiel for ‘*Lifelong service and contribution to marine science*’ at the 10th ITRS in Perth.

Edith Cowan University. A highlight was the Australian BBQ symposium dinner at the University Club, where Prof. Steve Hawkins presented an ITRS award to Prof. David Schiel for his long-time commitment to temperate marine science (Fig. 2). The dinner finished off with dancing at the Refectory. In proper ITRS tradition, academic and social interactions across countries, institutions and career stages were a pervasive feature in all situations. This is the glue that keeps the ITRS together – truly a meeting with a strong presence of community spirit.

Following a string of pearls of past ITRS[†], the bar was set incredibly high. However, the ITRS in Perth lived up to expectations and by all accounts has joined the ranks of highly memorable meetings.

Understanding ecological transitions in a rapidly changing world

This special issue was an invitation to temperate reefs scientists to contribute, not only papers presented at the Perth meeting, but more generally as relevant to understanding ecological transitions in a changing world. This resulted in 17 contributions^A covering a variety of the many issues faced by temperate reefs. A brief outline of these papers is provided below.

Hawkins *et al.* (2016) provides a historical overview of rocky reef science and the importance of natural history as a foundation for interpretations of experiments and increasingly applied modelling, macro-ecological and meta-analytical approaches. Sustained quantitative observations over time are required to fully understand the natural dynamics of variable ecosystems. Using decades of monitoring data on giant kelp abundance in California, Reed *et al.* (2016) illustrates this point. Similarly, Wahl *et al.* (2016) reviewed the literature on ocean acidification

experiments revealing a mismatch between highly controlled experimental conditions and fluctuations in natural systems, making the point that current inferences are strongly constrained by the overly artificial experimental condition. Collectively these three papers provide a strong reminder of the importance of spending sufficient time in the field, making observations and testing hypotheses in field experiments under realistic ‘natural’ conditions. This is particularly pertinent in a time where ecologists increasingly spend time in front of their computers, completely removed from the world they are trying to understand.

One theory which has received considerable attention by temperate reef ecologists, is the theory of alternative stable states which is often used to explain rapid and difficult-to-reverse transitions between different community configurations (Petraitis and Dudgeon 2004; Ling *et al.* 2009). Petraitis and Dudgeon (2016) considers the application of catastrophe theory, a theory that has been largely overlooked by ecologists, to the understanding of multiple stable states in marine communities and find that they can provide new experimental tests for alternative states in nature.

Australia has one of the largest coastal estates in the world (Martínez *et al.* 2007). A characteristic feature of the southern, temperate half of the continent is an interconnected system of large intertidal platforms and extensive shallow rocky reefs. Bennett *et al.* (2016) define this system as ‘Australia’s Great Southern Reef’ (GSR) and estimate that it contributes at least AU\$10 billion year⁻¹ to Australia’s economy through ecosystem services such as biodiversity, recreational and commercial fishing and tourism. Most Australians live near the GSR, yet have little awareness of its value and significance. Currently, the GSR receives less than 10% of the public funding directed towards Australia’s less valuable but more charismatic tropical

^ARinde *et al.* was to be part of the ITRS special issue, but was not finalised in time to be included in the printed version.

coral reefs (Bennett *et al.* 2016). The GSR is a significant natural asset that deserves recognition and investment.

Land-based activities are increasingly impacting coastal waters, especially from nutrients and sediments (Connell 2007), yet there is little effective policy specifically accommodating land-sea connections. Schiel and Howard-Williams (2016) discusses holistic approaches to management using examples from New Zealand, and argue that worldwide, renewed effort is needed with a very long-term perspective to ensure effective solutions.

A significant impact of ocean warming is the poleward movement of species' distribution, including the expansion of warm-water species into temperate reefs (Smale *et al.* 2014; Vergés *et al.* 2014; Rinde *et al.*, in press). Warm-water kelps have recently established in the southern UK (Smale *et al.* 2014). Smale and Vance (2016) used a natural experiment – a season of unusually severe winter storms – to show that native kelp forests were highly resilient to storm disturbance whereas newly arrived warm-water kelp forests appeared far more susceptible, suggesting that climate-driven shifts in species abundances may erode the resilience of some kelp forests to physical disturbance. The appearance of herbivorous fishes in temperate seaweed dominated reefs has caused concerns for the persistence of seaweed forests (Vergés *et al.* 2014). Basford *et al.* (2016) show that juvenile tropical surgeonfish display higher feeding rates than their warm-temperate counterparts, particularly in warmer temperatures. These results help explain the increased herbivory pressure on temperate seaweeds under warm conditions where tropical species have become more common (Bennett *et al.* 2015). Herbivorous sea urchins have also extended its range southward in Tasmania over the past decades, causing serious overgrazing or rocky reefs in the region, with negative effects on lucrative fisheries (Ling *et al.* 2009; Johnson *et al.* 2011). Sanderson *et al.* (2016) tested if diver-base culling of sea urchins might work as a management option and found that it could be effective at small scales, allowing recovery of seaweeds in patches. Herbivores are however not all bad. McSkimming *et al.* (2016) show that native herbivorous gastropods have some capacity to absorb the negative consequences (seaweed turf proliferation) of local and global stressors through compensatory feeding.

Invasive species are also expanding their ranges with potentially serious impacts on local reef communities. Rinde *et al.* (in press) showed how future temperatures would likely increase the spread and establishment of invasive pacific oysters (*Crassostrea gigas*) in northern Europe. At present, the kelp *Undaria pinnatifida* is one of the world's most successful invasive species and can become highly abundant in invaded ecosystems. South *et al.* (2016) tested *Undaria*'s effects on the structure and productivity of rocky intertidal assemblages in New Zealand but found few overall effects, presumably because the abundance and distribution of *Undaria* was highly variable throughout the year. In contrast, Pinho *et al.* (2016) examined kelp communities in three regions in Portugal and found these to be consistent through time.

Coastal infrastructure and defences are proliferating in response to growing populations and climate change and there is increasing need for ecologically sensitive design in their construction. Evans *et al.* (2016) and Firth *et al.* (2016) tested

the habitat quality of artificial rock pools and substrate orientation on intertidal breakwaters. Rock pools and north-facing shaded substrata enhanced the ecological condition of man-made reef. Thomsen *et al.* (2016) also studied habitat – biodiversity interactions, demonstrating the consistent integrity of a seaweed-epiphyte-invertebrate facilitation cascade across transitions from intertidal to subtidal habitats. Testing the effects of seaweed harvesting on associated communities, Stagnol *et al.* (2016) found the biggest effects when dominant monospecific canopies were removed.

The papers contained within this special issue represent a broad range of topics, habitats and organisms. This reflects the diversity of temperate reef science and temperate reef scientists. Bringing this diverse community, with a common interest in temperate reefs ecology, together creates a fertile arena for discussion and exchange of ideas. This is what the ITRS is all about!

See you in Pisa!

Acknowledgements

Special thanks goes to the many enthusiastic Temperate Reefers who continue to make these meetings fun and academically stimulating. Also thanks to the many limpets, seaweeds and fishes who have been manipulated over the years – without them ecology would still be in the dark ages. The 10th ITRS in Perth would not have been the roaring success it was, if it wasn't for the hard work and engagement of Thibaut de Bettignies, Scott Bennett and Emily Gates, who all went well beyond reasonable call of duty! Also thanks to Gary Kendrick and Mat Vanderklift for co-hosting the event, and many student volunteers. The University of Western Australia, The Department of Fisheries Western Australia, BMT Oceanica, CSIRO, CSIRO Publishing and Edith Cowan University provided generous sponsorship of the meeting. Additional support was provided by a UWA and Perth Convention Bureau Career Development Award to T. Wernberg. Finally, many thanks are due to the authors of the papers in this special issue, for their contribution and patience, to the editorial and production staff at CSIRO Publishing and to my co-editors Nova Mieszkowska, Gary Kendrick and Steve Hawkins, without whom this special issue would not have come together. T. Wernberg was funded by an Australian Research Council Future Fellowship.

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