Links Between Local Ecological Knowledge and Wealth in Indigenous Communities of Indonesia: Implications for Conservation of Marine Resources

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Abstract: Accumulated knowledge about nature is an important part of people's capacity to manage and conserve the environment. Local ecological knowledge is vital if natural habitats are to receive sufficient public support for their conservation and if local capacity for self-management is to be maintained. Loss of traditional knowledge is a worldwide phenomenon, resulting in reduced environmental awareness and diminished local capacity for sustainable use and conservation of natural resources. Economic development leading to environmental disconnection through reduced local resource dependence and interaction is causing local knowledge to be hybridised and lost or replaced with modern knowledge systems. Simultaneously, globalisation and increased opportunities to trade can result in severe overexploitation. To date, there have been few cross-cultural and quantitative studies to describe this knowledge loss. This study illustrates the loss of local knowledge using an Indonesian case study, the Kaledupa sub-district of Wakatobi Marine National Park. Kaledupa has a population of around 17,000 comprised of two distinct cultural groups, Kaledupan Islanders (Pulo) and traditionally nomadic boat people (Bajo) now living in permanent houses on stilts over the sea. Marine resources are heavily exploited for income, food, building materials and waste disposal by both groups. Marine ecological knowledge differed significantly between Bajo and Pulo communities ($U = 1305.000$; $p < 0.001$). An inverse relationship was shown between marine ecological knowledge and wealth ($Rs = -0.395$; $p < 0.001$), and a positive relationship between marine ecological knowledge and support for traditional management practices ($Rs = 0.396$; $p < 0.001$). This has implications for the future management of marine and coastal systems in the area and in similar small island communities worldwide.

Keywords: Local Ecological Knowledge, Economic Status, Natural Resource Management, Self-Management, Sustainability, Marine Ecosystem

> *"…it would be of great benefit if the best of modern management practices could be blended with the best of their traditional counterparts in the development of cost effective management systems…" (Ruddle 1994).*

Introduction

ALL HUMANITY DEPENDS on Earth's ecosystems and the goods and services they provide (UNEP 2006). However, over the past 50 years, humans have changed these ecosystems more swiftly and comprehensively than in any other comparable human period (Millennium Ecosystem Assessment 2005, UNEP 2006). Most of the changes made result in a loss of biodiversity, the maintenance of which is crucial to the continued well-being and survival of all human populations (Norse 1993, Millennium Ecosystem Assessment 2005, Sala & Knowlton 2006).

Importance of Marine and Coastal Resources and Urgency for Successful Management

More than one-third of the global population live in coastal regions and depend on marine and coastal resources for their livelihoods and well-being (UNEP 2006). In the tropics coral reefs in particular are well renowned for their biological diversity, high productivity (Berg et al. 1998, Hoegh-Guldberg 1999, Wilkinson 2002) and economic significance (Costanza et al. 1997, Cesar 2000, UNEP-WCMC 2006).

In Indonesia more than 60 percent of people live in coastal regions. Marine and coastal resources provide livelihoods for more than 14 million people (Tomascik et al. 1997a). This amounts to approximately 7 percent of the total population, accounting for around 25 percent of the Gross Domestic Product (Riopelle 1995, Tomascik et al. 1997b).

Coastal communities depend directly on marine and coastal resources for food and raw materials;

around 65% of the total protein consumed by the Indonesian population comes from fisheries and approximately 90% of the Indonesian marine catch is still derived from artisanal fisheries for subsistence consumption or local markets (Riopelle 1995, Tomascik et al. 1997b).

Inevitably, such high dependence on natural resources creates conflicts between stakeholders (Dijksterhuis 1996), and between conservation objectives and human aspirations for improved living conditions (Randall 1991). These conflicts can only be resolved through the development of appropriate management strategies, without which the result is excessive consumption and overexploitation (Tomascik et al. 1997b).

Despite their ecological and economic importance, marine and coastal resources worldwide are being degraded or destroyed by human economic activities (Arrhenius & Backe 1992, Wilkinson 2004, UNEP 2006). Unabated, this continued degradation will result in severe ecological and economic losses (Wilkinson 1996).

The Role of Traditional or Local Ecological Knowledge

Indigenous knowledge has only recently, in the past decade or so, begun to receive attention (e.g. Gadgil et al. 1993, Dunn 1997, Berkes 1999, Rönnbäch & Primavera 2000, Berkes 2004, Moller et al. 2004, Hamilton 2005, Arunotai 2006). This is mostly due to the recognition of its potential value in maintaining biodiversity and providing environmental management solutions (Berkes 1999, Gadgil et al. 2000). For many generations indigenous societies have flourished and diminished as their cumulative wisdom of nature was tested against the strict criterion of environmental sustainability (Evans et al. 1997, Pilgrim et al. 2007). The term 'local ecological knowledge' (LEK) refers to the traditional knowledge that these societies hold about their environment and that they used to sustain themselves (Pilgrim et al. in press). The greatest use of LEK within small island communities has traditionally been to manage and sustain local fisheries (UNEP 2006).

Knowledge of natural resources and ecosystem dynamics has traditionally existed within communities that have regularly and over long periods of time, utilised them for subsistence and income (Gadgil et al. 1993, Berkes et al. 2000). These knowledge systems related to biodiversity conservation have been fundamental to human life throughout much of Asia, particularly in remote areas, mainly because of the high dependence of local communities on traditional food production and provision for other basic needs (Langton et al. 2003).

The breakdown of traditional management systems has occurred all over the world and has been well documented (e.g. Pomeroy 1995, Evans et al. 1997, Veitayaki 1997, Langton et al. 2003). There has been a tendency for ownership and responsibility for natural resources to be removed to central governments, therefore removing the sense of associated pride and protection from local communities often resulting in a more cavalier local attitude towards resources (Evans et al. 1997). As a result there has been an increasing trend of loss of knowledge passed from one generation to the next (Gadgil et al. 2000, Davis & Wagner 2003) which has been exacerbated by environmental disconnection through socioeconomic changes induced by exposure to markets and economic development (Amanor 1994, Arunotai 2006).

LEK Management Applications

Non-use policy is not an option for dependent communities so natural resources must be utilised in a way that allows long term economic and ecological sustainability. The sustainable use of marine and coastal resources in the future is unlikely under western–style management systems (such as exclusion) as so far they have been inadequate and unsuccessful (Hviding 1994).

The United Nations Conference on Environment and Development (UNCED) in 1992 highlighted the use of LEK in producing innovative strategies for sustainable resource management (Veitayaki 1997). With high success in the past, these practices could be used to help develop dynamic management strategies today. This means that LEK could be the link between conservation and sustainable development (Ramakrishnan 2001).

In response to the global problem of ecosystem degradation many governments have already sought to introduce new management regimes to replace pre-existing indigenous systems that have been lost. It has been argued by some that the key to success in these new management regimes is the inclusion of local communities in the decision making process and subsequent implementation of management actions (Djohani 1989, Majors 1995, Shepherd & Terry 2004). This not only allows inclusion of valuable LEK, but also empowers the communities involved; however, it also depends on the existence and survival of LEK within these communities.

Berkes & Folke (1998) suggest that successful ecosystem management requires the following three criteria: 1) knowledge of resource and ecosystem dynamics; 2) development of practices that interpret and respond to ecological feedback; and 3) flexible institutions and organisations with the capacity for adaptive management. Maintenance of knowledge is therefore directly relevant but its loss also leads

to a reduced capacity of local dependent communities for self management and inclusion in adaptive co-management (Pretty & Ward 2001, Olsson et al. 2004, Jones 2006, Smith et al. 2007, Pilgrim et al. in press, Smith et al. in press). Analysis of socioeconomic change and its impact on LEK is essential to identify ways to prevent further loss and potential disappearance of this crucial information required to fulfil these criteria (Arunotai 2006).

Study Site

Work was carried out within the Kaledupa sub-district of Wakatobi Marine National Park, formerly Tukung Besi Islands (Tun et al. 2004), SE Sulawesi, Indonesia (figure 1). Kaledupa was chosen for three important reasons: 1) biological diversity and ecosystem health; 2) cultural diversity; and 3) high local dependence on marine natural resources.

Biological Diversity and Ecosystem Health

The Kaledupa sub-district is positioned at the centre of one of the world's biodiversity hotspots (Hopley & Suharsono 2000). It contains exceptional coral reef, mangrove and seagrass habitats, with high conservation value (Unsworth et al. 2007). Most of the coral reefs in the region are considered to be in relatively good health but there is growing concern over the rapid destruction and deterioration of some of the more accessible reefs suffering from high fishing pressure (Tomascik et al. 1997b, Elliott et al. 2001, Tun et al. 2004).

Cultural Diversity

The people of the Wakatobi Islands cannot be collectively characterised in simple socioeconomic or ethnic terms as there is a large degree of variation between islands in terms of socioeconomic and ethnic composition (Donohue 1999). On Kaledupa however there are two distinct cultural groups the traditional Kaledupan Islanders (known locally as *Pulo*), who are traditional land-dwellers (Donohue 1999), and traditional sea nomads (known locally as *Bajo*). These communities have very different cultural backgrounds, beliefs, values and dependence on natural resources (Sather 1997, Tomascik et al. 1997b, May 2005). Within and between these cultural groups there are clear socioeconomic distinctions (Cullen 2007). In particular *Bajo* communities lag behind *Pulo* communities in terms of their education and economic standing (Saat 2003). *Bajo* generally avoid social contacts with *Pulo* except those related to economic exchange (Sather 1997).

High Local Dependence on Marine and Coastal Resources

41% of households within the sub-district depend directly on marine and coastal resources for their primary income. 100% of households in both *Bajo* and *Pulo* villages depend on seafood as their major or only source of protein. Additionally marine and coastal resources are used as essential raw materials for construction and fuel by both communities (Cullen 2007).

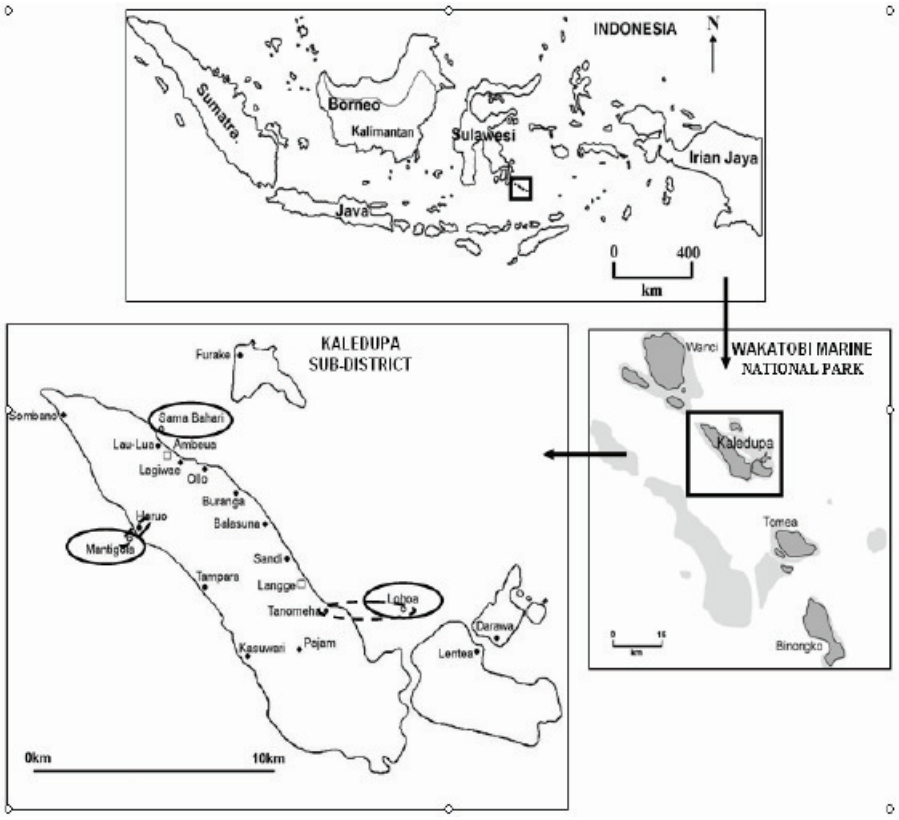

Figure 1: Location of the Kaledupa Sub-District within Wakatobi Marine National Park, SE Sulawesi, Indonesia. Within the Kaledupa Sub-District Locations of *Pulo* (Kaledupan Islanders) and *Bajo* (Traditional Sea Nomads) Villages and Sub-Villages. *Bajo* Villages are Circled with a Solid Line and Sub-Villages Linked with a Broken Line

Community Characteristics

Pulo remain land dwellers with a high dependency on agriculture for income (25% of households), but due to their location within a small island chain there exists a strong maritime community within the group and a higher dependence on marine and coastal resources for income (37% of households), food and raw materials (Cullen 2007). Traditional fishermen within this group are very knowledgeable about species, fish lifecycles, spawning grounds and locations yielding seasonally high fish concentrations. In the past when fishing was spread evenly through small coastal communities this knowledge was essential for the survival of local people (Tomascik et al. 1997b).

Bajo, no longer nomadic, live in permanent villages in houses on stilts over the sea. *Bajo* livelihoods remain largely dependant on fishing with around 70% of households stating fishing as their primary income source (Cullen 2007). *Bajo* livelihoods have always depended directly on the sea (Sather 2002), which is reflected in the traditional knowledge base they hold about marine and coastal resources, their uses and how best to exploit them (Pilgrim et al. 2007). This knowledge relates again mainly to fish lifecycles, spawning areas, and seasonality, not to the sustainable use of resources *per se* (Tomascik et al. 1997b). The traditional method of sustainability for the *Bajo* was to move to a new area once resources began to decline. Since the *Bajo* have been forced into a more sedentary lifestyle their fishing grounds have become smaller resulting in a higher intensity of resource extraction (Tomascik et al. 1997b), however their knowledge of the marine environment remains strong (Pilgrim et al. 2007).

Pulo occupy 14 villages and 2 sub-villages within the Kaledupa sub-district, and have a population of around 15,000. *Bajo* occupy 1 village and 2 sub-villages, each sub-village associated with a *Pulo* land based sub-village, although the sub-villages remain very much separate entities (figure 1). *Bajo* have a population of around 2000 in the sub-district but account for approximately 50% of all fishers (Cullen 2007).

Aims of the Study

The aims of the present study were three-fold: 1) to compare the wealth and knowledge of traditional nomads with settled people within the same geographical location; 2) to quantitatively investigate the relationship between local (marine) ecological know-

ledge and wealth (using household income as an indicator of wealth); and 3) to highlight the implications of this relationship for conservation, sustainable utilisation and management of marine and coastal resources.

By examining the case study of *Bajo* and *Pulo* communities of the Kaledupa sub-district this paper outlines some of the potential benefits of using LEK in management contexts, and the importance of environmental association and maintenance of LEK for conservation of marine natural resources.

Methods

Economic Assessment

Household income was used as an indicator of household wealth. A household survey was conducted which comprised of a semi-quantitative interview, including 10% of all households from every village within the Kaledupa sub-district. Households were randomly selected for inclusion in the survey. 440 interviews were completed from March-September 2005, each lasting between 30 and 60 minutes. Of these, 389 were with *Pulo* villagers and 51 with *Bajo* villagers, reflecting an accurate household ratio. 20 market surveys and 10 key informant interviews were also conducted to help verify income data collected within the household surveys. Income was validated using a multi-method approach consisting of four elements as follows: 1) direct estimates of annual income from respondents for each household activity; 2) direct estimates of weekly/monthly income from respondents for each household activity and number of weeks/months involved per year; 3) direct estimates from respondents of harvest frequency (where applicable), harvest size (in appropriate units) and unit price; and 4) market surveys and key informant interviews (with middlemen) conducted to verify typical harvests and unit prices.

Ethnozoological Surveys

Based on the economic assessment, 6 villages, 3 *Bajo* and 3 *Pulo*, were selected for inclusion in the ethnozoological surveys and further analysis. These villages were selected to be cross cultural and include a range of mean household incomes. Ethnozoological surveys were used to assess local marine species knowledge (naming ability and resource use knowledge) and comprised of semi-structured interviews with species flashcards combined with Likert-scale questions to assess support for traditional management practices (scored 1 for lowest support and 5 for highest). In total, 192 interviews (96 *Bajo* and 96 *Pulo*) were carried out across the 6 villages between July and September 2005. Both men and women were sampled at equal ratios and all age groups were represented using purposive sampling techniques.

Statistical Analyses

Data deviated significantly from a normal distribution therefore non-parametric statistical analyses were conducted**.** Mann Whitney U was used to investigate differences in mean marine ecological knowledge between *Pulo* and *Bajo* villagers and Spearman rank-order correlation to investigate the relationships between marine ecological knowledge and wealth, and marine ecological knowledge and support for the introduction of traditional management practices.

Results

Comparison of Bajo and Pulo Marine Species Knowledge

Knowledge of marine species throughout Kaledupa was generally high, however, the *Bajo* were able to name a significantly higher ($U=1305.000, p<0.001$) number of species than the *Pulo* (91.1% ± 0.93 (n=96) and 74.5% ± 1.41 (n=96) respectively).

Relationship between Marine Ecological Knowledge and Wealth

There was a significant inverse correlation between wealth and marine ecological knowledge ($Rs=-0.395, p<0.001$) (figure 2). Villages with the highest incomes were least knowledgeable about marine species. The village with the highest mean annual household income (Rp 6,070,740 ± 1,190,570) had a mean species identification score of 75.5%, and was a *Pulo* village. The village with the lowest mean annual household income (Rp 1,275,617 ± 637,809) had a mean species identification score of 91.8%, and was a *Bajo* village. The three villages with highest relative LEK were *Bajo*; the three *Pulo* villages showed the lowest levels of LEK, with the reverse true for income. Income is shown in Indonesia Rupiah (Rp) (Rp 9000 is equivalent to approximately US$1).

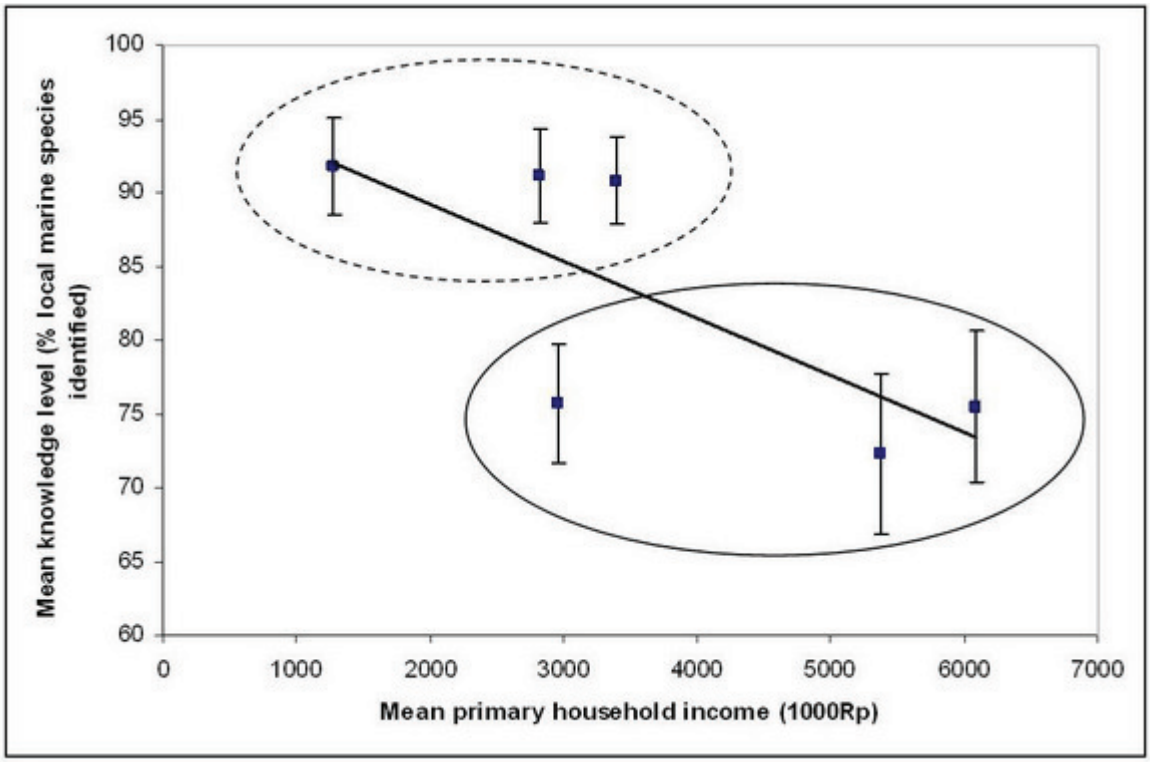

Figure 2: Relationship between Mean Marine Ecological Knowledge (Marine Species Named) and Mean Annual Village Income within the Kaledupa Sub-District of Wakatobi Marine National Park, Indonesia (±2SE) (n=192). Data shows a Significant Inverse Relationship (*Rs=-0.395, p<0.001*) between Knowledge and Household Income. *Bajo* Villages Circled with a Dashed Line, *Pulo* villages Circled with a Solid Line

Links between Marine Knowledge and Support for Traditional Management Practices

There was a positive correlation (*Rs=0.396, p<0.001*) between marine ecological knowledge and support for traditional management practices (figure 3); those individuals with the highest knowledge of marine species' showed the greatest support for the introduction traditional management practices. Villages showing greatest support for the introduction of traditional management practices were the three *Bajo* villages.

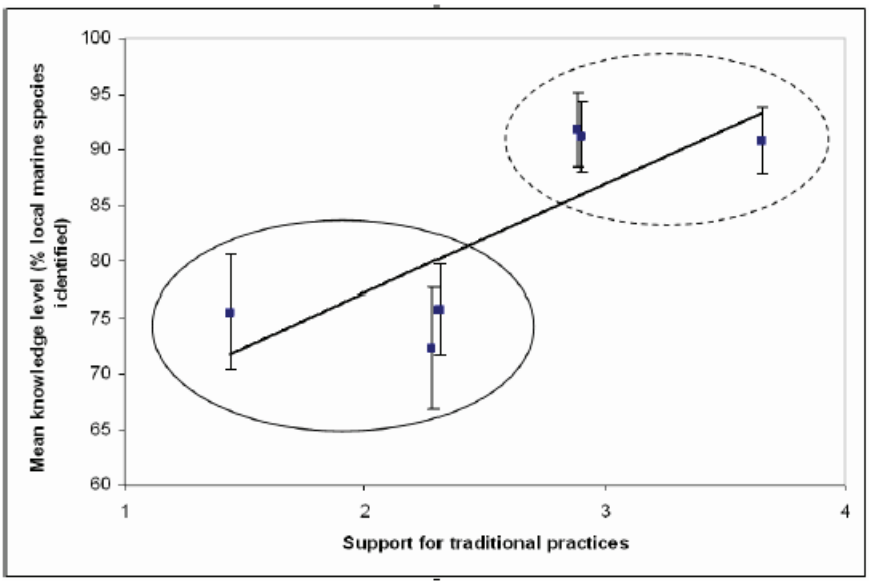

Figure 3: Relationship between Support for Traditional Management Practices and Marine Ecological Knowledge within the Kaledupa Sub-Region of Wakatobi Marine National Park, Indonesia (±2SE) (n=192). There is a Significant Positive Correlation (Rs=0.396, p<0.001) between Knowledge and Support for Traditional Management. Bajo Villages Circled with a Dashed Line, Pulo Villages Circled with a Solid Line

Discussion

Recognition of the importance of indigenous knowledge in the facilitation of sustainable development means that an understanding of the way local communities have utilised and responded to environmental and economic change is vital (Dunn 1997). Local knowledge should be incorporated into natural resource management policies to help develop sound management practices that allow economic development without the overexploitation of natural resources. However, to achieve this, appropriate knowledge bases need to be identified along with patterns of knowledge loss. The present study focused on patterns of local ecological knowledge loss associated with wealth using the Kaledupa sub-district in Indonesia as a case study including two very different cultural groups.

Bajo people were traditionally entirely dependent on the sea for food and livelihoods, setting foot on land only for fresh water or to trade their marine goods (Sather 1997, Tomascik et al. 1997b, May 2005). They are proficient at empty handed foraging (or reef top gathering) and free-diving to collect resources. They also hold essential knowledge of marine species and spawning grounds (Sopher 1977, Tomascik et al. 1997b, Arunotai 2006). The *Bajo* are however, and have been for centuries, part of a market system selling or bartering their marine goods (Sather 1997). As specialist marine hunter-gatherers they have been able to supply highly valued items such as sea cucumber, giant clam, top shell and live reef fish to island dwelling communities. In particular they traditionally traded dried fish which represented the major source of protein for insular Southeast Asia (Sather 1997, 2002).

An increased level of knowledge within the *Bajo* community most likely reflects their higher dependence on marine and coastal resources through their traditional lifestyle, and supports the notion that knowledge often results from necessity and through environmental connectedness (Pilgrim et al. 2007). As the *Bajo* still live and work on the sea their inherent connection to the environment is strong. The relatively reduced knowledge within the *Pulo* community most likely reflects increased opportunities on land for non-marine resource-based livelihoods and perhaps increased exposure to outside markets as sources of raw materials.

Further loss of marine ecological knowledge is inevitable under current management regimes as both community types are increasingly exposed to new economic pressures such as those associated with population increases and development (Tomascik et al. 1997b). Further development and environmental disassociation will result in the loss of a fountain of knowledge and an increased disregard for resources previously depended upon.

In the past the *Bajo* way of life was effectively harmonious with nature, due mainly to their nomadic existence, but with changing lifestyles and growing populations their association with the sea has become detrimental (Tomascik et al. 1997b). The more the *Bajo* are drawn into a market economy, the more they extract natural resources to fulfil their own needs for new consumer products. Additionally, they have been forced to leave behind their nomadic ex-

istence, so their fishing grounds have become smaller resulting in high intensity extraction (Elliott et al. 2001). However, the knowledge they still hold about species, spawning grounds and life cycles, whilst still strong, could be utilised within management strategies if they were invited and willing participants (Djohani 1989, Majors 1995, Shepherd & Terry 2004). In particular, traditional marine ecological knowledge has been shown to play an important role in the positioning and the management of coastal protected areas and fisheries (Johannes 1992, Johannes et al. 2000).

Traditional knowledge is only useful if local communities also understand that continued viability of natural resources depends directly on the health of the ecosystem as a whole and on their own actions (Tomascik et al. 1997b). This information may currently be lacking and a reason why management initiatives continue to fail, but if additional information is provided whilst local knowledge of resources remains strong this could foster renewed interest in sustainable utilisation.

The inverse relationship between wealth and ecological knowledge indicates that as income increases, environmental knowledge decreases reflecting a move away from natural resource use with the advent of higher incomes. Mean household income also reflects the documented difference in economic standing between the *Bajo* and *Pulo* communities (Saat 2003). *Pulo* have higher household incomes but less knowledge about the environment than the *Bajo*. As *Bajo* villages have the lowest household incomes, this trend also reflects increasing disconnection and livelihood independence from marine systems from the poorest *Bajo* villages to the wealthiest *Pulo* villages.

As *Bajo* are particularly dependent on marine resources, representing 50% of all local fishers, and their LEK is highest, this group should perhaps be the focus of renewed fishery management initiatives. This would also give them a renewed sense of empowerment and pride in the resources they know so much about, and perhaps foster a greater sense of the need for conservation and instil the impetus required for sustainable utilisation.

Economic development is inevitable and the human aspiration for improved living conditions entirely understandable (Randall 1987, Millennium Ecosystem Assessment 2005), so we need to ensure that communities realise the importance of maintaining healthy ecosystems for their own continued well-being (Millennium Ecosystem Assessment 2005). In the case of Kaledupa, where all communities are dependent on fish for protein and as a consequence local market forces are important, education programmes should perhaps be introduced in local schools to outline the direct and indirect values of conserving the environment for both ecological and economic reasons.

Support for traditional management practices is important which has been highlighted by the role that traditional management and local knowledge can play in maintaining biodiversity and providing environmental management solutions (Gadgil et al. 2000). The positive correlation we found between local ecological knowledge and support for traditional management practices provides some evidence for the link between LEK and an appreciation of the importance of marine and costal resources. It could be the case that people show support for traditional practices because these methods utilise the local knowledge base, this may not necessarily be indicative of a willingness to manage *per se* but the end points are equivalent.

The knowledge that fishermen, in particular, hold about stocks and spawning grounds could be most useful in determining management actions such as closed areas or seasons and where long term data sets are lacking, some fishers can describe historical changes in fisheries, which is knowledge that could help manage stocks (Johannes 1992, Johannes et al. 2000, Hamilton 2005, Langton et al. 2005).

Concluding Remarks

By examining a case study of *Bajo* and *Pulo* communities this paper outlines some of the potential benefits of using LEK in management contexts, and the importance of environmental association and maintenance of traditional knowledge for sustainable utilisation and conservation of marine natural resources.

Traditional indigenous knowledge, livelihoods and cultures represent a form of natural resource management and conservation (Moller et al. 2004, Arunotai 2006) and we need to find ways to incorporate traditional knowledge, combined with current science back into management initiatives (Gadgil et al. 1993, Berkes 2004). We need to find a balance between indigenous ways of life and conservation amidst rapid economic development (Arunotai 2006).

This work has provided quantitative evidence of a link between wealth and the loss of knowledge essential for successful indigenous management practices, and highlighted the importance of stemming further loss of knowledge to foster support for the introduction of traditional management practices.

Traditional knowledge can only be preserved through actual use (Arunotai 2006) hence recognition of the value of this knowledge and incorporation into natural resource management should result in its acceptance and future transfer. Lessons can be learned from traditional natural resource management systems based on traditional knowledge for current

complex systems management, however, these lessons must account for interactions across temporal and spatial scales as well as organisational and institutional levels (Pretty & Ward 2001, Pretty & Smith 2004, Pilgrim et al. 2007). Today natural resource management is often undermined by an emphasis on production and participation in a cash economy; so modern users must evaluate the situations under which traditional knowledge was gathered and make appropriate adaptations for today (Veitayaki 1997).

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References

Amanor KS (1994) Ecological knowledge and the regional economy: environmental management in the Asesewa district of Ghana. Development and Change 25: 41-67

Arrhenius E, Backe F (1992) Protecting tropical and subtropical coastal waters - a resource for future generations. Ambio 21:488-490

Arunotai N (2006) Moken traditional knowledge: an unrecognised form of natural resources management and conservation. International Social Science Journal 187:139-150

Berg H, Öhman MC, Troëng S, Lindén O (1998) Environmental economics of coral reef destruction in Sri Lanka. Ambio 27:627-634

Berkes F (1999) Sacred Ecology: Traditional Ecological Knowledge and Resource Management, Vol. Taylor & Francis Inc

Berkes F (2004) Rethinking community-based conservation. Conservation Biology 18:621-630

Berkes F, Colding J, Folke C (2000) Rediscovery of traditional ecological knowledge as adaptive management. Ecological Applications 10:1251-1262

Berkes F, Folke C (eds) (1998) Linking social and ecological systems: Management practices and social mechanisms for building resilience, Vol. Cambridge University Press, Cambridge, UK

Cesar HSJ (2000) Coral reefs: their functions, threats and economic value. In: Cesar HSJ (ed) Collected Essays on the Economics of Coral Reefs. CORDIO, p 14-39

Costanza R, d'Arge R, de Groot R, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O'Neil RV, Paruelo J, Raskin RG, Sutton P, van den Belt M (1997) The value of the world's ecosystem services and natural capital. Nature 387:253-260

Cullen LC (2007) Natural Resource Dependence, Resource Use Patterns and Development of Economic Performance Criteria within a Small Island Community. University of Essex

Davis A, Wagner JR (2003) *Who* knows? On the importance of identifying "experts" when researching local ecological knowledge. Human Ecology 31:463-489

Dijksterhuis OW (1996) Environmental education: a tool for coastal management? A study of the Caribbean region. Coastal Management 24:339-353

Djohani R (1989) The Marine Conservation Development Programme in Indonesia, WWF-Indonesia, Jakarta

Donohue M (1999) A Grammar of Tukang Besi, Vol. Mouton de Gruyter, Berlin, New York

Dunn JE (1997) Responding to pressure on local natural resources: the story of three villages in south-eastern Nigeria. Journal of Environmental Management 51:361-371

Elliott G, Mitchell B, Wiltshire B, Manan AI, Wismer S (2001) Community Participation in Marine Protected Area Management: Wakatobi National Park, Sulawesi, Indonesia. Coastal Management 29:295-316

Evans SM, Gill ME, Retraubun ASW, Abrahamz J, Dangeubun J (1997) Traditional management practices and the conservation of the gastropod (*Trochus nilitocus*) and fish stocks in the Maluku Province (eastern Indonesia). Fisheries Research 31:83-91

Gadgil M, Berkes F, Folke C (1993) Indigenous knowledge for biodiversity conservation. Ambio 22:151-156

Gadgil M, Seshagiri Rao PR, Utkarsh G, Pramod P, Chhatre A (2000) New meanings for old knowledge: the peoples biodiversity registers program. Ecological Applications 10:1307-1317

Hamilton RJ (2005) Indigenous ecological knowledge (IEK) of the aggregating and nocturnal spawning behaviour of the longfin emperor, *Lethrinus erythropterus*. SPC Traditional Marine Resource Management and Knowledge Information Bulletin 18:9-17

Hoegh-Guldberg O (1999) Climate change, coral bleaching and the future of the world's coral reefs. Marine and Freshwater Research 50:839-866

Hopley D, Suharsono (2000) The status of coral reefs in Eastern Indonesia, Vol. Australian Institute of Marine Science

Hviding E (1994) Customary marine tenure and fisheries management: some challenges, prospects and experiences. In: South GR, Goulet D, Tuqiri S, Church M (eds) Traditional marine tenure and sustainable management of marine resources in Asia and the Pacific. International Ocean Institute, Suava, South Pacific

Johannes RE (1992) Traditional marine environmental knowledge is invaluable for fisheries management, protected areas planning and environmental impact assessment. SPC Traditional Marine Resource Management and Knowledge Information Bulletin 1:6-8

Johannes RE, Freeman MMR, Hamilton RJ (2000) Ignore fishers' knowledge and miss the boat. Fish and Fisheries 1:257-271

Jones N (2006) The Role of Social Capital in Environmental Policy and Management. International Journal of the Interdisciplinary Social Sciences, http://wwwSocialSciences-Journalcom 1:163-168

Langton M, Rhea ZM, Ayre M, Pope J (2003) Composite Report on the Status and Trends Regarding the Knowledge, Innovations and Practices of Indigenous and Local Communities Relevant to the Conservation and Sustainable Use of Biodiversity. Regional report: Australia, Asia and the Middle East Convention on Biological Diversity. UNEP/CBD/WG8J/3/INF/4, Montreal, 8-12 December, p 161

Langton M, Rhea ZM, Palmer L (2005) Community-oriented protected areas for indigenous peoples and local communities. Journal of Political Ecology 12:23-49

Majors C (1995) Summary Results of the 1995 Marine Survey of the Wakatobi Islands, South-East Sulawesi and Proposed Survey Program for 1996, Operation Wallacea, report for LIPI/PHPA/WDI steering committee meeting

May D (2005) Folk taxonomy of reef fish and the value of participatory monitoring in Wakatobi National Park, southeast Sulawesi, Indonesia. SPC Traditional Marine Resource Management and Knowledge Information Bulletin 18:18-34

Millennium Ecosystem Assessment (2005) Ecosystems and Human Well-being: Synthesis, Vol. Island Press, Washington, DC

Moller H, Berkes F, Lyver PO, Kislalioglu M (2004) Combining science and traditional ecological knowledge: monitoring populations for co-management. Ecology and Society 9

Norse EA (1993) Global marine biological diversity: A Strategy for Building Conservation into Decision Making, Vol. Island Press

Olsson P, Folke C, Hahn T (2004) Social-ecological transformation for ecosystem management: the development of adaptive co-management of a wetland landscape in southern Sweden. Ecology and Society 9

Pilgrim SE, Cullen LC, Smith DJ, Pretty J (2007) Hidden Harvest or Hidden Revenue? Local resource use in a remote region of Southeast Sulawesi, Indonesia. Indian Journal of Traditional Knowledge 6:150-159

Pilgrim SE, Smith D, Pretty J (in press) A cross-regional quantitative assessment of the factors affecting ecoliteracy: Policy and practice implications. Ecological Applications

Pomeroy RS (1995) Community-based and co-management institutions for sustainable coastal fisheries management in Southeast Asia. Ocean and Coastal Management 27:143-162

Pretty J, Smith DJ (2004) Social capital in biodiversity conservation and management. Conservation Biology 18:631-638

Pretty J, Ward H (2001) Social capital and the environment. World Development 29:209-227

Ramakrishnan PS (2001) Increasing population and declining biological resources in the context of global change and globalization. Journal of Biosciences 26:465-479

Randall A (1987) Total economic value as a basis for policy. Transactions of the American Fisheries Society 116:325-335

Randall A (1991) The value of biodiversity. Ambio 20:64-67

Riopelle MJ (1995) The economic valuation of coral reefs: a case study of West Lombok, Indonesia. M.Sc. Thesis, Dalhouise University, Canada

Rönnbäch P, Primavera JH (2000) Illuminating the need for ecological knowledge in economic valuation of mangroves under different management regimes - a critique. Ecological Economics 35:135-141

Ruddle K (1994) Local knowledge in the future management of inshore tropical marine resources and environments. Nature and Resources 30:28-37

Saat G (2003) The Identity and Social Mobility of Sama-Bajau. Sari 21:3-11

Sala E, Knowlton N (2006) Global marine biodiversity trends. Annual Review of Environment and Resources 31:93-122

Sather C (1997) The Bajau Laut. Adaption, history, and fate in a maritime fishery society of South-East Sabah, Vol. Oxford University Press., Oxford, UK

Sather C (2002) Commodity trade, gift exchange and the history of maritime nomadism in southeast Sabah. Nomadic Peoples 6:20-24

Shepherd S, Terry A (2004) The Role of indigenous communities in natural resource management: the Bajau of the Tukangbesi Archipelago, Indonesia. Geography 89:204-213

Smith DJ, Pilgrim SE, Cullen LC (2007) Coral Reefs and People. In: Pretty J, Ball A, Benton T, Guivant J, Lee D, Orr D, Pfeffer M, Ward H (eds) Sage Handbook on Environment and Society. Sage Publications, London, p Chapter 35 (pages 1081-1117)

Smith DJ, Pilgrim SE, Cullen LC (in press) Coral Reefs and People. In: Pretty J, Ball A, Benton T, Guivant J, Lee D, Orr D, Pfeffer M, Ward H (eds) Sage Handbook on Environment and Society. Sage Publications, London, p 1081-1117

Sopher DE (1977) The sea nomads: a study of the maritime boat people of Southeast Asia, Vol. National Museum Publications, Singapore

Tomascik T, Mah AJ, Nontji A, Moosa MK (1997a) The Ecology of the Indonesian Seas: Part I, Vol VII. Periplus Editions (HK) Ltd

Tomascik T, Mah AJ, Nontji A, Moosa MK (1997b) The Ecology of the Indonesian Seas: Part II, Vol VIII. Periplus Editions (HK) Ltd

Tun K, Chou LM, Cabanban A, Tuan VS, Philreefs, Suharsono, Sour K, Lane D (2004) Status of coral reefs, coral reef monitoring and management in Southeast Asia, 2004. In: Wilkinson CR (ed) Status of coral reefs of the world: 2004, Vol 1. AIMS, p 235-276

UNEP (2006) Marine and coastal ecosystems and human well-being: A synthesis report based on the findings of the Millennium Ecosystem Assessment, UNEP

UNEP-WCMC (2006) In the front line: shoreline protection and other ecosystem services from mangroves and coral reefs., Vol. UNEP-WCMC, Cambridge, UK

Unsworth RKF, Wylie E, Bell JJ, Smith DJ (2007) Diel trophic structuring of Seagrass bed fish assemblages in the Wakatobi Marine National Park, Indonesia. Estuarine, Coastal and Shelf Science 72:81-88

Veitayaki J (1997) Traditional marine resource management practices used in the Pacific Islands: an agenda for change. Ocean and Coastal Management 37:123-136

Wilkinson C (ed) (2002) Status of Coral Reefs of the World: 2002, Vol. Australian Institute of Marine Science

Wilkinson C (ed) (2004) Status of Coral Reefs of the World: 2004, Vol 1. Australian Institute of Marine Science

Wilkinson CR (1996) Global change and coral reefs: impacts on reefs, economies and human cultures. Global Change Biology 2:547-558

About the Authors

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Leanne is shortly to begin work as an Environmental Scientist with CSIRO developing linked socio-cultural and biophysical indicators for the Queensland Wet Tropics World Heritage Area. Her PhD research looked at the direct economic value of natural marine resources to local dependants; resource use patterns; alternative livelihoods; and developed of a series of economic performance criteria to monitor the local economic impacts of management/non-management within a small island community living in a marine national park in Indonesia. Leanne has an MSc in Marine Environmental Protection (2000-2001) from the University of Wales, Bangor and BSc (honours) in Marine Biology from the University of Newcastle upon Tyne (1997-2000).

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Previous qualifications include a first class degree in Ecology and Environmental Biology and various field trip experience including expeditions to Indonesia, Greece and Southern India. Sarah is currently undertaking a PhD at the University of Essex under the supervision of Professor Jules Pretty and Dr David Smith. Her research focuses on identifying, and subsequently quantifying, differences in local ecological knowledge across different cultures and scales of development in India, Indonesia and the UK. TEK (Traditional Ecological Knowledge) has gained international importance in recent decades due to its widespread loss. This study aims to look at factors contributing to this loss and examining patterns in knowledge levels, for instance generational decline, gender differences, the way that attitude and experience of nature affects knowledge. The fear is that the loss of such a wealth of knowledge, primarily from indigenous groups undergoing modernisation, is irretrievable, like genes being lost from the gene pool, once ecological knowledge ceases to be transferred, no such long-term accumulation of observations can be replaced.