AUSTRALIAN MARINE SCIENCES ASSOCIATION INC.

Silver Jubilee Award – 2004

Professor Terry Hughes

Professor Terry Hughes from James Cook University was awarded AMSA’s most prestigious prize at AMSA2004 - AMSA's annual meeting, held in Hobart in July 2004.

Terry grew up in Ireland, where he obtained his primary degree in Zoology at Trinity College, Dublin, before moving to the USA. There he studied Jamaican coral reefs for his PhD studies while based at the Johns Hopkins University in Baltimore, Maryland. In 1984 he moved to Santa Barbara, California to take up an NSF Posdoctoral Fellowship, working with Joe Connell on population dynamics and community ecology of corals at Heron Island, Queensland. Terry moved to Australia in 1990 and quickly built up a large research team at JCU, which today forms the Centre for Coral Reef Biodiversity. Recent research focuses on large-scale processes, including gene flow in marine organisms, regional variation in the dynamics of the Great Barrier Reef, and biogeography of coral reefs. Hughes was awarded a Personal Chair in the School of Marine Biology & Aquaculture at JCU in 2000, and was elected Fellow of the Australian Academy of Sciences in 2001. Previous prizes include the Centenary Medal of Australia in 2003, and inclusion in Australia’s Smart 100 List by Bulletin Magazine. According to ISI Science Citation Index, Hughes is ranked #1 globally for citations to individual researchers in coral reef science. His 60 publications include ten papers in Science and Nature.

The following is an abbreviated transcript of Professor Hughes’s plenary talk presented at AMSA2004 in Hobart:

The title of my talk is Biogeography, climate change and the evolution of coral reefs. It looks suspiciously like the sort of thing you’d make up for a title when you’re not quite sure what you’ll say, but I am going to strenuously deny that because it’s only partially true. So, today, I’ll talk about biogeography of coral reefs, then I’ll move on to address the consequences of loss of biodiversity on reefs. Later, I’ll talk about phase-shifts from coral-dominated systems to alternative assemblages of species, and the resilience of reefs. By resilience I mean the ability of coral reefs to absorb disturbances and NOT undergo phase shifts. Finally, I will present a blue-print for the future management of coral reefs.

I’ll start off by showing you the classic research by Stehli and Wells which was published in 1971. Nowadays, this study would be called a meta-analysis, because they compiled information from the literature to produce global patterns – mapped as contours of biodiversity. They identified the central Indo-Pacific biodiversity hotspot, with steep gradients in biodiversity moving into higher latitudes, both to the north and the south, and also a steep gradient longitudinally across the Pacific Ocean.

How do these biogeographic patterns actually arise? I’ll focus next on two emerging approaches for looking at underlying mechanisms of regional-scale patterns of biodiversity. The first relates to patterns of speciation as revealed by phylogenetic analysis. This is work done recently by Alex Kerr, a postdoctoral Fellow at JCU, who has constructed a scleractinian “super-tree”. Alex also did a meta-analysis. Just like Stehli and Wells, he combined information from 28 published trees for smaller groups of scleractinians, and the combination of all those trees covers 358 species. I think this approach has great potential for looking at patterns of biodiversity. We can take the information summarized by the supertree, we know which species are endemics versus pandemics, we can get a measure of their relative ages, and we can map that information in geographic space to look at some of the potential mechanisms for regional-scale patterns of biodiversity.

The second approach to understanding patterns of biodiversity looks at barriers to dispersal and levels of gene flow. David Ayre (University of Wollongong) and I have shown that levels of gene flow in scleractinian corals are relatively low compared to other invertebrates or fishes that have longer larval durations. On the Great Barrier Reef, which is a classic stepping-stone system, gene flow for corals is low to modest, depending on species. In contrast, rates of gene flow to Lord Howe Island, are very close to zero. So, Lord Howe Island is a self-seeding system, and that makes it very vulnerable to disturbances like coral bleaching. As well as having low rates of gene flow to it, Lord Howe Island coral populations are also genetically depauperate. So, the implications for management are that dispersal of corals to and from marine protected areas (MPAs) is likely to be limited. Therefore, MPA's need to be larger and closer together to be effective, at least for corals. The genetic results also call into some question the prioritization of biodiversity hotspots for conservation. Arguably, locations like Lord Howe Island that are isolated, as well as taxonomically and genetically depauperate, are more vulnerable to climate change than highly interconnected systems like the Great Barrier Reef.

Worldwide, the major threats to coral reefs are over-harvesting, declining water quality and climate change. A healthy reef can absorb a certain amount of increased fishing or added nutrients but invariably if some threshold is crossed, the reef may undergo a phase-shift. Even the Great Barrier Reef (GBR) is far from pristine. There has been increased run-off on to the GBR since 1850. Stocks of many marine species have been dramatically reduced. Sea cucumbers and pearl oysters were industrial-scale export industries from the mid-1800s onwards. Shark-net data indicate about a 4-fold decline in the number of coastal sharks over the period 1962 up to 1988. My colleague, Garry Russ, recently measured the biomass of the coral trout, Plectropomus, which is a major fishery on the GBR, inside no-take zones and on adjacent reefs where recreational and commercial fishing is allowed. He found a 4-5 fold depletion of the biomass of this targeted fish in fished areas. As you may know, the GBR was re-zoned on the 1st July 2004, when the no-take proportion of the GBR was increased up to 33%. The GBR Marine Park Authority certainly deserves our congratulations on achieving this outcome.

What are the consequences of loss of large fish from reefs and in particular, does overfishing of herbivores reduce reef resilience to climate change? My associates and I have addressed this question on the Great Barrier Reef over the last few years using large-scale fish exclusion experiments, which we started about 2 years after the 1998 bleaching event. These experiments show that loss of fish biodiversity is very important. Excluding herbivorous fishes led to increased macro-algae, reduced coral recruitment, and impaired the resilience of the reef to absorb the impact of the '98 bleaching event. Managing fisheries, and also water quality, can prevent phase-shifts and help to maintain reef resilience to future climate change. That's an important message because it says that there are local, pro-active management actions that we can take. Management of local fisheries and of local water quality can go someway to responding to a much larger threat from global climate change. So we shouldn't just throw our hands up in the air and project that coral reefs will all be dead in 30 years.

The worldwide decline of coral reefs calls for an urgent reassessment of current management practices. I would like to present four recommendations, which my colleagues (David Bellwood, Carl Folke and Magnus Nystrom) and I have called " a blue-print for the future". The first recommendation is for more and bigger no-take areas as tools for resilience management, not just tools for managing fisheries. We suggest a 30% target for developed countries following the example of Australia's recent increase on the Great Barrier Reef, with aid for developing countries - because this level of protection doesn't come cheaply. Our second proposal is for improved management of reefs that are heavily impacted by people. We recognize that in many developing countries, you can't simply lock people out of the ecosystem, so we need a seascape approach for co-management of no-take and adjoining areas, aimed at preserving connectivity and stock recruitment relationships. Our third recommendation is for management to be inclusive, more proactive and more flexible. Governance systems need to be supportive of local empowerment and local ownership. Gunship conservation doesn't work. By proactive, we mean providing incentives for protection of critical functional groups, particularly herbivorous fish that support resilience, before the stocks collapse, in anticipation of uncertainty. By flexible, we mean interventions like restrictive closures that coincide with spawning periods. Our final recommendation, the most challenging, is for the creation of institutional frameworks that align the marketplace and economic self-interest with environmental conservation.

The ultimate aim is to secure future options for social and economic development. In all these endeavors, we are of course faced with a critical lack of knowledge. Our ability to continue to enjoy and exploit coral reef resources will depend critically on an effective combination of science-based management, public support and political will. Clearly, successful management of coral reefs will also require courage, creativity and willingness to move beyond traditional models and outdated perspectives.