

# in the face of climate change

Simon J. Foale

## Abstract

In this article I use the lens of natural heritage to examine the nexus between Western and Melanesian ways of conceptualising and valuing coral reefs. I discuss the impacts of various pressures, including rising sea temperatures, on the ecological functioning of coral reefs and their ability to deliver ecosystem services, primarily fisheries, to the people who own and depend on them. I argue that while demand from Chinese markets has led to over-harvesting of a number of artisanal fisheries, the impact of subsistence fishing is still limited by relatively low human population densities. Escalating pressure on sharks (for their fins) looks likely to seriously damage shark populations in the near future. Despite these threats the ecological resilience of most Melanesian reefs, with localised exceptions, does not appear to be seriously threatened at present. However projected increases in the severity and frequency of coral bleaching, along with increasing subsistence and artisanal fishing pressures are likely to lead to significant and possibly irreversible degradation of reefs in the region before long, unless more culturally enlightened approaches to marine resource management and economic development are embraced by aid donors and non-government organisations.

## Introduction

The coral reefs of Papua New Guinea (PNG) and the Solomon Islands (hereafter referred to as 'Melanesia'), and the fauna and flora that inhabit them, have very different meanings to the people who own them and use the ecosystem services that they provide, than they do for the scientists, environmentalists and development specialists who are engaged in global-scale discourses about coral reef conservation and management. As a marine scientist I engage with global debates and information flows about coral reefs and the 'coral reef crisis' (Bellwood *et al.* 2004), and as someone interested in the social dimensions of marine resource management, I have conducted research on the ways in which other people, especially coastal Melanesians, think about the ecology of coral reefs, and the sustainability of the coral reef resources they use. In this paper I analyse some of the issues related to the disparities in world-view between scientists and Melanesian subsistence and artisanal fishers that are brought into focus in the context of environmental management and sustainable development projects in this region.

Working with Melanesian fishers has changed my own views about science a great deal and in particular has made me much more aware of the extent to which science is socially constructed (Foale and Macintyre 2005). At the same time, I remain a staunch defender of science as a way of understanding the world (Haack 2003), and I agree with contemporary scientific arguments that: human-generated carbon dioxide (CO<sub>2</sub>) is warming up the earth and the oceans; ocean warming causes coral bleaching (see below); and the increased concentrations of CO<sub>2</sub> in the atmosphere are

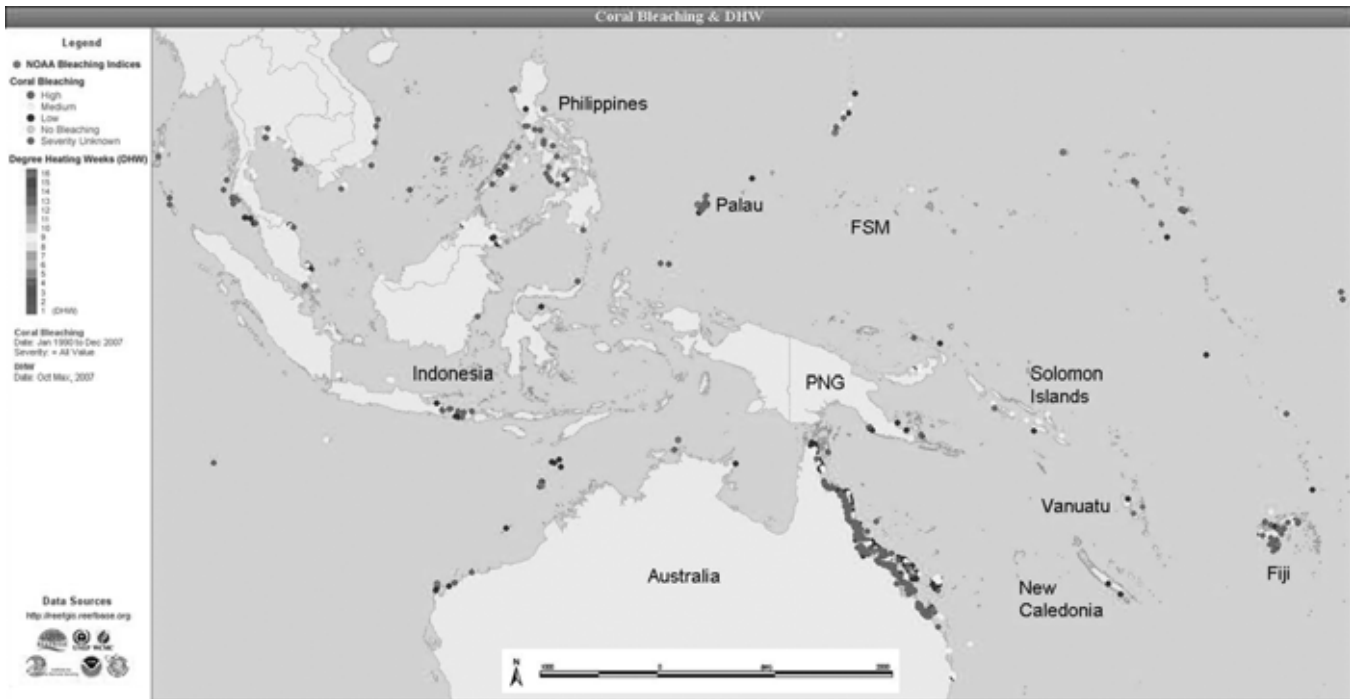
driving down the pH of the oceans, with disturbing implications for all organisms that create calcium carbonate skeletons, including reef-building corals and many species of phytoplankton (Kleypas *et al.* 1999; Hoegh-Guldberg *et al.* 2007). In this paper I present an overview of scientific understandings about Melanesian coral reefs, their heritage value and the outlook for the preservation of this heritage, and *then* present my understanding of the ways in which reefs are valued by the people *who* actually use and own them. I discuss the differences and similarities between these views and what they imply for the role of western scientists, and western capital, in Melanesia.

## The scientific perspective

When it comes to conceptualising 'heritage' as it pertains to coral reefs, marine scientists by and large think about it in terms of *conserving biodiversity and preventing species extinction*. Less rigorous thinking allows aesthetics – the beauty of the reef and all its pretty fish and invertebrates – to become conflated with scientific ideas about biodiversity (see Foale and Macintyre 2005), but for the purposes of this argument I focus on debates about biodiversity conservation as they are informed by contemporary ecological and biological paradigms. The centrality of the theory of evolution and the concept of geological time to modern biological and ecological thinking means that in the present context of accelerated extraction of reef resources, and degradation of reef ecosystems by other mechanisms (including the threats of climate change), scientists are collectively alarmed by the concomitant threats of biodiversity loss and species extinction. The scientific assumption that all life forms on our planet, and the ecological relationships among them, are the product of an immensely long period of evolution underpins the moral obligation to try to do something about the accelerating rates of species extinction.

Some forms of ecological degradation cannot be reversed. This irreversibility has been given a name – *hysteresis* – by the exponents of the discipline of 'resilience ecology' (Walker and Salt 2006). In the Caribbean and parts of the Western Indian Ocean coral reefs have in many places undergone irreversible 'phase shifts' from a state in which corals are the dominant primary producers, to one in which macro-algae, mostly species of *Sargassum*, become dominant and corals largely disappear (Hughes 1994; Hughes *et al.* 2007). This happens typically in response to one or more environmental stresses, especially the removal of grazing fish species such as surgeon fishes and parrot fishes, but also sedimentation and increases in nutrient levels from terrestrial erosion. Below I outline the magnitude of these and other threats to Melanesian coral reefs.

For scientists the heritage value of Melanesian coral reefs is strongly influenced by the fact that they support very large numbers of species. They are mind-bogglingly species-rich, indeed they are sometimes described as 'mega-diverse' or as



**Figure 1:** Map of Southeast Asia and the Western Pacific, showing locations and severity of bleaching events since 1990. Map c/- Reefbase ([www.reefbase.org](http://www.reefbase.org)).

a biodiversity ‘Hotspot’. They fall within the so-called ‘coral triangle’, which boasts the highest marine species richness on the planet. In the minds of some scientists, and many conservationists, this mega-diversity increases the moral imperative to conserve these reefs, because they argue that by prioritising scarce conservation funding in areas where both species richness and threat level are high, you maximise return on your conservation investment – you save more species per dollar (Myers *et al.* 2000). However, this argument ignores two key facts. Firstly, the number of marine species extinctions in the coral triangle to date is extremely small (Munday 2004), and secondly, current ecological theory holds that high levels of species richness in general tend to confer greater functional redundancy (Walker 1992), and therefore resilience. This then implies that conservation dollars are probably better spent in species poor, usually temperate ecosystems, which are more ecologically fragile and therefore more likely to collapse or degrade in response to relatively low levels of stress, with far more serious consequences in terms of loss of ecosystem services (Kareiva and Marvier 2003). I return to this argument later, but in the meantime, it is necessary to review what is known about current and future threats to Melanesian coral reefs, and their likely impacts.

## Current and future threats to biodiversity on Melanesian coral reefs

### Coral Bleaching

Climate change and coral bleaching are adding to the stresses on coral reefs world wide. Coral bleaching happens when the coral expels its symbiotic zooxanthellae algae – its life-support system – when the temperature has risen above the point at which the algae are able to function normally. They then start to produce oxygen free radicals, thereby poisoning their host (Jones *et al.* 1998; Warner *et al.* 1999). Bleaching events typically correspond to summer maxima during El Niño years and bleaching can to a large extent be inferred from satellite

temperature maps, which now provide weekly global coverage in one-degree pixels going back to 1981. Bleaching has been recorded since the early 1980s, perhaps before, but did not really dominate scientific discourse until after the massive global bleaching event in 1997/8. Since then there have been major bleaching episodes in 2000, 2002 and 2005. The 2005 bleach occurred mainly in the Caribbean, and although it was severe, generated surprisingly little scientific writing or media attention. Hoegh-Guldberg (1999) believes that bleaching will be an annual event in the Caribbean, the Great Barrier Reef and Southeast Asia by 2020, and globally by 2050 (Coral bleaching events are indicated on Figure 1).

Coral bleaching in PNG and the Solomon Islands is poorly documented compared to the Great Barrier Reef and the Caribbean; however the available reports suggest more complex (possibly because of the relative complexity of current systems in this region) but generally less severe patterns of bleaching over the past decade (Davies *et al.* 1997; Quinn 2002; Rotmann 2001; Srinivasan 2000). There has clearly been significant damage from bleaching events around Melanesia, though it has not resulted in nearly the magnitude of coral mortality reported for the Central Pacific and the Indian Ocean.

### Sedimentation

Damage to coral reefs in Melanesia from sedimentation is patchy and is mainly associated with logging, mining and oil palm plantations (Munday 2004; Albert *et al.* 2008), particularly where these are adjacent to the coast, and in the case of logging and plantations where there is a significant slope. In most places it is nowhere near the scale of sedimentation that occurs on the Great Barrier Reef as a result of sugar cane farming and grazing (McCulloch *et al.* 2003).

### Overfishing

Over-harvesting of grazing fish is as yet not widespread in Melanesia, mainly because, with the exception of places where population density is unusually high, or there is a significant

local market demand for fresh fish (Sabetian and Foale 2006; Albert *et al.* 2008) there is not sufficient population pressure on subsistence fishing. There are no major export markets for these fish, as there are for beche-de-mer, sharks and various molluscs harvested for their pearly shells.

There is a long tradition of harvesting marine organisms for commodity markets in Melanesia. In the 19th century whaling was a major industry (Bennett 1987), and given the reported abundance of sperm whales then, and their scarcity now (Green *et al.* 2004), it would appear that populations of this species have not recovered. Bêche-de-mer, a category that now encompasses at least 20 species of 'sea cucumbers' or Holothurians, has also been fished since the middle of the 19th century, and populations of some species have been overfished to a degree that they are unlikely to recover for some time, if at all (Skewes *et al.* 2002). Some pearlshell species, including the pearl oysters (*Pinctada* spp.), and a large gastropod called Green Snail (*Turbo marmoratus*) have also been overfished, and in places for which good survey data exist (Green *et al.* 2006) these species have been depleted to the point where recovery is unlikely for many decades, if at all.

At present the fishery for shark fin is growing rapidly around the world (Clarke 2004; Clarke *et al.* 2006), and causing great concern among fisheries scientists. There is no proper management of this fishery in PNG or Solomon Islands, and there is a growing body of evidence that shark populations have been seriously depleted across the region, including on the Great Barrier Reef (Robbins *et al.* 2006).

Other burgeoning fisheries in Melanesia are for live reef food fish (particularly groupers and the Maori Wrasse – *Chelinus undulatus*), live ornamental fish, and live and dead corals for the ornamental trade.

Despite the fact that these fisheries, like the forest resources, are all poorly managed (if at all), their collapse does not immediately threaten the subsistence security of rural Melanesian people, and as such they are effectively dispensable. Most Melanesians are rural people who enjoy a high level of food security, thanks to their subsistence farming lifestyle and the very low human population densities across most of PNG and Solomon Islands. The average here is 12 to 16 people/km<sup>2</sup> which is almost two orders of magnitude lower than the island of Java, at around 1000 people/km<sup>2</sup>). On the other hand they have very poor health and education services (Otter 2002; United Nations Development Programme 2006), and much of the economic aid directed to the region is targeted at improving these services.

The ecological impacts of over-harvesting of these various commodity fisheries are at present poorly understood. However for many species the impacts are unlikely to be all that dramatic, *in the short term*. (I will discuss longer-term impacts below). Will the disappearance of say three or four out of twenty-odd species of sea-slugs, most of which feed on detritus, bacteria and algae on the surface of sediments on the sea-bed, cause irreversible ecological shifts in these habitats or will the other detritivores – the worms and little crustaceans that live in the sediment, and various species of bottom-feeding fish – simply expand in number to replace them? There is certainly empirical evidence that the removal of shark populations in the temperate northwest Atlantic has triggered measurable and indeed dramatic changes in the structure of the fish community in which they occupied the position of top predator (Myers *et al.* 2007). The extent to which this will also

happen in the relatively species-rich coastal seas of the western Pacific, and whether it will impact on the ability of Solomon Islanders or Papua New Guineans to catch fish for their dinner, is yet to be determined.

## Melanesian understandings of coral reefs and biodiversity

What do the people who actually own these aesthetically beautiful and species rich environments, and depend on their fisheries for subsistence and cash, actually think about them? Four examples illustrate the ways in which local ways of thinking about coral reef fauna differ importantly from accepted scientific paradigms:

### Folk taxonomies

Melanesian folk taxonomies for reef fauna display some key differences to scientific taxonomies – they are essentially utilitarian, so they 'lump' species that have little or no use, such as damselfishes or corals, and they 'split' species that are very useful, such as fish that are eaten on a regular basis (Akimichi and Sakiyama 1991; Foale 1998a; Hviding 2005). Similarly, for seafaring people in Milne Bay, there is no single word that glosses as 'sea'. Instead there is a myriad of terms to describe bodies of water depending on depth, current, waveform and other qualities (Martha Macintyre, personal communication).

### Aesthetic and evolutionary meanings

While night snorkelling with a Solomon Islander in the Nggela Islands I found a Spanish Dancer nudibranch (*Hexabranchnus sanguineus*), and reached into the boat to get my camera. My colleague, a highly knowledgeable fisherman who knew the local names for at least 200 species of fish, but had little formal education, asked what it was. I told him the English name, and explained that, like other nudibranchs, it was an evolutionary marvel, belonging to a group of shell-less gastropod mollusks descended from a shelled ancestor, which have evolved a range of intriguing chemical and other alternative defenses, usually advertised by warning ('aposematic') colouration. I observed that its spectacular red and white 'skirt' was a good example of this and also mentioned that Australian divers typically got excited when they found one of these nudibranchs on the Great Barrier Reef. He nodded politely and asked, 'Can you eat it?'

### Extinction

The wife of a friend who worked in the Western Solomons once asked my friend's key informant, in exasperation, as he brought ashore a hawksbill turtle: 'what would you tell your grandchildren if you knew that you had killed the last hawksbill turtle on earth?' He said, 'I'll tell them how good it tasted'. (See Foale and Macintyre 2005 for a more detailed discussion of Melanesian attitudes about the idea of extinction).

### Magic and spirits

In Melanesia the sea is full of spiritual meaning. There are 'place spirits' that can manifest as particular creatures such as sharks, rays or dolphins, and there are also totemic species that are the subject of various prohibitions and restrictions (Carrier 1982; Hviding 1996; Macintyre 1987). There are places where people have been buried at sea which are spiritually charged and often the location of fishing prohibitions for years, decades or perpetuity (Macintyre and Foale 2007). When

people are lucky in fishing they are as likely to attribute their success to magic as to any other factor. And when a fish stock becomes depleted this is usually not attributed to the activities of fishers. People of course are conscious of having some agency over the abundance of fish (Foale and Manele 2004), but magic and other supernatural forces are far more likely to be invoked than any scientific rationale that relates recruitment strength to stock density (Foale 2006a). While experienced fishers have a rich knowledge of many aspects of the biology and behaviour of fish, an important aspect of knowledge that is normally missing is the set of processes by which populations of fish replace themselves, along with the impact of fishing on these processes (Foale 1998b).

There is little or no evidence of a conservation ethic in most parts of the Solomon Islands and Papua New Guinea (Bulmer 1982; Pernetta *et al.* 1982). This is hardly surprising, as the low population densities in most places have meant that people never encountered the limits of either terrestrial or marine resources (Foale 1998b; Johannes 2002). Nevertheless this has not deterred romantically inclined westerners from projecting the image of 'ecological nobility' (Foale and Macintyre 2005; Krech III 1999; Redford 1991) onto subsistence farmers and fishers in Melanesia – a fantasy many Melanesians seem happy to indulge.

If the gross mismanagement of the forestry resource in both Papua New Guinea and Solomon Islands is any indication, then marine resources also appear destined to be serially depleted (mined) as they become commodified. Chinese demand for marine products and other primary resources from the Indo-Pacific region has been accelerating rapidly in the past decade and shows no sign of slowing at the time of writing. Clarke (2004: 53) reports that 'results of a survey of Hong Kong traders provide insight into their attitudes toward harvest, economic and regulatory factors, and suggest that conservation efforts are unlikely to emerge from, or be actively supported by, dried seafood trade organizations'. Add to this the impacts of increased frequency and intensity of coral bleaching, and ocean acidification (Hoegh-Guldberg *et al.* 2007), along with inexorable human population increase, and the business-as-usual scenario looks gloomy. Eventually the combined stresses on the ecosystem will precipitate an ecological shift that will impact on food security (Hughes *et al.* 2003; Hoegh-Guldberg *et al.* 2007). It almost goes without saying that Melanesian countries account for an insignificant proportion of global carbon emissions, yet have little or no control over the emissions of the rich, industrialised countries. Apart from getting the rich countries to reduce their carbon emissions, logical solutions to these problems include establishing sustainable fishery management, reducing sediment runoff from terrestrial developments and finding alternative sources of cash that make it easier for people to reduce fishing pressure on the reefs.

But sustainable alternative economic developments, like fishery management, are stymied in PNG and the Solomon Islands by what might be called the 'Subsistence Curse'. To put it briefly, capitalist modes of development have had a very low rate of success in Melanesia for two main reasons. Firstly, traditional Melanesian economic systems are based on redistribution, rather than the accumulation of material wealth (Young 1971; McDougall 2005), which means that social pressures to share profits either constrain or subvert most attempts at capitalist entrepreneurship (Brooks 1996; Curry 1999; Gregory 1999).

Secondly, because average human population densities are so low, most people know that if and when their aid-funded development project (or other cash-generating enterprise) does fail, they can still eat, for there is still plenty of land on which to grow enough food to survive (e.g. Koczberski *et al.* 2001: 24). The successful capitalist entrepreneurs in Melanesia tend to come from the most densely populated places, such as the Sepik region, parts of the highlands and around Rabaul in PNG, and North Malaita in the Solomons (see Hanson *et al.* 2001 for data on population density and land pressure by region for PNG). Of course the up side of having low human population densities, as I have mentioned, is that subsistence pressure on marine resources, and any concomitant ecological damage, throughout most of Melanesia is not high, at least at the moment.

Even if we assume, for the sake of argument, that the global economic playing field is flat and fair (or even will be in the future), the worst-case scenario is that the cultural change required for people in Melanesia to engage successfully and sustainably with the global marketplace is not likely to happen before quite a lot more of their terrestrial and marine natural heritage (of both scientific and economic value) has been lost. Notwithstanding what I have documented above, much of the cultural heritage associated with coral reefs – including knowledge about the natural and spiritual realms – has already been lost and continues to be lost. Most of this knowledge is unwritten, and since much environmental knowledge is bound up with magical practices that were considered undesirable by the early missionaries (Macintyre 1989), many forms of environmental knowledge have been subject to systematic disparagement for up to a century. In part due to this, but in part also due to a more generalised cultural self-deprecation that is linked to Melanesian engagements with development (Robbins 2005), many people are disinclined to take pride in, and consciously preserve, their traditional environmental knowledge (Foale 2006b; Macintyre and Foale 2007) as lifestyles and cultures transform.

## Conclusions

So we are left with some quite difficult questions. Should a society whose value system is largely incompatible with capitalist behaviour be encouraged, cajoled, or bullied into embracing neo-liberal models of development, in an already unfair marketplace, so that they can conserve a *scientific* heritage whose values they largely do not share? If we assume (as I do) that the Millennium Development Goals (<http://www.un.org/millenniumgoals/>) are worth pursuing in Melanesia, then a significant change in approach is required from the major donors as well as a number of the Big International Non-Government Organisations (BINGOs) currently working on coral reef conservation programs in the region. A scientific approach that emphasises maintenance of ecological functions, in the interest of sustaining food security and cash benefits from reef-associated resources (Kareiva and Marvier 2003; Foale and Macintyre 2005), would be far more useful than the 'Biodiversity Hotspot' approach that has been so enthusiastically embraced by some of the BINGOs. Fishery management efforts should make use of *all* the available management tools, not just no-take closures (Hastings and Botsford 1999; Hillborn *et al.* 2004), and governments should be supported in this function as well as communities. While they have some potential, no-take closures are likely to be far

more difficult to implement successfully in Melanesia (Foale and Manele 2004) than in rich countries like Australia where the state controls access to marine resources, has abundant funds for monitoring and enforcement, and is able to buy out commercial fishing licenses.

In the Solomon Islands and PNG various attempts have been made to set up networks of no-take permanent closures (e.g. Lincoln-Smith *et al.* 2006; Green *et al.* 2007). Most of these are too new to have achieved anything more than a slight increase in abundance of fish within the closure, which means nothing in terms of actual economic benefits to villagers (Russ *et al.* 2004). Even in the case of the Arnavon Islands Marine Protected Area in the Solomon Islands, which has now been enforced for well over a decade, there has been no measurable increase in fishery production outside of the protected area as a result of the anticipated 'spillover effect' (Lincoln-Smith *et al.* 2006). Nevertheless, a senior fishery biologist with long experience working with the communities around this closure recently informed me that a number of villagers on neighbouring Isabel and Choiseul Islands have been inspired to establish closures on their own reefs after visiting the Arnavons and witnessing the large numbers and sizes of fish and commercial invertebrates inside its boundaries (Peter Ramohia, The Nature Conservancy, Personal Communication). The major unknown in such situations is the extent to which grass-roots initiatives like these are able to establish management regimes that are both appropriate for the life-histories of the species they seek to manage (Foale 1998b; Foale and Manele 2004) and institutionally resilient to pressures from within communities to over-harvest subsistence and artisanal fisheries as human populations grow and market prices inevitably increase. In the meantime the complete closures of beche-de-mer fisheries by the national governments of Solomon Islands (in late 2005) and Vanuatu (in late 2007) are a testament to the failure of both 'traditional management' (i.e. the serial closure system typically referred to as *Tambu* or *Tapu*) and BINGO-driven no-take schemes. The six-month closed season for beche-de-mer in Milne Bay, Papua New Guinea is likely to have been a more effective management strategy than other more localised approaches, but it has not prevented at least two species of beche-de-mer (*Holothuria scabra* and *H. nobilis*) from becoming over-fished to the point where stocks are unlikely to recover for many years (Skewes *et al.* 2002).

Is there a case to be made for communicating ideas to Melanesian people about the scientific values of coral reefs, including the idea of the inherent value of species, as well as scientific knowledge about processes of stock replacement in fisheries, and the threats posed by climate change without proselytising or unfairly privileging science over local environmental cosmologies? I think there is (Foale 2006a), but approaches to this task need careful research, cultural sensitivity and a lot of two-way communication. I have been working on developing culturally appropriate science education materials for schools in PNG over the past four years, and while it is a challenging process, much can be achieved. In the medium to long term, a great deal of money needs to be spent on improving education standards in general, and science education in particular, before scientific paradigms such as evolutionary theory, coral bleaching, and the ecological resilience of coral reefs to burgeoning, multiple stresses can be incorporated into peoples' worldviews in Melanesia (Foale 2006b).

We are now at a very complex crossroads when it comes to the

role of scientists in the fraught arena of biodiversity conservation and sustainable economic development in Melanesia. Melanesian countries have been engaged in intense economic and cultural exchange with the rest of the world since the beginning of the whaling period in the late 18th century, and profound cultural, economic and environmental changes have taken place ever since then (Bennett 1987; Macintyre 1983; Macintyre and Allen 1990). The Solomon Islands and PNG are both now heavily dependent on aid, for political and social stability as well as for the maintenance of critical services such as health and education. Conservation of the scientific, cultural, and other heritage values of coral reefs in these countries is and will continue to be inextricably bound up with aid programs and NGO projects, and therefore becomes the responsibility of a broad range of actors, requiring the synthesis of a broad range of intellectual disciplines. The added stress imposed by climate change on ecological, economic, social and political systems in Melanesia only magnifies the urgency with which solutions to the already very complex conservation and development challenges in this region must be found.

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