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Coral reef health indicators: integrating ecological and perceptual assessments of anchor damage

Thesis Submitted by

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in December 2004

For the degree of Doctor of Philosophy

In the School of Tropical Environment Studies and Geography

James Cook University

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The research presented and reported in this thesis was conducted within the guidelines for research ethics outlined in the *National Statement on Ethics Conduct in Research Involving Human* (1999), the *Joint NHMRC/AVCC Statement and Guidelines on Research Practice* (1997), the *James Cook University Policy on Experimentation Ethics. Standard Practices and Guidelines* (2001), and the *James Cook University Statement and Guidelines on Research Practice* (2001). The proposed research methodology received clearance from the James Cook University Experimentation Ethics Review Committee (approval number H1359).

_____ _____

Elizabeth Dinsdale Date

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PAPERS ARISING FROM THE PhD THESIS

Dinsdale E.A. 2003 Indicators of coral reef condition: integrating views of society. Proceedings of the World Congress on Aquatic Protected Areas, Cairns. 1:415-420. Presented in chapter 2

Dinsdale E.A. and Harriott V.J. 2004 Assessing anchor damage on coral reefs: a case study in the selection of environmental indicators. Environmental Management 33(1):126-139. Presented in chapter 3

Dinsdale E.A. and Fenton D.M. 2004 Assessing coral reef condition: eliciting community meanings. Society and Natural Resources, in review. Presented in chapter 4

Dinsdale E.A. 2004 Coral Reef Health Indicators: ecological and perceptual assessments of anchor damage. In prep Society and Natural Resources. Presented in Chapter 5.

Dinsdale E.A. 2004 Evaluating management: ecological and perceptual assessments of a program to protect coral reefs from anchor damage. In Prep Environmental Conservation. Presented in Chapter 6

Other publications arising during my candidature, which are presented in Appendix 2.

Dinsdale E.A., 2002 Abundance of Black-band disease on corals from one location on the Great Barrier Reef: a comparison with abundance in the Caribbean region. Proceedings of the Ninth International Coral Reef Symposium, Bali. 2:1239-1243.

Hughes T.P, A.H. Baird, **E.A. Dinsdale**, V. J. Harriott, N.A. Moltschaniwskyj, M.S. Pratchett, J.E. Tanner and B.L. Willis 2002 Latitudinal patterns in larval recruitment: Detecting regional variation using meta-analysis and large-scale sampling. Ecology 83: 436-541.

Hughes T.P, A.H. Baird, **E.A. Dinsdale**, N.A. Moltschaniwskyj, M.S. Pratchett, J.E. Tanner and B.L. Willis 2000 Supply side ecology in reverse: the link between adults, fecundity and larval recruits. Ecology 81:2241-2249.

Willis B.L., C. Page and **E.A. Dinsdale** 2004 Chapter 3. Coral disease in the Indo-Pacific. pp 69-104. Loya Y. and R. Rosenberg (eds) Coral health and disease. Springer, Berlin.

ABSTRACT

The ecosystem health concept is an integrative approach to environmental management and while conceptually logical, it is difficult to implement. The false dichotomy of nature and culture, and the way in which knowledge is constructed has led to many of these problems. To understand the relationship between knowledge systems, the ecosystem health concept is explored here by assessing the condition of coral reefs associated with different intensities of anchoring, using both an ecological and a social perspective. Specifically, the research aims to: 1) identify environmental indicators to evaluate management strategies; 2) identify perceptual meanings ascribed to coral reefs; 3) evaluate the relationship between perceptual meanings, health judgments and environmental indicators; and 4) use the ecosystem health indicators developed to assess a coral reef management strategy.

Because environmental conservation can alienate scarce natural resources from competing uses, it is important to gain support for conservation programs by demonstrating that management actions have been effective in achieving their goals. One way to do this is to show that selected significant environmental variables (indicators) vary between managed and unmanaged areas, or change over time following implementation of a management regime. However, identifying indicators that reflect environmental conditions relevant to management practices has proven difficult. Initially this thesis focuses on developing a framework for choosing indicators in a coral reef habitat. To identify indicators suitable to measure the success of a management strategy to reduce anchor damage to a coral reef, twenty-four candidate variables were identified and evaluated at sites with different intensities of anchoring. In this study, measures which reflected injuries to coral colonies were generally more efficient than traditional measures of coral cover in describing the effects of anchoring. The number of overturned colonies was identified as the single most useful indicator of coral reef condition associated with anchoring intensities. The indicator selection framework developed has the advantages of being transparent, cost efficient, and is readily transferable to other types of human activities and management strategies.

To further the development of collaborative management, an understanding of the meanings people hold for the environment is required. Therefore, community meanings for coral reefs were elicited by asking participants, with a range of experiences, to describe photographs of the coral reefs surveyed to identify the environmental indicators. Three important meanings ascribed to coral reefs were elicited. The most important meaning was "evaluation", whether the scenes were perceived positively or negatively. The second meaning was "activity", whether the scene depicted movement through the variation in numbers of fish and types of coral. The third meaning was "diversity", describing highly diverse scenes compared to monocultures of coral. Participants with and without a working association with coral reefs all ascribed these meanings and had a remarkably consistent conceptualisation of coral reefs. Coral reefs with high levels of anchoring were associated with the constructs "unhealthy", "boring", "lacklustre" and "dead", suggesting they had lost much of their value.

A health judgement was added to the ecological and perceptual meanings of the coral reefs to identify the usefulness of the ecosystem health concept. The three assessments described changes to coral reef condition associated with anchoring. The ecological measures identified an increase in the number of overturned corals and a reduction in soft and branching corals, the perceptual meanings identified a loss of visual quality and the health judgements identified a reduction in health of the coral reef sites associated with high levels of anchoring. Comparing the three perceptual meanings with the health judgement showed that the evaluation dimension was highly correlated with coral reef health judgements, suggesting that when people enter an environment, the first and most important feature they identify is whether the environment is healthy. Health judgements were related to key ecological measures or environmental cues, the most important being the amount of damaged coral followed by amount of branching coral and perceived activity.

The three ecological measures and normative health judgement were used as indicators to evaluate the effectiveness of the Reef Protection Program implemented to protect coral reefs from the effects of anchoring. To conduct the evaluation, three coral reef sites with high levels of boating, but a reduced number of anchor drops, because of the management

strategy, were surveyed in addition to the six coral reef sites associated with low and high levels of anchoring intensity. The Reef Protection Program would be effective if the level of each of the indicators at the protected sites resembled that of the sites associated with low levels of anchoring. Two of the indicators, the number of overturned coral colonies and the judgement of health, showed that the condition of the protected coral reef sites were proceeding towards that of the coral reef sites with low levels of anchoring. However, the condition of the other two indicators, cover of soft corals and corals in the family Acroporidae, showed that the protected coral reefs sites were similar to the coral reef sites with high levels of anchoring intensity. Therefore, the Reef Protection Program is effective in reducing damage and improving the health of the coral reefs, but the reef condition had not yet returned fully to the condition described for the reefs associated with low levels of anchoring intensity.

The coral reef case study showed that the ecosystem health concept, although contentious, is an appropriate concept for incorporating community and scientific information into environmental management decisions. People's first assessment of coral reefs is a judgement of its health. The similarity in health judgements provided by the two groups of participants shows that health judgements are understood by a wide range of people and could be used to discuss concepts between various stakeholders. The health judgements were related to ecological measures and were useful in describing changes in condition associated with anchoring and a management strategy designed to protect coral reefs from the effects of anchoring. The evaluation of the Reef Protection Program showed that if the environment is managed to promote ecosystem health, humans can in some circumstances, change the way they are using the environment, to increase their use without causing detrimental effects to the environment.

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