Collaborative ecological research with

indigenous Australians: the trepang project

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Northern Territory University on 1st February 2001.
SIGNED THESIS DECLARATION

I hereby declare that the work herein, now submitted as a thesis for the degree of Doctor of Philosophy of the Northern Territory University, is the result of my own investigations, and that all references to ideas and work of other researchers have been specifically acknowledged. I hereby certify that the work embodied in this thesis has not already been accepted in substance for any degree, and is not being currently submitted in candidature for any other degree.

Signature  .................................................................

Date  .................................................................
Many people made a valuable contribution to this research, and I thank them all. However, a few individuals made outstanding contributions to the work and are specifically mentioned.

My highest tribute is paid to the traditional owners and their families of Maningrida and the Cobourg Peninsula for accepting me and the research. Despite the long, difficult and dangerous work, the research brought little, if any, opportunity to “do trepang again”.

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</tr>
</thead>
<tbody>
<tr>
<td>BAC</td>
<td>Bawinanga Aboriginal Corporation</td>
</tr>
<tr>
<td>CDEP</td>
<td>Community Development Employment Program</td>
</tr>
<tr>
<td>CEPANCRM</td>
<td>Commonwealth Employment Program for Aboriginal Natural and Cultural Resource Management</td>
</tr>
<tr>
<td>CYPLUS</td>
<td>Cape York Peninsula Land Use Strategy</td>
</tr>
<tr>
<td>DEETYA</td>
<td>Department of Employment, Education, Training and Youth Affairs</td>
</tr>
<tr>
<td>EA</td>
<td>Environment Australia</td>
</tr>
<tr>
<td>FATSIS</td>
<td>Faculty of Aboriginal and Torres Strait Islander Studies</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>ITAB</td>
<td>Industry and Training Advisory Board</td>
</tr>
<tr>
<td>MPA</td>
<td>Maningrida Progress Association</td>
</tr>
<tr>
<td>NACS</td>
<td>North Australian Continental Shelf</td>
</tr>
<tr>
<td>NLC</td>
<td>Northern Land Council</td>
</tr>
<tr>
<td>NTFIC</td>
<td>Northern Territory Fishing Industry Council</td>
</tr>
<tr>
<td>PRA</td>
<td>Participatory Rural Appraisal</td>
</tr>
<tr>
<td>PWCNT</td>
<td>Parks &amp; Wildlife Commission of the Northern Territory</td>
</tr>
<tr>
<td>TEK</td>
<td>Traditional Ecological Knowledge</td>
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</tbody>
</table>
ABSTRACT

This thesis describes and analyses the process of conducting a collaborative ecological research project. The project was conducted by a Ph.D. candidate at the Northern Territory University, Australia, and community rangers and traditional owners living on Aboriginal land in two areas of Arnhem Land. One study area was a national park jointly managed by traditional owners and the Northern Territory government; the other was solely managed by traditional owners with assistance from community-based organisations. The ecological research project was designed to investigate sea cucumbers that inhabit the intertidal and subtidal zones around the coast in those areas. Standard western-based ecological survey techniques were employed to conduct the sea cucumber research. A framework to guide the researcher and enhance community participation in the research was developed, and data about the research process collected and analysed. Research findings from applying the process at the two study areas are narrated. Roles, structures and mechanisms that were useful in the research and during the process are detailed. The thesis recommends an alternative process for conducting participatory ecological research with indigenous Australians, a process that offers greater equity in the research partnership. This ideal process is used as the platform for analysing the similarities and differences between the study areas. Implications for future participatory research with indigenous Australians are discussed and linked to current knowledge. The thesis concludes that large components of the work did not fit the description of collaboration, largely because of the divergent worldviews present. Results suggest that western worldviews prevail and manifest themselves in current approaches to participatory research, in ways that perpetuate inappropriate research paradigms and worldviews. The thesis recommends that western researchers make the same cultural shift as Aboriginal Australians have taken in recent generations to redress the inequity in current participatory ecological research projects.
CHAPTER 1: INTRODUCTION TO THE RESEARCH

ISSUES AND QUESTIONS

Protection of ecosystems, species, and genetic diversity are increasingly being linked throughout the world to the principles of ecologically sustainable land use and management in a manner that incorporates the needs and concerns of indigenous people, including their responsibilities for management (Walsh 1995:89, Webb 1996:97-98). Not only are there strong economic and ecological reasons for integrating conservation and development, but maintenance of cultural sustainability is increasingly advocated in natural resource management because ecologically sustainable development principles suggest that conservation and development are related and need not conflict with each other.

Representatives of many nations, including Australia, that attended the 1992 United Nations Conference on Environment and Development became signatories to the subsequent Agenda 21 and the Convention on Biological Diversity. Those signatory nations indicated their support in principle for environmental and natural resource management programs that respect and use indigenous intellectual input as a means of ensuring cultural sustainability. The reality of implementing such programs appropriately has received far less attention and commitment from Australian natural resource institutions than the related rhetoric.

Deep-seated philosophical understandings about environmental management underpin knowledge creation and associated research in this field. Current international academic debate about linking western environmental management with indigenous environmental management inevitably involves discourse such as the premises on which ecosystem knowledge is based, and how the differences in environmental knowledge contribute to a common understanding about biodiversity.

The Centre for Biodiversity and Indigenous Knowledge is an applied research centre that was established in Kunming, southwest China in 1995. Members of the Centre aim to conserve both nature and culture through acknowledging their fundamental interdependence, and attempt to advance this urgently needed area of environmental
management (CBIK 2000). Staff specialise in various fields including ethnobotany, resource management, participatory rural appraisal (PRA), gender analysis, watershed management, social forestry and community development, and carry out interdisciplinary research and participatory approaches for socially equitable and environmentally sound development. These specialists claim that the priority issues in this area of research are to determine appropriate approaches that bridge cultural gaps, generate intercultural dialogue, promote joint learning processes, and encourage dialogue between non-governmental and governmental agencies and inter-sectoral collaboration. They maintain that a critical examination of structures, the roles of researchers, and threats posed by external processes, including a review of participatory approaches, is necessary, so that both the potential and challenges of linking and collaborating across cultures can best be used to protect cultural and ecological diversity. The research on which this thesis is based attests to the validity of that position.

Australian domestic policy on natural resource management has begun to recognise the importance in principle of Aboriginal values and traditions. For example, objectives of the National Strategy on Ecologically Sustainable Development and the National Strategy for the Conservation of Australia’s Biological Diversity discussed by Bennett (1996:2, 4), and the (draft) national policy on Managing Natural Resources in Rural Australia for a Sustainable Future produced by the Steering Committee of the National Natural Resource Management Policy Statement (NNRMP 1999:10, 36-37, 75, 81) include greater incorporation of Aboriginal values and traditions in resource management. In 1991, the Commonwealth Ecologically Sustainable Development Working Group on Fisheries noted that government agencies should

find ways to engage indigenous communities in all aspects and levels of management. Also, an appropriate framework must be found to work within the customary tenure systems which extend over the land–sea interface and coastal waters by indigenous groups in much of Australia … (Commonwealth of Australia 1991:153).
However, in practice, natural resource programs that interface with indigenous Australians have mostly tended toward a tokenist involvement with indigenous resource managers. Research into appropriate processes to advance the theoretical and practical aspects of cross-cultural environmental management must occur if collaboration between indigenous and non-indigenous resource managers is to be optimised. This is a difficult aspiration because researchers from both cultural backgrounds must attempt to understand and articulate the worldview, perceptions and values of members of a culture different from their own; and then they must disseminate their interpretations to colleagues from within their own cultural research background. Such approaches take time and require flexibility, and because of their inevitably non-linear approach to the research process, they often result in complicated hypotheses and objectives that must be frequently revisited during the course of the research. However, the difficult and indistinct nature of the work should not prevent Australian researchers from tackling the problem. The urgent need to conduct this work before cultural diversity is lost suggests that this type of research is long overdue.

While the overriding theme in linking environmental and cultural research is an acknowledgement that community participation improves the effectiveness of resource management programs, research that tests and evaluates the effectiveness of participatory natural resources research with indigenous people has been scant, particularly in Australia. It is important to examine the current approaches and practices that have been advocated in ecological research programs with indigenous Australians and, if necessary, to challenge the status quo and suggest the development of novel approaches.

The aim of the thesis research was to conduct a collaborative ecological research project with Aboriginal Australians. To adequately carry out this aim several research questions had to be answered:

- What approaches are advocated for conducting current community-based ecological research?
• How can these approaches best be implemented with indigenous Australians?
• What are the results of applying a program designed to optimise collaboration with indigenous Australians?
• What do an analysis and critical examination of the findings suggest for improved future approaches in environmental management with indigenous Australians?
• What components of the research are useful for advancing international practice in community-based ecological research programs?
• What are the important implications of these findings for both western and Aboriginal environmental management?

The chapters that follow are based on western academic research that provides insight into these questions. Western academic research is located within a particular, culturally based, value system. Because no research is objective or value-free, acknowledgement of the strengths and weaknesses of this and other approaches is important. The utility of the research also goes beyond the academic arena; it extends to government and non-government staff and industry personnel of agencies such as mining companies who work with indigenous resource managers, so that they can initiate novel and equitable environmental management programs. In this way future partnerships that are equitable and beneficial to all stakeholders can be forged. External collaborators wishing to conduct research on Aboriginal land or sea will be better equipped to deal with cultural differences and situations that arise in relation to the natural resource components of the landscape. Western environmental managers may also develop a clearer understanding of the worldviews of Aboriginal traditional owners, rangers and community members engaged in environmental management, and of concepts and ways to approach collaboration with them.

RESEARCH STRATEGY AND THESIS STRUCTURE

The research on which this thesis is based explores the process of conducting a participatory ecological research project with indigenous Australians. Throughout
This thesis refers to two research projects. The first is the major thrust: an analysis of a participatory research project with indigenous Australians. However, to analyze participatory research, an ecological research project with indigenous Australians was necessary, forming the second project. This ecological research focused on trepang (sea cucumber product) aspects. Both projects are detailed in the appendices. The terms 'environmental management' and 'natural resource management' are used interchangeably. Ecological research is the central component in environmental or natural resources research. Participatory research was designed to involve indigenous people from inception to completion. ‘Participation’ and ‘participatory research’ are generic terms covering any community members’ participation. In Australia, these terms refer to collaboration, except in this thesis where collaborative approaches are more discussed. The thesis presents its findings through empirical research.
a comprehensive analysis of the collaborative process, much of which describes Aboriginal decision-making about collaborative research. Examples of decisions include who should be involved in the work and where it should be carried out.

The concept of 'community' is complex and often used with different meanings in different contexts. Throughout the thesis 'community' appears in references both to theory and in application. In chapter 2, 'community' is used when discussing theory, where it generally means a group of people associated with a contiguous area or locality. In chapter 3 two study areas are defined both geographically and in terms of the local players and social structures through which people interact. Thus when discussing the specific study area applications, the term 'community' is defined by the particular local players and their social networks in the locality described in chapter 3.

This chapter introduced the research topic (i.e. to conduct a participatory ecological research project with indigenous Australians). It next outlines the research strategy, presented in chapters that are designed to trace the research from the original idea, through to developing the means of implementing the research, to analysing and providing new knowledge about the topic, and finally to suggesting recommendations for future research.

Chapter 2 reviews recent and relevant literature and issues surrounding the nature of research, directions in natural resource management and participatory research, and the interests of indigenous Australians in environmental management programs. A synthesis of this contemporary literature presents the rationale for implementing a participatory ecological research program with indigenous Australians as a means for linking cultural and environmental sustainability.

Chapter 3 describes the methods used in the research. It describes the development of a guiding framework using information from research protocols, literature and experienced professionals. This framework aimed to facilitate the implementation of an ecological research program in a participatory manner with indigenous Australians. The chapter also presents the background to the ecological research project implemented to study trepang. The ecological research project was
conducted under the guiding framework with members of two Aboriginal communities. The chapter presents relevant background material about the two areas where the research was conducted and those involved in the research, to provide important contextual information for describing and interpreting the research process. Finally, terminology used to simplify the narratives presented in subsequent chapters is defined.

Chapter 4 describes the research process in the first locale — the land and sea around Maningrida in the Northern Territory of Australia. This community is located on Aboriginal-owned and -managed land. The research process is narrated according to data collected during the process and presented with respect to the guiding framework described in chapter 3. The results are illustrated using data that significantly influenced the research questions in terms of either their frequency of occurrence or their impact on the direction and understanding of the research process.

Chapter 5 describes the research process in the second location — the land and sea adjoining the Cobourg Peninsula in the Northern Territory. This is a community in the sense that traditional owners of this area are collectively involved in joint management of a national park, through arrangements with the Northern Territory government. The process is again narrated according to data collected during the process and presented with respect to the guiding framework developed in chapter 3. Again the results are illustrated using data that significantly influenced the research questions in terms of either their frequency of occurrence, or their impact on the direction and understanding of the research process.

Chapter 6 presents the major similarities and differences in the research process in the two areas. The level of participation is evaluated by examining important roles, structures, and mechanisms that enhanced or impeded participation. The findings from the two areas together provide input to an analysis of the research and its ability to deliver participatory ecological research programs. Part of the analysis draws on contemporary national and international research findings, and results are presented with respect to the guiding framework developed in chapter 3.
Chapter 7 evaluates the relevance of the ecological research program to a participatory research process. It provides some examples of the major impediments encountered when implementing the ecological research project. Following from the analysis of the research process in chapter 6, it concludes that the current approaches to conducting collaborative ecological research with Aboriginal Australians are inappropriate for linking environmental and cultural sustainability in the manner advocated by many governments that support such a linkage. Using the analysis presented in chapter 6, it proposes an alternative approach to the conduct of collaborative ecological research with indigenous Australians, tentatively termed an ‘equitable research partnership’. Chapter 7 concludes by using this equitable research partnership process to interpret the reasons for some of the similarities and differences in the research process in the two study areas. In this way, chapters 6 and 7 are not a linear approach to research but a complex cyclical interplay between results, interpretations, recommendations, and re-interpretations. Presenting the results in this way more closely reflects the research as it actually occurred, rather than conforming to a predetermined approach to research that would potentially limit conclusions.

Chapter 8 links the findings of this research to current knowledge and concludes that epistemological and cultural biases in research perpetuate paradigms and methods that may be inappropriate for participatory research with indigenous Australians. The implications for future participatory ecological research with indigenous Australians are discussed. The chapter concludes that the cultural shifts that indigenous Australians have undertaken in recent generations are also required by outside researchers to establish equity in participation.
CHAPTER 2: NATURAL RESOURCE MANAGEMENT AND PARTICIPATORY RESEARCH

This chapter reviews literature surrounding a range of themes pertaining to research, science, natural resource management, community participation and indigenous interests in these pursuits. When conducting a participatory ecological research project for natural resource management, the relevant issues in all these themes must be examined.

This chapter first explores the concept of research as defined in western academic tradition and literature. It explains that research is simply a culturally accepted way for generating interpretations from information (or data) that eventually achieve acceptance as knowledge within that culture. Knowledge generated is used within society for many purposes, including as a basis for decision-making and management.

The ‘scientific research process’ is used to conduct research. Science is an alternating process of rationalism and empiricism, that is, intelligent reflection on observations about phenomena, and conversely, observations about those reflections. As so defined, there are many ways to conduct science, and indeed, to carry out research. A description of the dominant western tradition of scientific research, based on the objectivist epistemology, is presented. An alternative epistemology, that of constructionism, is also presented. An integrative paradigm is explored because a coordinated integration of both philosophical worldviews about science may be a means with which to advance future directions in research. In this way the strengths and weaknesses of a range of philosophies and approaches about conducting research and science can be integrated. An integrative paradigm supersedes that of a multidisciplinary approach, which frequently is not adequately coordinated. Sometimes this inadequacy occurs because an emphasis is placed on a particular paradigm, or a particular type of data collected.

Some contemporary thoughts about natural resource management are summarised. Many practitioners within and outside the field of natural resource management regard the philosophies and approaches applied in past research in that discipline as
having failed to solve countless contemporary environmental crises. The western approach to conducting research for natural resource management based on an objectivist epistemology is discussed, along with the current issues and discourse and the directions faced by contemporary resource management. The section suggests that if professionals within the field are to be held accountable to the wider public, mutual recognition of the need to consider alternative approaches is required.

An alternative approach espoused by some activists is a bilateral focus on ecosystem management and community participation, an example of integrating paradigms for research purposes. In ecosystem management, ecological processes and functional relationships are studied, rather reducing ecosystems into their component parts. A focus on uncertainty rather than on predicting events is advocated. Acknowledging humans as part of ecosystem management, rather than maintaining a supposedly objective, detached, human–nature dichotomy is advocated because humans, and their activities, their individual and collective thoughts, and their social institutions also constitute the dynamism of an ecosystem. All too often these components are downplayed or completely ignored in the dominant western research tradition based on objectivism. The directions that some researchers in natural resource management now face to carry out ecosystem management are related to research that will manage the human use of resources and not just manage resources alone.

The second component to emerge in the recent past from the field of resource management is community-based resource management, based on the concepts of community participation. Since this thesis draws largely on community participation as an underlying premise, the section on participatory research is expanded. An in-depth exploration of the philosophies and approaches of community participation from a theoretical basis, along with a review of some of the common tools and techniques frequently used in participatory research, is given.

Because there is no simple linear relationship between theory and technique, researchers should be aware of the range of techniques that can be selected according to various circumstances. Techniques are not necessarily related to the theoretical hierarchies of participation, nor to underlying power relations and other factors. Technique will vary with each unique situation and study area. Neither can
conclusions easily be drawn from a review of existing literature and techniques that have not been critically analysed for their relevance to collaborative approaches.

At both international and national levels, appeals to integrate the cultural obligations of indigenous people into broader resource management programs are widespread. These petitions are presented; they suggest that such integration provides more complete ecosystem analysis and management. Adopting participatory resource management is considered a promising approach to natural resource management; and that approach in turn may also be applied to conducting research that will provide information for natural resource management.

While these participatory approaches have been initiated in other parts of the world to help promote natural resource management with indigenous people, scant attention has been paid to participatory resource management with Aboriginal Australians. Although Aboriginal Australians have repeatedly expressed their cultural obligations for resource management to Australian societal and political institutions, little genuine attempt to conduct this type of research with Aboriginal people has been published, and no analysis of the results obtained during such a process has been presented. To conduct such research requires an understanding of these contemporary issues related to Aboriginal resource management, and a summary of these issues is presented. Participatory resource management is considered a means for conducting research about natural resources with Aboriginal people. This approach should, theoretically, concurrently satisfy the issues that pertain to both western and indigenous requirements for research and natural resource management, thus linking cultural and environmental sustainability.

**RESEARCH, KNOWLEDGE, MANAGEMENT**

**What is research?**

Research by those who practice it in the western tradition is generally understood to be a systematic process in which original investigation creates new knowledge and understanding, which is subjected to peer appraisal and made widely available. The information gathered is always new, because it emanates in the light of differing contexts, times, people or directions in collective thought. This information,
combined with the experiences and adaptations of previous information, is used to generate knowledge.

There is a great deal of debate about the form of knowledge warranted in research and about the methods chosen to acquire knowledge. Though there is some common ground, human beings differ in their perceptions of reality, and there is some diversity between individuals and groups. Concepts are interpreted according to the cultural background, values, way of knowing, social organisation, and biophysical environment of an individual because those components have evolved simultaneously over time (Kaplan 1984:26, 27, 31, 35, Norgaard 1987:24–25). This means that knowledge is gathered and interpreted according to an individual’s scientific culture or paradigm and the associated intrinsic set of assumptions (Pinheiro et al. 1998:1211).

All knowledge generated is equally valid, and there is more than one way to create knowledge. Research is therefore common to different cultures and societies, as all people generate information and knowledge on which to base decisions and take action. While this broad concept of research is common to groups of people, the specific activities, interactions and connections between places and materials may differ, depending on the intellectual tradition of each individual.

The knowledge generated by research is used for management. Management attempts to integrate all relevant knowledge, to satisfy the needs and aspirations of all stakeholders, and to help managers, from the individual through to communities and bureaucrats, with everyday decision-making and action. The role of research is merely as a provider of knowledge, necessary for informed decision-making and to formulate best practice strategies for implementing decisions or adapting them as necessary.

Research and science for management purposes may be conducted using a range of culturally based approaches. Western-based research can be categorised as basic or ‘pure’ (generates new knowledge to satisfy curiosity), strategic (solves particular problems), applied (develops knowledge peculiar to a context or situation), and adaptive (effects changes for specific regions or groups).
Pure forms of research generate knowledge to answer theoretical questions, and are thus useful in generalising about situations. However, these approaches can be difficult to justify with the resource management crises that are rampant throughout the world and critical issues and problems increasing at an unprecedented pace. Furthermore, the concept of truth is seemingly elusive to the researcher, who continuously has new and evolving issues to confront with escalating questions and research topics. All approaches must be linked so that knowledge is advanced in interplay of codependent research styles. Research styles are linked because, for example, knowledge generated from basic research provides answers to a question, while an applied research style alters the results of the basic research, or of solutions derived from strategic research.

Researchers, being accountable to the rest of society, must seek optimal solutions and approaches to manage the peculiarities of resources and their dynamic interface with humans. Within western-based tradition, research styles that best suits natural resource management are probably those of the applied or adaptive approach, because they are are context specific, and are applied over and over again in differing situations to refine predictions from basic and strategic research. From this information managers may adapt, confirm or revolutionise their current thinking in order to implement the best possible decisions, solutions and actions.

The descriptions of different research approaches are useful when considering that social, political and commercial directions have an important influence on contemporary research, which is accountable to a prevailing ‘user-pays’ philosophy. These influences mean that solutions to topical questions and issues are urgently required by society, politicians or industry. There is also an increasing need to tailor research products to the needs and aspirations of a changing society. Research is also increasingly funded by external agencies, industry and institutions with mandates and agendas for priority funding, frequently directed by political will, economic benefit or some other driving force, and this has the effect of commercialising or politicising research. There is no such thing as ‘nonpolitical’ research (Agar 1996:29).
Refinements of the research process are also required, particularly when working with people from vastly differing cultural backgrounds, where the research approach can often offer only limited applications. Refinements of the research process across cultures entails a fundamental shift in scientific thinking.

The research process

In all research, the ‘scientific research process’ is used. Science is conceived of by its practitioners as a systematic, rational process revolving around successive cycles of reasoning and empirical observations — that is, rationalism and empiricism (Graziano & Raulin 1993:9). In other words the process of combining logical thought and observable facts, through experimentation, constitutes science. The principles of rationalism guide the development of tentative hypotheses based on foundations assumed to be accurate. The principles of empiricism guide the recording of facts (events which can be directly and repeatedly observed), the drawing of explanations, and the making of general predictions that can be tested against external data. The principles of rationalism and empiricism are common to the varying disciplines, although content and observations vary.

Despite the distinctions often drawn between scientific theory and practice, components of the process are intertwined in research because theory neither follows nor precedes description. Theory guides the search for data and makes sense of the data, but data collected may change theory. Parts and relationships have been found to change with time, and seemingly conclusive concepts found to be premature, even in the physical sciences (Kaplan 1984:31, Norgaard 1987:25), so that the research process is in fact iterative and cyclical. The dominant western research is in reality a portion of a larger research process that is continuous and evolutionary.

Graziano and Raulin (1993:38–43) propose a ‘model of the universe of the research enterprise’ to simplify the process common to all sciences, and to emphasise important aspects of the research process. They stress that phases are successive but overlap, because during or after the project is finished further questions and research are generated so that in reality the process is cyclical. They suggest that the research process encompasses the phases of:
• idea generation — a topic of interest is generated from vague thoughts, creative ideas, conversations etc. This phase is deductive in that theory guides the question asked;
• problem definition — an idea is refined into a question by examining literature and past research conceptualisations and methods. The question may be a specific hypothesis, or exploratory;
• procedures design — the observations, conditions, methods, recording requirements, statistics, subjects etc. are determined;
• observation — data are observed and recorded;
• data analysis — data are organised, analysed and evaluated according to the question asked;
• interpretation — the analysis is used to provide answers to the question, and to contribute to knowledge in this field. This phase is inductive in that specific results are used to generalise and make or confirm theories;
• communication — findings, procedures, and rationales are communicated to allow replication or scrutiny by peers.

All scientific research results in repeated observations and reflections, which generate knowledge in an adaptive and evolving manner. The various philosophies and approaches are merely components of a wide-ranging research enterprise and each has the potential to generate knowledge which, if accepted after peer scrutiny, can be valid, applicable and useful to the evolution of knowledge.

Levels of constraint within different scientific research designs occur. They are the degree of control that the researcher can exercise. For example, the research may be exploratory, or highly specific with precise hypotheses, but precision and control may not always be ideal because the trade-off is loss of flexibility. The choice of research methodology is related to the research and varies with setting. However, all levels of constraint imposed by a research program are applicable to a process combining observation and rational inference over research phases. Some research methodologies are described below to give an idea of the range of control a researcher may exercise:
• The naturalistic observation level of constraint requires the researcher to observe subjects in their natural environment. Procedures used make no attempt to change or limit the environment or behaviour of subjects. The only constraint is that the researcher imposes his/her observational method. Strong hypotheses that demand a particular set of observational procedures are generally not required so that greater flexibility is common in early stages about a given topic. Criticisms relate to poor representativeness of a small number of cases compared to the true variability among human beings and ecosystems, inability to generalise to a wider population, and the difficulty of replicating the research.

• Participant observation has advantages over unobtrusive observation because participating makes the situation more natural whereas during observation a subject may alter their behaviour because they are being observed.

• Case-study methods of observation may have a high constraint because the researcher intervenes with the subjects functioning, for example, by asking questions. However the approach retains flexibility.

• Correlational research attempts to quantify the relationship between two or more variables so that precise (constrained) procedures are used for measuring each variable. This allows predicting values of one variable from another. The effect of confounding variables can rarely be eliminated.

• Differential research compares one variable in different groups, so that variable must be measured in the same way in each group. The variable that defines the groups is preexisting and not under the researcher’s control for example, age or socioeconomic class of group. Again, the effect of confounding variables can rarely be eliminated.

• Experimental research compares subjects under different conditions. Subjects are assigned to groups of conditions in an unbiased manner (e.g. random) whereas in differential research subjects are defined on a preexisting variable.

Some researchers hold a view that only high levels of constraint can be considered scientific methods. However, all are effective when properly used and the nature of the question helps determine the level of constraint to use. There are circumstances when it is appropriate to use naturalistic observations, others where it is appropriate
to use other forms of enquiry. Ethical constraints are a major consideration in choice of research methodology. It may be useful to test findings from high constraint research in low-constraint naturalistic settings and vice versa.

Not only is there a range of philosophies and methodologies that can be invoked for generating knowledge; there are also various degrees of control that the researcher can employ. The methods selected to study a problem can also change as questions evolve and new issues arise, so that it is not necessary to continue with a single research methodology. Experimenter expectancy effects can occur in any research if the researcher selects data that support the hypothesis postulated, uses statistical techniques that show particular effects but not other effects, and interprets results in a biased manner. These factors need to be taken into account and understood by any researcher guided by any philosophy and employing any methodology.

**Relevant western approaches to research**

Within the western scientific research tradition there are many approaches to gaining knowledge. Different research approaches derive from fundamentally divergent epistemological positions and their associated paradigms (Crotty 1998:2–9). A paradigm is more than a choice of method: it is derived from the worldview that guides a researcher through all stages of the research from ideas generation to results interpretation (Pinheiro *et al.* 1998:1211). A review of two epistemological positions used in western research, those of objectivism and constructionism, is presented below. In this way the argument that there is more than one accepted approach to generating valid knowledge, even within the western cultural academic tradition, is illustrated.

*Objectivism, the positivist paradigm and reductionist methodologies*

The predominant epistemological position of western knowledge systems, known as objectivism, is founded on the concept that knowledge is a universal truth, which can be acquired through independently understanding the world’s parts and processes in a systematic way. This position espouses the view that the human mind, its perceptions and interpretations, are independent of knowledge creation, so that questions, thoughts and actions do not influence the world’s parts and processes. In this way, knowledge is considered to be ‘objective’ (Norgaard 1987:22). Theories
are developed to organise observations and inferences, and to predict and explain observed phenomena. Theories can be inductive, deductive, functional, or models and are judged not on how right or wrong they are but how useful they are to organise information, explain phenomena and generate accurate predictions (Graziano & Raulin 1993:38).

Positivism is the paradigm used by adherents to an objectivist epistemology, that is, researchers who are guided by a belief in a single source of knowledge that is objective and independent (Pinheiro et al. 1998:1211). Those who search for the reality of an uncontested knowledge use techniques that are purported to make the knowledge rational, undeniable, exactly reproducible and therefore likely to be accepted. These researchers advocate operationalised concepts and definitions, objectivity between the researcher and the subject, and an understanding of causal relationships between variables studied. Hypotheses are formulated in advance and observations test the empirical validity of these hypotheses (Caldwell et al. 1998:1030). This approach requires the researcher to view events or data from the outside by a cluster of empirical concerns with little regard for meaning from the subject’s viewpoint, or indeed, for the assumptions, preconceptions and learning process instituted by the researcher.

However, research questions are based on the findings of previous subjective interpretations made by researchers using the same paradigm, perpetuating a progression of thought guided by a single theory and by presumptions about the objectivity of their data collection techniques, data categories, interpretations and generalisations or refinements of the theory. Even components of the phenomenon under research used to characterise that phenomenon are subjectively determined.

Many scientists do not contemplate these issues unless an alternative mode of thinking emerges, or experiments repeatedly indicate something contrary to existing knowledge, or knowledge does not work when applied to reality, as found by Norgaard (1987:21). This point is made, in particular, by experts in the biophysical sciences whose work had spanned decades of the tradition, who later explored and taught the philosophy of science for academic purposes. They speculated as to why their tradition failed to equip them with such a relevant background, and instead, had
taken western science to be the nature of knowledge (e.g. Kuhn 1970:viii, 9, Berkes 1999:xii).

When alternatives are suggested, assumptions are challenged or solutions of low credence or practicality are produced, crises for the discipline and fundamental shifts in thinking and approaches result. For example, many agricultural experiments and the subsequent knowledge generated have not been successful in practice, and the new traditions such as agroecology have emerged to understand the human–ecological interface rather than to research the purely biological component parts.

It is rare for researchers advocating objectivism to operate in anything but a positivist paradigm. Reductionist methodologies such as survey and experimentation are employed, and quantitative methods are generally used to gather data about the phenomena researched.

Despite a long-standing scholarly tradition in developing the philosophy of knowledge, most scientists who collect data about biophysical phenomena, and many social scientists, tend to use the dominant western positivist-reductionist approach, and many argue that there is no other means to generate knowledge. This is either because of their lack of exposure to alternative approaches or because of ulterior motives to demonstrate a superior ‘expertise’ that advances a western supremacy base, postulated by Berkes (1999:12).

Constructionism, alternative paradigms and related methodologies

Researchers who believe that individual experiences are distorted by the positivist paradigm have challenged it on the basis that there can never be perfect knowledge of ecological processes in non-equilibrium systems (e.g. MWLR 1999). Some propose an alternative epistemological position, such as constructionism, which is the belief that knowledge has multiple sources constructed by individuals and societies and through the interaction between researcher and subject (Pinheiro et al. 1998:1211).

Adherents to constructionist epistemology challenge the presuppositions of scientific objectivity because they assert that the world is best understood from the point of
view of the subject through ‘lived experience’ and value neutrality (Finn 1994:26). In other words, to create knowledge of greater integrity, data generated in research should be interpreted according to the worldview of the subject and their interaction with the phenomena studied.

Constructionists believe that research guided by a positivist paradigm uses arbitrary variables, chosen to determine causal relationships that may mean nothing to the complex system it is supposed to represent. Values also enter into the observation of facts and the conduct of theoretical analyses as well as their interpretation. These critics suggest that quantitative analyses that characterise data based on statistical criteria frequently ignore the variance in the data, with a result that similarities and differences are not adequately explored (Kaplan 1984:32). Even minimax and confidence intervals are chosen from value systems, and accepting or rejecting hypotheses does not adequately describe the range of potential scenarios in the data. It is also important to disprove a concept, and not simply accept that two scenarios cannot be disproven to be different (i.e. accept a null hypothesis) which tells the researcher very little.

Adherents to the constructionist epistemology also believe the researcher is an actor in the research process and brings preconceived inferences and preconceptions to the hypotheses, observations, methods and interpretations of the research program, so that the research has an inherent observer effect (Kaplan 1984:34, Agar 1996:4 and passim). The procedures that are chosen and the values of the researcher determine what is to be measured and therefore influence the results of a research problem. However, by making explicit the role of the researcher in the research process, any data that interact with the phenomena being researched are recorded and used in the analysis, thereby explicitly stating the interpretations and understandings, shifts in thinking and individual learning that arises during the course of the research. Thus the researcher is a variable in the system under study, and the knowledge generated is dependent on the researcher and his or her involvement in the research process.

The preferred paradigms of adherents to constructionism are likely to include those such as interpretivism and critical inquiry. These paradigms require close involvement with the subject, an understanding of the context of a behaviour or
event rather than characterising data, an emphasis on novel and unanticipated results, and the possibility of altering research practices to explore specific hypotheses that develop during the research process (Bryman 1984:84, Agar 1996:32 and *passim*). Together these help the researcher understand the subjects’ meaning systems and the way they interpret information. Ethnography, action research, discourse analysis, phenomenological research, and heuristic inquiry are examples of alternative methodologies.

There is need to point out that the term ‘subject’ can be used to refer to more than the human subject, and indeed can include any subject researched. For example, I may interpret the absence of sea cucumbers from a particular habitat on a particular occasion as being because the water is too rough, when the reality from the point of view of the sea cucumber (the subject researched) is that the water temperature was too high. Unless the researcher can emulate what is researched, the interpretations, however robust, may be incorrect with regard to the reality of the sea cucumber. There are a myriad variables and explanations underlying both research and the generation of knowledge. Fixation on a predetermined hypothesis, inadequate characterisation of variables or simply an inability to produce significant statistical differences when analysing data leads to differences in the knowledge generated. If some universal truth were to be determined it is important to understand the variables from the point of view of the subject researched, rather than that of the researcher. Such an approach requires thorough involvement between researcher and phenomena researched. Interpretations may alter over time as new information emerges and new observations are made about the phenomena researched.

*Selecting methods*

Quantitative and qualitative techniques refer to technical aspects of research rather than the philosophy of the knowledge base and their associated methodologies. That is, quantitative and qualitative methods are chosen, covering a variety of techniques, but the terms ‘quantitative’ and ‘qualitative’ relate to the characteristics of the technique rather than to the underlying philosophy of acquiring knowledge.

Quantitative data are said to be best employed when the information sought is reasonably specific and familiar to respondents, when the researcher has prior
knowledge of the problem and likely responses, or simply when the research goals require quantitative data. Quantitative techniques include fixed measurements, quantifying the relative proportion of parts or relative strengths of relationships to help predict effects and changes, and statistical methods that infer causality.

Qualitative techniques are usually more prolonged than quantitative field work, because the researcher is involved in a system in which a response to an input depends on the person who receives it. Communication, observations and interactions are involved, which may induce change in the researcher. Because the researcher participates in the research process power and responsibilities are shared, and advances in learning occur because communication is circular with feedback processes. Qualitative techniques include unstructured interviews, life histories and participant observation.

Qualitative approaches are said to be more sensitive to, and therefore best applied to, complex phenomena (e.g. complex social relationships, intricate patterns, constructing situations and flows of events, or inferring values and belief systems) because quantitative indicators may not satisfactorily explain the situation, relationships and multiple causations, nor facilitate understanding. For example, categorising a child according to only certain behavioural criteria does not capture the complex psychology and array of responses the child may choose in a particular instance, nor the reasoning behind such a choice.

Opponents of qualitative techniques argue that close involvement with a subject can obscure other phenomena that should be measured or researched; and that the research is not objective. However, a scientist using qualitative techniques attempts to discard bias and to not make value judgements, but rather to understand why the culture or person expresses or manifests a thought, behaviour, action etc. The approach requires that the researcher know the values and beliefs of the subject, person or culture with which he or she is interacting and neither adopt nor reject those values, thus remaining neutral (Kaplan 1984:27). In this way judgements can be made that are well founded, critiqued and examined. Even so, value judgements are not problematic as long as they are recognised, which usually happens when researchers confront their own subjectivity in constructing and understanding a
situation (Finn 1994:29, Pinheiro et al. 1998:1212). The rationale behind the research is fully exposed as part of the research, and is open to scrutiny. Sources of error can be insulated, cancelled or discounted by introducing counteracting variables, cross-checks and falsification tests (Kaplan 1984:28).

Opponents of qualitative techniques also suggest that the unstructured and exploratory nature of the approach, and the lack of specific hypotheses, make this research simply precursory to subsequent verification by more ‘rigorous’ methods. The argument that qualitative research is precursory to quantitative research diminishes the epistemological basis on which the research is founded. It expresses a lack of confidence in the theory of knowledge generation and belittles the research by suggesting that it needs to be confirmed by a superior approach (Bryman 1984:85). Sometimes subjectivity may be required in the first instance of a research program to understand individuals, beliefs, values and norms from within a differing culture; objectivity can be imposed at a later stage. However, anomalous results have also been generated from quantitative methods, which have required checking against data obtained by qualitative methods for a ‘fuller’ understanding. Indeed knowledge from both traditional and western knowledge systems has sometimes been found incorrect, and likewise both knowledge systems have generated additional insights not previously formulated by the alternative knowledge bases.

It is often argued that experiments involving quantitative techniques such as control plots, formal measurements or multiple sites allow for extrapolation to other sites, whereas other methods are simply offerings of innovations and ideas. However even with standard designs and statistical rigour conventional experimental trials, survey results or other findings are plagued with variability including varying levels of researcher interest and interpretation. Quantitative questionnaires and individual interviews can also be viewed as non-participatory, extractive and disempowering (Okali et al. 1994:108), so that the wishes of interviewees may need to override those of the researchers, who frequently attempt to extract a specific set of information to answer predetermined questions.

The real challenge, then, is designing and testing research. Depending on the phenomena studied, one or a combination of philosophies, methodologies and
methods may be appropriate in any discipline. It cannot be considered objective practice to continue perpetuating positivist-reductionist approaches when other methods may in fact produce better data interpretations, depending on the situation and research. It is not objective to assume that one method is correct; researchers should ideally ponder the research phenomena with a fuller understanding of the philosophy of knowledge and the practices with which research can be conducted. Some practitioners argue for an integrative paradigm where possible approaches and techniques are considered and synthesised to generate more complete knowledge.

An integrative paradigm
Disciplinary integration is suggested as an appropriate paradigm for resource management, focusing on evolutionary and adaptive management. Integrated approaches are now described in integrated resource management, integrated environmental management, integrated catchment management, watershed management, environmental planning and bioregional planning. Integrated approaches are useful in complex circumstances, where interests and objectives are numerous and in conflict, information and knowledge is incomplete, ends and means are ambiguous, control is fragmented and the external environment in flux. Sharing information and perspectives, developing a mutual understanding of differing disciplinary viewpoints, and developing holistic target approaches to managing the system are thought to be characteristics useful to integrated environmental approaches. This requires a relinquishment of the dominant paradigm used in western scientific research and acknowledgement that there are many ways and means with which knowledge is generated.

Although there are many research programs that employ techniques from both paradigms, few individual researchers have crossed the epistemological gap between the diverging research traditions (Bryman 1984:80). There are few forums for researchers to cross disciplinary boundaries and little practical guidance for field workers who wish to facilitate integration of disciplines or trial new concepts.

Sometimes, too, one discipline is favoured, either by funding agencies and institutions, or simply by individual researchers working within a multidisciplinary team. For example, the Cape York Peninsula Land Use Strategy (CYPLUS), an
environmental planning initiative conducted in north Queensland, failed to equitably allocate finances, resources and time to a participatory component in the research. The program was heavily weighted toward biophysical data collection and analysis at the expense of resourcing the participatory component of the project; a point criticised by some researchers as being unacceptable (Dale & Bellamy 1998:86).

People who operate under differing paradigms frequently aim for different research goals and fail to recognise the strengths and weaknesses of alternative theoretical stances. Williams (1986:40) suggests that multidisciplinary studies such as those linking people and the environment may benefit from building on both commonalities and disputes between the component disciplines, rather than simply constructing components of the research independently from the theories and practices of segregated disciplines prior to the research. This is indicative of an integrative approach rather than a multidisciplinary approach, because frequently multiple disciplines never coordinate their independent approaches, a vital component of research that requires skill in itself.

Following Williams’ (1986) argument, the theoretical basis of truly interdisciplinary research emerges throughout the course of the research as specialists interact. Such interactions would facilitate new ideas about methods for data analysis and interpretations that are strictly interdisciplinary, and these in themselves are significant outcomes of a research project. The methods are applicable to the phenomena researched. In other words, the methods are chosen based on whether phenomena are repeatable and structurally similar across time, space or individuals, versus those which are highly individual, unique and continuously restructured.

Kuhn (1970) was a major contributor to academic thought because he showed how cycles of paradigms have emerged and declined through time, and guided the way researchers think. It is clear that research is continuously changing and being shaped, sometimes through hypotheses being disproven or simply obstacles that challenge research. Often these paradigms also reflect societal thought and changing attitudes.
Patterson and Williams (1998:283) suggest that the science in natural resource management needs to move beyond Kuhn’s (1970) idea of revolutions toward the concept of pluralism — the idea that differing scientific paradigms can coexist within a discipline. This requires that some disciplines relinquish their narrow approaches and philosophies, their belief in a single paradigm, and their arrogant suppression of alternative approaches. In this way the limitations of each theoretical stance and the problems to which they can be applied are defined. Furthermore, nontraditional standpoints (such as hermeneutics) can help to establish a critical pluralist perspective for the appropriate exploration and evaluation of the phenomena being researched.

Selecting a particular technique does not negate the underlying epistemological differences between techniques and often demonstrates intellectual commitment to a particular philosophical stance. However, even the notion of ‘appropriateness’ of the technique will vary (Bryman 1984:79). Agroecologists, for example, are still developing their epistemological beliefs and consequent techniques, and in the absence of consensus, have resorted to pragmatism (Norgaard 1987:25). This discipline and others such as geography, sociobiology and systems theory share a base with the anthropological subdiscipline of cultural ecology, and together may be suggesting a turning point in the biophysical sciences (Norgaard 1987:25-26).

Even methods usually employed under one paradigm may contain elements of both. For example, quantitative data records may show some data collected as ‘comments’, while qualitative interpretations often express the terms ‘many’, ‘frequently’ or ‘some’ to express findings (Bryman 1984:88). Some researchers argue that combining quantitative and qualitative methods produces a better overall view of reality because the two approaches link and cross-check findings, or point out the eccentricities of a technique used. Some researchers have also attempted to develop new strategies that combine characteristics of both approaches; however, it is not always easy to neatly dovetail the results.

The more recent disciplines neither reject western knowledge and its insights and answers, nor the explanations from traditional systems that have survived the test of time: a period longer than any scientific enquiry and incorporating long-term
changes and dynamics with which no laboratory experiment can cope. As Hunn (1993a:13 in Berkes 1999:5) suggests, traditional systems of generating knowledge pre-dated a western scholarship tradition, and were based on generations of intelligent reflection that withstood the ‘rigorous laboratory of survival’. These knowledge processes are founded on processes of trial and error, selection, cultural learning and feedback. For this reason the new sciences advocate not only the sharing of an epistemological base, combining appropriate traditions of the West for improved knowledge, innovative practices and policy, but also those traditions not founded in a western-based tradition.

**Research, knowledge and management: some conclusions**

It is clear that research is culturally determined, undertaken according to the cultural background of an individual. The research process, being based on observations and a rationale, is common to all scientists, regardless of discipline and culture.

Within western science there are separate epistemological bases and growing calls to integrate the many philosophies, methodologies and methods in a manner appropriate to the phenomena researched. Of paramount importance is choosing the approach that will generate the best knowledge in relation to the phenomena researched. It is therefore argued that there is no one superior way of accumulating knowledge; rather, the technique should be selected for its ability to understand what is researched (Williams 1986:42).

When working across cultures, there is potential to integrate research further by incorporating not only the differing approaches within the western tradition, but also the differing research processes for knowledge acquisition and science in alternative cultures. This may require a combination of worldviews and their related practices so that a truly integrative approach can be adopted. Some worldviews emanate not just from within western tradition, but cross cultures and advance the concept of knowledge beyond that generally considered from any western academic viewpoint. Using such an integrated approach across cultures may bring about an enhanced interface between cultural and environmental sustainability.
RESEARCH DIRECTIONS FOR NATURAL RESOURCE MANAGEMENT

Natural resource management encompasses acquiring information about the scope, nature and potential use of biophysical resources; and implementing decisions about the resource uses by preparing and implementing management plans. The profession of natural resource management and public policy formulation developed under the paradigm of rational, neutral, fact-based science, where the positivistic premise suggested that empirical measurement and rational thought were the only basis for objective research (Cortner & Moote 1994:167).

One of the assumptions in this approach is that while there may be some randomness and unpredictability, the universe operates primarily in an orderly, lawful way. This implies that scientific relationships are universal, objective, independent of a context or viewpoint, and replicable through controlled experiments. Using this viewpoint, the principles of relationships between ecosystem components are thought to be detectable through systematic scientific research, and in this way, change and its consequences can be predicted with precision, scope and accuracy.

However, knowledge of the universe is always incomplete. New knowledge alters existing ideas and theories, rendering all knowledge and theories tentative until a more appropriate framework for acquiring knowledge, or paradigm, is advanced to counter anomalies in the previous one (Kuhn 1970, Cortner & Moote 1994:168). When there are no challengers to the dominant paradigm, research generally adds scope and precision to questions posed within that paradigm or improves the precision of methods already in use.

The methodological approaches used within the natural sciences have ignored the possibility of an alternative interpretive approach and shown a lack of attention to epistemological issues and assumptions (Patterson & Williams 1998:280). This may be attributed to a seemingly ingrained belief that science is about methodology. Positivist perspectives have been criticised because measurements and interpretations are not objective, but are influenced by a researcher’s experience and background; empirical observations and measurements are theory-dependent, being developed from within the context of the theory; replication can never occur because
either time or space varies; inductive reasoning is unable to generalise interpretations into laws and theories; and the problems with the hypothetico-deductive approach because even falsifying statements are subject to falsification (Charlesworth 1982).

The findings from ecological research projects and other biophysical data are the predominant input to natural resource management. Since the 1960s ecology has experienced a trend toward experimentation in a bid to be endorsed as a basic science (Brunner & Clark 1997:52), because basic or ‘pure’ science was considered to be the mark of intellectual endeavour when discovering and understanding knowledge.

Applied science, in contrast to basic science, aims to clarify the feasibility and consequences of alternative actions in particular contexts rather than pursuing claims to the attainment of academic endeavour. The myriad factors and interactions that can be neither anticipated nor controlled in a situation are acknowledged, despite the infinite number of possible variables and relationships. In the practice of applied science, general and context-specific knowledge is integrated into interpretations and judgements about that situation. Expectations, consequences and goals are modified in light of the experience that follows action, in an action research cycle of reflective enquiry.

Current ecological researchers have recognised the limitations of ecological paradigms, theories and techniques because many global environmental problems are insoluble or will not disappear in the short to medium term (e.g. Schramm & Hubert 1996:8, 9, Brunner & Clark 1997:53, Dale & Bellamy 1998:34). They acknowledge that science is limited in its capacity to identify and predict causal relationships and to provide an understanding of the ecological significance of many situations. The functional relationships derived from basic science are not suitable for ecosystem management decisions because they cannot be considered universal, particularly through space and time, regardless of the number of successful predictions and replications in the laboratory. Vagueness in concepts such as sustainability and biodiversity; contradictory or ineffectual data; and increased demands on, and deterioration of, natural resources, have invalidated the traditional

Some researchers argue that the changes required for natural resource management are not revolutionary, although there is a general consensus that the process is evolutionary (Schramm & Hubert 1996:8). However, this position is problematic: there is a danger that acquiring new tools for scientific methodology might becomes the major issue so that any change would be in methods rather than in opposing worldviews. Even those natural scientists prepared to incorporate both qualitative and quantitative tools at the methodological level of their research program seldom explore further the epistemological position and the normative structures of their discipline (Patterson & Williams 1998:283).

Another alternative paradigm has yet to be developed into satisfactory principles for practical purposes (Brunner & Clark 1997:51). While constituent values, theories, methodologies, tools and techniques for the emerging approach are still to gain consensus and sanction from the broader scientific community, particularly from stalwarts immune to the weaknesses of their preferred tradition, there appear to be two broad principles advocated by progressive resource management practitioners: ecosystem management and community participation (Cortner & Moote 1994:167, Schramm & Hubert 1996:6 and passim, Dale & Bellamy 1998:1). These are discussed in turn below, followed by a more detailed presentation of community participation approaches.
**Ecosystem management**

Since the mid-1980s scientists have increasingly advocated management at the scale of ecosystems rather than relying on optimisation models, single species research and short-term or crisis responses (Cortner & Moote 1994:169, Brunner & Clark 1997:48, Dale & Bellamy 1998:34). Multiple-use approaches to natural resource management have been advocated but rarely implemented (Cortner & Moote 1994:168). These are attempts to integrate a myriad resource uses into environmental management. While they may acknowledge a great many factors and variables important in decision-making, these attempts are still based on the positivist position that knowledge is objective, and so are merely extensions of the existing example. There is a shift toward identifying risk and recognising that risk and uncertainty in environmental management are part of the planning process.

The essence of ecosystem resource management is that it needs to be based on a paradigm that recognises complex, non-linear systems that adapt and evolve; constant and discontinuous change; ever-present uncertainty; chaos and order; and the interdependence between humans and the biosphere (Dale & Bellamy 1998:34). Managing such complex ecosystems requires an adaptive approach that is anticipatory rather than reactionary (i.e. that deals with uncertainty by recognising that change is inevitable) and is ecologically based by focusing on the integration and sustainability inherent in complex, interrelated ecosystems.

Targets are set for ideals such as biodiversity, social and cultural values and the protection of indigenous rights, rather than the consumptive use of resources. The practice of ecosystem resource management therefore also requires knowledge of resource capabilities; community values, attitudes and preferences; and the losses and benefits associated with particular choices about the use of the resource. This is because stakeholder demands, values and uses are also vital components of ecosystem management, although as yet they are seldomly taken into account in the existing philosophy (Schramm & Hubert 1996:9).

**Community participation**

Because natural resource management involves the human–ecological interface there is a trend toward integrating holistic, multi-use, multi-value stakeholder views
into research programs that incorporate or synthesise many disciplines (Cortner & Moote 1994:169, Schramm & Hubert 1996:9, MWLR 1999). A transnational recognition of the relationships between environmental degradation and issues of social justice, rural poverty and indigenous rights has led to attempts to link environmental management and social justice agendas (Brosius et al. 1998:158). A major development has been that of participatory natural resource management programs, policies and projects, which are a form of local resource management supported by these transnational goals.

Both international and local experience dictates that because ultimately human factors most directly affect the integrity of ecosystems through sustaining or degrading actions, resource management regimes must now involve a wide variety of stakeholders at institutional, community and individual levels (QDPI 1993:5, Schramm & Hubert 1996:9, Claridge & Claridge 1997:9). Failure to do so can lead to failure of the management regime.

In some biophysical sciences, particularly agricultural research and extension, research projects have failed to achieve objectives because of conventional centralised (‘top-down’) approaches rather than participatory (‘bottom-up’) approaches (Razaak 1998:1222). Some conservation biologists and resource management practitioners have heeded these warnings, moving toward alternative observational and analytical methods that integrate stakeholder concerns about economic, social, cultural, legal or political issues (Brunner & Clark 1997:52) and suggesting a balanced approach between basic and applied science. Some resource management agencies have also broadened their mandates to include the entire ecosystem and social system in which resources are located.

**Other issues**

Property rights, administrative decentralisation and interagency coordination are thought to be key issues in the emerging resource planning and management paradigm. Property rights issues emerge because of conflicts between government, community needs and private landowners due to the growing property rights movement. Issues of decentralised decision-making present the dilemma that management at the landscape scale, often required for the expenditure of public
monies, is difficult. Regional databases and ecosystem models need to be used, but these are generally incomplete and not fully understood. Information generated from these tools is fed into umbrella organisations that are required to coordinate data and encourage interagency coordination, but the purpose of these umbrella agencies — to make institutional linkages — runs counter to decentralised decision-making (Cortner & Moote 1994:172). Furthermore, when resources (human, time, and financial) are applied to the on-ground implementation of institutional policies, it is at the expense of public involvement. Legitimate public claims to natural resource decision-making are thus denied (Cortner & Moote 1994:171).

Brunner and Clark (1997:50) suggest that in a pluralistic political arena the goal of ecosystem management is ambiguous because it must integrate multiple, frequently incompatible, or incommensurable goals. They propose that ambiguity occurs not simply with the balance between ecological concepts and their transfer to similar environments, but with the moral and intergenerational dimensions of sustainability within fuzzy political, legal and moral constraints. The appropriate course of action often becomes unclear in the practice of ecosystem management. However a decision to do nothing does not befit professional practitioners who must advance a collective and enduring evolutionary research process to reduce ambiguities and improve environmental management options.

Brunner & Clark (1997:50) propose a practice-based approach where research, education and action are built into administrative, legislative and judicial processes. However, increased public awareness of environmental concerns does not equate to changed behaviour, so social norms and public awareness campaigns also need to focus on and facilitate an individual stewardship ethic (Claridge & Claridge 1997:13–14). Political accountability to future generations, cost sensitivity and public–private collaboration also need to be tackled (Cortner & Moote 1994:171, 172).

**Natural resource management directions: some conclusions**

Clearly the calls for a deep-seated shift in natural resource management relate to two themes — ecosystem management and community participation. Both themes are integral to this thesis, which links cultural and environmental sustainability.
Given the range of issues affecting ecosystem management and community participation it is clear that much work remains to come to terms with the issues entailed in the two themes. Ecosystem management and its component parts and processes constitute a thesis in itself, although ecosystem management and participatory resource management are inextricably linked because segregating the two negates their very meaning and purpose. However, for the purposes of this thesis, the participatory research component is discussed more fully below.

**PARTICIPATORY RESEARCH FOR NATURAL RESOURCE MANAGEMENT**

Participatory research, also referred to as community-based research, action research, participatory action research, collaborative research and in other terms (Claridge & Claridge 1997:10, CDS 1999), is rapidly increasing and well documented in a range of disciplines. Calls for public participation are prevalent in education, international community development, social work, health, organisational psychology, environmental justice, agriculture, forestry, and fisheries (Finn 1994:28, Okali *et al.* 1994:1, Patterson & Williams 1998:279, 281).

**Participatory philosophy**

Participatory research is based on the premise that participation by local people in research programs increases effectiveness through greater ownership of the work, an increased chance that outcomes will be implemented, and lower costs through on site management or reduced compensatory payments. Community-based management is built around the principles that local people have greater interest in a resource than distant or corporate managers, greater awareness of environmental intricacies, and greater ability to manage resources because of local and traditional access regulations (Brosius *et al.* 1998:158). Participatory approaches are increasingly demonstrating these benefits and it is now widely held that participatory development is critical for sound resource management (MWLR 1999).

Participatory research is a form of enquiry that is informed by and responds to needs expressed by people, usually those who are marginalised in some way. For this
reason it has two agendas: democratisation of the research process (where people share information and its accumulation at all stages); and an emphasis on social change (where research produces action to reverse inequalities and transform society). Proponents aim for research that is purposeful and empowering to grassroots organisations and individuals (CDS 1999). Thus the process is about promoting egalitarian relations between researcher and subject in order to redress false divisions and power imbalances found in past research processes (Finn 1994:26). The concept is surrounded by ideological debates such as the nature of knowledge and the appropriate interface between dichotomies such as the formal/informal approach, government/non-government, insider/outsider or local and non-local systems.

Participation is thought to be necessary to produce data of integrity, otherwise they remain cryptic (because data are extracted — that is, taken, rather than voluntarily provided without prompting). Participatory research is advocated by many researchers in single and cross-disciplinary research because the process and techniques have the potential to span the gap between theoretical research and practice. Participation is not merely an end in itself but a means to securing tangible benefits to achieve more sustainable resource management practices. Detailed outlines for action are not devised at the outset because problem solving is based on partnerships and cooperation rather than on a need to achieve some externally identified goal. The knowledge and understanding needed by groups to continue the process can be transferred only through active participation.

Modes of community participation lie along a continuum from complete control and management by external agencies to complete community control and management (Claridge & Claridge 1997:10). Arnstein (1989 in Claridge & Claridge 1997:10) describes a ladder of participation modes, from least to greatest community control:

- manipulation
- therapy
- informing
- consultation
Claridge and Claridge (1997:10) argue that this classification is value-laden. Other researchers agree that there is no ‘right’ level of community control or involvement, but a continuum of participation (Finn 1994:28, Okali et al. 1994:21). They suggest that it is more important that participation be meaningful and appropriate to the capabilities and characteristics of stakeholders than to categorise participation as one or another hierarchical level. They also suggest that there are times when less active forms of participation may be desirable; for example, there might be occasions where citizen control, with a high level of community control and minimal government control, could be adverse to resource sustainability. This would vary with the issues under debate and the particular community defined, but might occur when people prioritise immediate or particular needs, as opposed to long-term and wider-reaching benefits. The main issue raised is the importance of outside researchers knowing the appropriate level of community involvement, and attempting to increase local participation.

There is a danger in this statement because outside researchers may attempt to move community capacities toward implementing only western style research projects. This means that they may assess community capacity only on the community members’ capacity to perform western science activities. High degrees of community control could surely be expected were community members perform research from within their own cultural tradition.

The quality and scope of participation are often limited by the type of project and by the objectives, practicalities, technologies and socioeconomic environment in which the research is implemented. Activities at the two ends of the continuum of participation vary greatly and both types have implications for the clients. They can sometimes be problematic because small amounts of involvement by local people can then be justified by outsiders (Finn 1994:28). However, the idea is that over
time, community-based research and resource management progress along the continuum toward the end of highest community control.

To initiate actions that increase participation it is necessary to know the characteristics of the situation and the stakeholders. In other words, baseline information about stakeholder needs, aspirations and perceived directions are required so that the research process can be measured according to stakeholder performance criteria.

An alternative classification of agricultural participatory research was proposed by Biggs (1989 in Okali et al. 1994:20–21). This scheme categorises research programs according to the extent that local knowledge and practice are part of the process. He suggests that there are four types of participatory research, each with increasing degrees of farmer involvement in decision-making, and increasing equity in the process:

- contractual (researchers merely hire the farmers, land and services);
- consultative (researchers diagnose problems and find solutions);
- collaborative (researchers and farmers are partners and collaborate in activities);
- collegiate (researchers actively encourage farmers in their informal research and development agenda).

The key objective is to move toward more collegiate participation (Okali et al. 1994:93). Alternatively, Pretty (1994 in Pinheiro et al. 1998:1214) suggests that power and participation are intimately linked. He classified seven types of participation according to increasing degrees of power and responsibility:

- passive participation;
- participation in information given;
- participation by consultation;
- participation in exchange for incentives (e.g. improved conditions);
- functional participation (perform some tasks);
• interactive participation;
• participation by self-mobilisation.

In reality the difference between the schemes is arbitrary, and conceptually the continuum of participation remains an appropriate construct. Pinheiro et al. (1998:1215) say that in agricultural research farmers have mostly been involved with the lower or intermediate levels of participation of the classification.

Borrini-Feyerabend (1996 in Claridge & Claridge 1997:9) attempted to distinguish among stakeholders and their entitlement to responsibility in collaborative management. They suggested using the following criteria to signify entitlements:

• existing rights to land or natural resources;
• continuity of relationship (for example, residents versus visitors or tourists);
• unique knowledge and skills about the resources to be managed;
• losses and damage incurred by a resource management process;
• historical and cultural relations with the resources;
• degree of economic and social reliance on the resources;
• degree of effort and interest in management;
• equity of access to resources and the distribution of benefits of their use;
• compatibility of interests and activities with government conservation and development policies;
• present or potential impact of stakeholder activities on the sustainability of the resource base.

For example, in a recent study assessing the effectiveness of the Federal National Property Management Planning Campaign introduced in 1992, farmers believed the role of government agencies was to provide financial support in the form of subsidies and relief, technical and managerial advice, and management guidelines, while their existing tenure allowed them to make decisions and implement land management practices, unless they were contrary to government legislation (Claridge & Claridge 1997:22). Sometimes a distinction between primary stakeholders (who participate in decision-making) and secondary stakeholders (who
participate in a consultative process) is made when considering the degree of stakeholder entitlement to resource management.

However, there is potential that some of these criteria conflict with local stakeholder interests. The most obvious area would be the instance where local stakeholder interests are not compatible with government policies. This may be due to environmental concerns; however, other underlying factors such as fear of voter backlash may result in governments retaining of policies that are incompatible with stakeholder values. The fact that a group of stakeholders is in opposition to the government of the day cannot negate their legitimate claims to resource management.

There is ongoing theoretical debate about whether planning and resource management are technical and scientific processes, or whether they are political processes involving a plurality of stakeholders. These alternative disciplines are known as the technical and the participatory and political schools in planning (Dale & Lane 1994:253). (There is a further distinction between the participatory and political terms.) Another emerging ‘bargaining’ school in planning acknowledges that complex resource planning issues require both technical and political dimensions (Lane & Dale 1995:33-34). Despite theoretical debate surrounding the assertions that resource planning and assessment are political activities, no practitioners are modifying their approach to respond to these concerns, and researchers are therefore using failed and outdated instruments and procedures, with reform long overdue.

Project failure in community-based research can be attributed to short-term players with an agenda of career enhancement, religious indoctrination, or the securing of private commercial interests. The disparate views on project objectives of clients and donors also contribute to project failure when there are inadequate mechanisms to mediate between opposing viewpoints. The inability to adequately negotiate, convoluted procedures for accessing funding, and insufficient community participation further inhibit success. Government resourcing and institutional commitment may be the real indicators of participatory success, because these factors show that participation requires commitment from government as well as
from local stakeholders. Thus participation is a two-way process and failure cannot be written off as an inability of local stakeholders to conform to government-directed funding programs and policies.

**Participatory research processes**

Approaches to participatory research tend to break the research process into different stages. For example, Bagnall-Oakeley *et al.* (1998:987–988) developed a participatory approach at seven levels:

- identify target groups (e.g. gather district profiles and select representative villages covering ecological zones, and characterise target group makeup);
- form target groups;
- set and prioritise research and extension agenda;
- design experiment;
- evaluate technology;
- work with farmer groups;
- regional and national level farmer participation (not well attended because people seem more inhibited at this level than at the community level).

In contrast, Stassart (1992 in Okali *et al.* 1994:49) describes a participatory process where the research stages involve starting the research, deciding priorities and actions, executing the activities, sharing results, and sustaining the process. Within each stage, important considerations for the research are implemented. For example, the planning stages involve getting to know farmers; the agenda stage involves devising a schedule; executing includes improving techniques; sharing results includes disseminating results and ensuring their wide diffusion; and sustaining the process involves ways to ensure that the process continues when external support is withdrawn. Alternatively Defoer *et al.* (1998) describe a process of diagnosis, planning, implementing, experimenting and evaluating.

The modes of participation described above can be applied to various stages in the research program, i.e. different types of participation occur at different stages (for example during problem diagnosis, research design, implementation, monitoring,
evaluation and decision-making). There is no set agenda for the research strategy, and processes found to be successful in one situation may not be relevant for another group (Walsh 1995:88).

**Participatory methods**

Scientists are increasingly being asked to work with and empower communities to deal with their own needs (MWLR 1999). As well as new philosophies, these new issues for science require development of new methodologies and techniques. Most locally held knowledge is transmitted orally, may be held by different members of the community (whole or only in part) and may vary in its exact content, i.e. is similar but not identical in every respect (Caldwell *et al.* 1998:1030). Anthropology has developed methods to draw out local knowledge by allowing information to emerge from a set of key factors, not fully known by the participant observer at the start of the research. Positivist methods such as planned replication, and even written and numerical observations, are often foreign to farmers and local resource managers. In the 1980s agrobiologists used such methods, but they were challenged in the 1990s by new ideas from social scientists who emphasised informal testing by farmers and verification in terms of farmer acceptability. Social scientists also use detailed iterative studies with open-ended discussions and participant observation. These methods can be used as stand-alone ways of collecting data or to cross-check interpretations (referred to as triangulation in some literature). Biological scientists have come to accept that variations in anthropological methods used in farming systems research and extension, under the names of ‘rapid rural appraisal’ and ‘participatory rural appraisal’, have an advantage in understanding farmer knowledge.

Participatory techniques are a means to explore opportunities offered by an alternative approach. For participatory approaches to succeed, they require creative blends of traditional and new approaches to knowledge development and the exploration of new opportunities offered by a diverse range of disciplines (Finn 1994:35).

Within different research stages of a program, a number of participatory tools are used because no single tool could provide the answer either in the short term or over
a longer time-frame. Typical participatory tools include unstructured and semi-structured interviews, matrix analysis, locality mapping and flow diagrams. A summary of common participatory tools is presented in Table 1.

Many researchers enter participatory research with little or no training. The question of how to conduct participatory research is a complex one and there are some unresolved issues. Difficulties relate to the resolution of theory and practice; finding appropriate mechanisms for negotiating responsibilities and accountabilities; incorporating structures to adapt participatory research as the program progresses; ways to organise action; the extent to which useful results are circulated outside the community; the practical tools necessary; how to secure funding; and how to broaden the culture of participatory research.

However, Pinheiro et al. (1998:1218) warn that many agricultural participatory research projects carried out to date are making little difference, probably because there has merely been a change in methods and models, not a change from the dominant positivist paradigm. Sometimes this is because participation is seen merely as a goal to achieve predetermined outcomes — for example changing local resistance to research recommendations, creating local interest or fostering the adoption of some technology. Further, problems occur because increased accountability is required by institutional sources, thereby reinforcing traditional measures of scientific validity based on western-based standards and through publication in refereed journals according to these formal western criteria. Pinheiro et al. (1998:1219) suggest that a constructivist approach, such as the one employed by the Landcare program in Australia, may be useful for participatory research.

**Participatory research: some conclusions**

Local participation in natural resources research or management is a principle thought to enhance environmental management. The principles of participatory research suggest that such an approach is useful when attempting to link cultural and environmental sustainability, an ideal requested by international advocates, because of the desire to have active participation by local people in natural resource management programs.
<table>
<thead>
<tr>
<th>Participatory Technique</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rich pictures</td>
<td>Pictorial representation of important elements in a situation (e.g. people, organisations, landscape). Assists with understanding interactions between stakeholders and issues; ensures that responses are comprehensive; assists with shared understanding. Best in a small group.</td>
</tr>
<tr>
<td>Brainstorming</td>
<td>Many ideas are listed quickly, without discussion or judgement; analysis occurs at a later stage, although some combination may occur. Mind-mapping or card techniques can be used. Small or large groups.</td>
</tr>
<tr>
<td>Visioning</td>
<td>A shared long-term vision is articulated; although immediate issues are ignored. Participants think creatively and imagine a point in the future, and their desired outcomes or successes in that situation.</td>
</tr>
<tr>
<td>Questionnaires and survey</td>
<td>Structured information is gathered from specific questions. Professional assistance for wording and analysis is usually required. Questions are less concerned with people’s perceptions and concerns than in other techniques.</td>
</tr>
<tr>
<td>Mind mapping</td>
<td>Ideas are clustered and links between them shown. The process usually starts with a central issue or question and a dendrogram (tree) of ideas is constructed. Priority issues should be placed first.</td>
</tr>
<tr>
<td>Cause and effect mapping</td>
<td>Causal reasons for a situation are explored, not symptoms. A ‘fishbone’ is constructed with the outcome or effect at the head and causes on the bones. Symptoms are sub-branches. Information is analysed and organised and covers all possibilities.</td>
</tr>
<tr>
<td>Historical analysis</td>
<td>History and background are explored to understand changes and perceptions. Information is recorded in two columns, one showing the date and other key local/external events; influences by people/groups; changes (social, environmental, economic); and trends. Best in groups.</td>
</tr>
<tr>
<td>Method</td>
<td>Description</td>
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<tr>
<td>Locality mapping</td>
<td>Participants draw a map of the local area: local conservation activities, land degradation, improvements and so forth are shown. Process is to first draw the town, boundaries, infrastructure etc., followed by participant’s information or ideas.</td>
</tr>
<tr>
<td>Focus groups</td>
<td>Information about a broad issue is collected from a small group. A person records and summarises information.</td>
</tr>
<tr>
<td>Semi-structured interviewing</td>
<td>Collects information from individuals or small groups about an issue. The context of the interview topic is presented and some broad open-ended questions are asked that do not constrain conversation; focusing or probing questions then arise as a result of the conversation in a cyclic manner. Questions should first be tested.</td>
</tr>
<tr>
<td>Flow diagrams</td>
<td>Diagrams that illustrate and analyse the consequences of issues and actions (positive and negative). The action is drawn, followed by the necessary steps and factors to be considered.</td>
</tr>
<tr>
<td>SWOT analysis</td>
<td>Strengths, weaknesses, opportunities and threats are recorded in separate columns. These can be brainstormed or analysed/synthesised from other information.</td>
</tr>
<tr>
<td>Institutional linkage/Venn diagrams</td>
<td>Illustrates the overlap between individuals, services, groups, the project and other components, and the importance of each to the issue. Each entity is represented by a circle (size depicts the importance) and the distance between circles represents the degree of interaction. A small circle inside another is a component of an organisation. Differences obtained within or between groups can be discussed.</td>
</tr>
<tr>
<td>Information tabulating and graphing</td>
<td>Information is presented in tables or graphs for ease of analysis and comprehension.</td>
</tr>
<tr>
<td>Matrix analysis</td>
<td>The value of an activity is ranked according to certain criteria; e.g. an activity is rated against attendance, cost, or value to members. Rows show items and columns show criteria. Scores are summed to show the most beneficial item.</td>
</tr>
<tr>
<td>Issue analysis</td>
<td>Issues are identified from other activities (notes and common ground), and grouped according to a theme that links them. Quantitative scores, such as the number of times an issue arises, can be given.</td>
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<td>-------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Card technique/Delphi technique</td>
<td>Each issue/idea/information bit is written on sticky paper, and information is clustered, organised and ranked. The elements are grouped and the groups are named, and can be ranked again.</td>
</tr>
<tr>
<td>Interrelationship diagrams</td>
<td>Important causes and relationships are identified: potential causal factors are identified, discussed and examined, after which one-way arrows are drawn if one is causal. Eventually the driving cause is identified and priorities determined.</td>
</tr>
<tr>
<td>Nominal group technique</td>
<td>Ideas are listed (written, verbal) and voted on. Group members rank proposals and decide the most important ideas by totalling scores. Scores from each group (for each proposal) are fed back to plenary. Members may need to vote again on the top three or four issues. Seen as promoting equality of opinion within the group.</td>
</tr>
<tr>
<td>Action planning</td>
<td>Tasks, resources, timetables and responsibilities are identified in columns in a table.</td>
</tr>
<tr>
<td>Problem census</td>
<td>Questions are asked and problems listed without discussion. Individuals report to small groups and each group discusses and devises a group list. Final lists are reported to plenary and small groups place them in order of priority. Generates several priority lists that may need further discussion, actions, or another meeting.</td>
</tr>
<tr>
<td>Situation analysis</td>
<td>Breaks situation into component parts: one or many parts, how many actions needed, whether there is consensus on the issue, definitions, improvements etc. The emphasis is shifted from opinion to verifiable information.</td>
</tr>
<tr>
<td>Setting priorities</td>
<td>Considers each concern in three dimensions: the seriousness of the concern, the time urgency, and the best estimate of its probable growth. Concerns are judged in order of importance, available resources and solutions, and public support.</td>
</tr>
<tr>
<td>Method</td>
<td>Description</td>
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<td>-------------------------------</td>
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</tr>
<tr>
<td>Force field analysis</td>
<td>Based on the view that the present system is in equilibrium and that forces acting to change the situation (driving forces) are equally balanced by forces opposing change (restraining forces). Aims to reduce restraining forces, not driving forces. Identifies a problem/situation; driving factors are listed and rated by order of importance; repeated for restraining forces. A course of action is adopted.</td>
</tr>
<tr>
<td>Social and technical analysis</td>
<td>A wide group of stakeholders meets from which a sub-group is selected, representative of the social system. A small task is chosen, and programs with alternatives to be implemented devised. A matrix is used to score each program against three criteria (social values, political values and technical analysis). Criteria are then scored on order of importance.</td>
</tr>
<tr>
<td>Decision analysis</td>
<td>Decides a decision statement and alternatives to be satisfied (e.g. maximum cost). Decides preferred conditions (e.g. length of time). Group evaluates alternatives against criteria (musts and wants) and may rank the wants by importance.</td>
</tr>
</tbody>
</table>

*Note: Two of the key sources (manuals for participatory methods — one Queensland and one Australian source) list these as the more commonly used tools. Many of the tools are referred to or mentioned in participatory literature but detailed description is contained only in the manuals.*

A range of tools has been developed to help outside researchers and local resource managers conduct environmental research and management. However, many of these tools are used with little or no corresponding change in the underlying epistemological basis of employing them. In many projects there has not been a change from the dominance of the positivist-reductionist approach in participatory natural resource management. This may be because most programs are initiated at the passive end of the spectrum of participation as described above. Moves toward more active participation require community direction and control of the research process, the appropriate methods and techniques being selected within the process.
PARTICIPATORY RESOURCE MANAGEMENT WITH INDIGENOUS PEOPLE

Internationally, there are many case studies of participatory natural resources projects, such as those examples reviewed by Pinkerton (1989) and by White et al. (1994b:96–106). Interest in indigenous peoples’ management of resources also centres around community participation in natural resource management programs. The 1980 World Conservation Strategy initiated integrated conservation and development projects, or ICDPs, described by Alpert (1995:857). Although as yet largely untested, these programs are thought to be promising approaches to conserving biodiversity in low income nations because of the interdependent nature of conservation and development. People in low income countries are usually more directly dependent on local natural resources, and government agencies frequently lack the means to manage resources in remote areas. The 1991 version of the World Conservation Strategy stressed the need for communities to care for their own environments (White et al. 1994a:2).

Webb (1996:97–98) discusses other international conventions to which Australia is signatory, such as recommendations from the 1992 United Nations Conference on Environment and Development Agenda 21, an action plan for the 1990s and beyond to implement environmentally sustainable development in all countries (UNCED 1992). Component themes from Agenda 21 (UNCED 1992:1–4, 14–15, 89–104) include the recognition that environmental issues are best handled through the participation of all concerned citizens; and that indigenous people/communities (and other local communities) have a vital role in environmental management because of their knowledge and traditional practices. This implies that governments should recognise and support their identity, culture, and interests and make possible their effective participation in the achievement of sustainable development programs. Although these recommendations are not legally binding, they urge nations to recognise traditional values, to strengthen indigenous peoples’ involvement in policies and programs, and to protect indigenous people from socially, ecologically and culturally inappropriate development. Those recommendations require that non-indigenous people understand or at least accept what may be offered by local people.
as culturally appropriate. It is not up to non-indigenous people to determine what is culturally inappropriate.

In Australia, recommendations for Aboriginal involvement in natural resource management have been strongly endorsed in several government reports. For example, the Recognition of Aboriginal Customary Law (Australian Law Reform Commission 1986:226), the Royal Commission into Aboriginal Deaths In Custody (in Woenne-Green et al. 1995:378), the Coastal Zone Inquiry (Resource Assessment Commission 1993:370-375), the ANZECC Task Force (1996:14–15) and the House of Representatives Standing Committee on Environment, Recreation and the Arts (HRSCERA 1993:61–75) contain these recommendations. Indeed the Uluru National Park Plans of Management require that any research be subject to decisions by traditional owners regarding its purpose, relevance and conduct. These plans and other studies relating to resource management recommend that research into traditional knowledge and management practices be undertaken and that government agencies respond to Aboriginal requests for information and assistance with implementing management activities (Rose 1995:41, 55, 106).

Lane and Dale (1995:31–32) point out that many development projects have been implemented on indigenous lands, including agricultural, tourism and mining ventures, and that some, although well-intentioned, have had negative impacts on Aboriginal communities because they failed to recognise the importance of cultural factors in successful environmental management. The projects were often an intervention in indigenous communities, frequently resulting in a substantial increase in outsider numbers, regulation and bureaucracy. The social impacts of intervention have been assumed to be positive. While some benefits may accrue (potentially through employment or royalties) minimal consideration has been given to the potential negative social implications of project or process failure. Negative impacts may be lost employment opportunities, environmental degradation, non-recognition of traditional knowledge, personal hardship, increased dependency, damaged pride, financial loss, and indirect impacts such as substance abuse and health costs (Lane & Dale 1995:36, Dale 1996:113). Frequently impact assessment has been little more than project advocacy. Furthermore there has been a greater emphasis on natural scientists and engineers, compared with social scientists, which
compounds the difficulties of inter-disciplinary research. While large-scale resource development has had profound implications on indigenous communities throughout Australia, impact assessment tools designed to mediate between local communities and the global economy and to mitigate impacts have failed to capture indigenous perspectives.

Dale and Lane (1994:254) point out that marked power differentials exist between local communities and others involved in resource planning and management, a fact that underlies the debate over project development affecting indigenous Australians. Because resource development should accommodate the perspectives of a range of stakeholders with differing capacities to participate in the planning and decision-making process, they suggest that techniques appropriate to a dispersed and fragmented context be applied. They recognise that the social and political context surrounding complex environmental management issues (including value choices such as lifestyle concerns) is more appropriately tackled by encouraging bargaining and negotiation among stakeholders, using participatory techniques. However, the approach is more than simply resolving conflict among local stakeholders, because a substantial share of stakeholder power belongs to bureaucrats and industry groups.

Some researchers have refuted the existence of assumptions of neutrality in resource management because these assumptions serve the interests of the proponent and decision-making agencies rather than the community. In recent social impact assessment programs with Aboriginal people, the dichotomy between supposedly objective, neutral and technical approaches as opposed to approaches that consciously protect community interests presented a dilemma for the impact assessors (Dale & Lane 1994:256, Lane & Dale 1995:33). The dilemma was a choice between providing neutral, technical advice to bureaucratic decision-makers on the one hand, and on the other recognising the political aspect of decision-making and advising local groups on strategies for resource negotiation that redressed inequity in the process.

While there is much rhetoric, there is little evidence of advances toward practically trialling and refining approaches so that participatory resource management with indigenous Australians is widely implemented. Aboriginal people have expressed
their desire to be involved in nature conservation and management, but to date very little progress has been made toward successfully integrating indigenous aspirations in conservation and sustainable use of the environment with those of mainstream government agencies in a collaborative approach.

**RELEVANT LITERATURE: SOME CONCLUSIONS**

In the first section of this chapter we saw that research can be conducted and knowledge generated according to differing cultural traditions. The literature reviewed the directions in natural resource management, which to date have relied on the positivist-reductionist approach. There are now growing calls for changing this approach, at least in some projects, to approaches that more adequately encapture knowledge about ecosystem management and community participation in environmental management. Community participation is seen as the way forward for this new way of natural resource management.

In the light of the growing international calls for integrating cultural and environmental sustainability in environmental management programs, participatory natural resource management approaches should be ideally suited to link indigenous and western environmental management. There is much need to develop this field internationally, within the paradigm of natural resource management theory and practice. A participatory approach may be one of the best means of conducting a natural resources research project with Aboriginal people in Australia.

Much has been written about Aboriginal relationships with terrestrial and marine resources, their management practices, and their aspirations for management of their resources (e.g. Williams & Hunn 1982, Stevenson 1985, Coombs et al. 1990, Johannes & MacFarlane 1991, Smyth 1993, Rowse 1993, Ross et al. 1994, Rose 1995, Sinnamon 1997, Peterson & Rigsby 1998). However, little work in Australia has attempted to apply a resource management research program with indigenous Australians on a participatory basis.

Brosius et al. (1998:159) suggest that in order to understand some of the problems and prospects of participatory natural resource management, case studies of
participatory natural resource management should be advanced. The specific historical and political contexts in which they are planned, promoted, implemented and institutionalised by local, national and transnational organisations need to be examined. In this way, all aspects of participatory resource management can be disseminated. Too often, the process and detail of community-based resource management programs are given little space in scholarly publications, the process playing a subservient role to reports of the resources studied. Unless the process and relevant impacting factors are recorded and analysed, this promising approach will not bear fruit. In many cases improvement will require analysing the power relations and differences that impede community-based research. Issues specific to the concerns of indigenous people present an added dimension to the research required.

The purpose of analysing this literature has been to understand the process necessary and appropriate for implementing and conducting participatory resource management with indigenous Australians. This is the background and framework for presenting in-depth analysis of the research conducted at two areas in the Northern Territory. The two research studies capture a diversity of contextual data and considerations, which are presented, examined and compared. A synthesis of the lessons to be learnt and the current state of play in indigenous resource management and Australia is presented in subsequent chapters.
CHAPTER 3: GUIDING FRAMEWORK, ECOLOGICAL PROJECT AND STUDY AREAS

To undertake resource management in a participatory manner with indigenous Australians, an approach is required for working with a knowledge system and culture that differ from those in which European biophysical sciences emerged. A guiding framework was developed as a means of ensuring that a structured approach to the research occurred, aided by an ethnographic style. This framework was designed to address the theoretical issues described in chapter 2, and to guide the use of techniques, such as those described in Table 1, throughout the process.

Ethnography is a social research method that makes sense of differing social situations, actions and cultures. This research style places emphasis on understanding the situation and what has occurred, rather than predicting the value of a variable given the knowledge of others (Agar 1996:113–127).

Such research involves collecting data about everyday situations, conversations, events and observations. The technique is participatory, relying on using an abductive (or interpretive) research logic (as explained in Agar 1996:35–47). This type of research frequently cannot predict its endpoint because there is no linear movement from hypothesising to data collection and then to analysis, although the data can be analysed and interpreted through formal tests of verification, falsification and distribution checks. Results and conclusions are reached by the emergence and revision of knowledge. What is required is a commitment to personal involvement, abandonment of traditional scientific control, an improvisational style, and an ability to learn from mistakes.

Such an ethnographic approach was used to frame this project from its initial conception to its completion. While the research method was designed to be ethnographic in style, a goal-oriented strategy to guide the research process was necessary.

The research framework described in this chapter is used to discuss research conducted at two locations. Characteristics of the components of the research
process are described in detail with reference to the case studies in chapters 4 and 5. The case studies are presented in the first person since it was the author who recorded the field data. Relevant sections in other chapters are also presented in the first person. It is essential to include the role of the recorder in describing participatory research in order to understand how that role contributes to the conduct and outcome of the research.

I did not attempt to seek community-based performance criteria for the research process. I believed that it might bias results by influencing people to become more involved in the research than they might otherwise have done. In other words, they might have been more ready to take on another cultural knowledge system and its practices, than they would otherwise have wished.

DEVELOPMENT OF A FRAMEWORK FOR PARTICIPATORY RESEARCH WITH INDIGENOUS AUSTRALIANS

A guiding framework was developed to structure the research (Fig 1). The framework was conceptualised in 1995 on the basis of relevant protocols, literature and interviews (see below): however, it was not recorded in its schematic form until 1997.

In 1999 the framework was found to be conceptually similar to that of van Bueren and Blom (1997), who formulated principles, criteria and indicators within a hierarchical framework for the goal of sustainable forestry management. They argued that such a hierarchical framework was important to guide a research process because, among other things, a framework provided a complete set of parameters that avoided redundancy yet maintained a workable, transparent standard, free from confusion. Based on their work, in 1999 the terminology of goal, stages, principles and attributes was adopted to provide labels for the various levels of the framework for this thesis.

The goal
Key features of the guiding framework developed were the goal, stages, principles and attributes of the research. The goal is the ideal, which needs further elaboration
to make it meaningful. In this case the goal was to undertake and understand participatory ecological research with Aboriginal communities. The goal of participatory research and its component parts needed to be considered, through analysis of the stages, principles and attributes.

**Fig 1: Schematic presentation of the guiding framework and component levels**

**The stages of the research**

The first hierarchical level splits the goal into component research stages, as many participatory research programs are divided into stages (see chapter 2). Research stages were formulated based on the accounts of ecological researchers working with Aboriginal people and communities. In these works, a recurrent general theme is the need to involve traditional owners in all phases of the research, including planning, data gathering, interpretation and recommendations (Baker & Muṭitjulu 1992:175, 187, Reid *et al.* 1992a:250, Birkhead *et al.* 1996:128). Based on this information, the conceptual hierarchical framework divided the project into four
research stages: planning the research, data gathering, interpreting results, and making recommendations from the research.

**Deriving the principles**

Within each research stage, principles were developed to direct research implementation. Principles are fundamental laws or rules governing the basis of reason or action (van Bueren & Blom 1997:18) and make the meaning of the goal more explicit. Principles may be generic or specific. Greater specificity creates less confusion, but more principles can result in a loss of an overview of the process needed to achieve the goal; a balance needs to be struck between specific detail and what is pragmatically optimal to present the overview.

Principles were derived using sources such as guidelines for research with indigenous communities produced by institutions, literature sources, and interviews with researchers who had worked with indigenous Australians.

Four sets of guidelines produced by institutions were obtained: those of the Centre for Aboriginal and Torres Strait Islander Participation, Research and Development (1995) from James Cook University in Townsville; CYLC — the Cape York Land Council — (1995) in Cairns; the Batchelor College Research Program (1995) at Batchelor in the Northern Territory; and NARU — the North Australia Research Unit — (undated) in Darwin.

Six main sources in the literature were identified as containing important background material for collaborative research: Baker and Mutitjulu Community (1992), Walsh (1995), Reid *et al.* (1992a), Rose (1995), Ross *et al.* (1994), and Coombs *et al.* (1990).

Interviews were conducted by means of 23 telephone calls to people with experience working in Aboriginal communities. Of these calls, 12 were to naturalists/resource managers/biologists, 4 to linguists, 4 to educators, 2 to anthropologists and one to a person whose profession was not recorded but who provided relevant information. (The person in question had been recommended to me by one of the previous telephone contacts.)
Relevant information from each of the guidelines, the literature and from three of the telephone calls was summarised as one or more than one principle within each research stage. Although data from only three telephone interviews were recorded (one each to a biologist, an educator, and a person whose disciplinary background was not recorded), each person contacted generally supported the concept of collaborative research, offered suggestions, or indicated other contacts such as members of Aboriginal communities and/or other professionals who had worked with Aboriginal communities.

Development of the component principles of the framework is presented in chapter 4, where the framework is applied to the first narrated case studies. This is because, in reality, developing the principles, which generated the framework, was part of planning the research project (stage 1). The results obtained from deriving the component principles of the framework were then fed back into the framework in an interplay of the methods and results components of the research. Although developing the principles of the framework were also a part of planning the project at the second study area, the process is the same and thus is included in the study narrative in chapter 4, but not repeated for chapter 5.

Formulating attributes
At the final hierarchical level, attributes were formulated. Attributes are measures or prerequisites necessary to realise goals (as opposed to principles, which are guiding laws and rules) and thus should not be formulated in advance of the process because they are elements that emerge when the principles are implemented. The function of an attribute is to characterise the principles more clearly.

During the collaborative research about trepang, data about the research process were collected from interactions, observations, situations and conversations using the tools of participant observation and unstructured interviews. Participant observation is not listed among the participatory tools presented in chapter 2, but is a key technique in ethnographic research, and is occasionally referred to in participatory literature. An analysis of substantial participatory literature showed that this technique is absent from many participatory environmental research
programs, sometimes thought to be because it requires more time and financial expenditure from donors.

From the data, attributes that characterised each principle were identified. The attributes were used as indicators of the research process; however, data collected to form each attribute was sometimes stand-alone, or sometimes combined at my discretion, to present a balance between pragmatic application and attention to detail.

These data were explored and similar interactions grouped as a single attribute within each principle. All data relevant to a similar attribute were tallied. In developing attributes I had no preconceived ideas about the nature of the attributes that would emerge. Attributes are tallied for each protocol and the entire research framework is presented in Appendix A. (As well as presenting the guiding framework in a tabular form, appendix A also combines the results of the two study area applications, described in chapters 4 and 5. Because the table combines methods and all results it is important stand-alone information, and needs to be presented independently of any single chapter. It is thus presented as an appendix rather than in the body of the text).

Principles and attributes are described with reference to the research stage where they were most appropriate (planning, data gathering, interpreting results, and making recommendations). However the research stages, principles and attributes were neither isolated nor fixed in their sequence in the guiding framework. In reality, all components overlapped in time, frequently occurring concurrently or episodically throughout a substantial portion or the entire duration of the research process. Furthermore, many attributes of one principle are also attributes of another principle and thus in many cases are recorded and described more than once. For these reasons, the list is neither exhaustive nor necessarily replicable, but it does show the results of the research at a particular time and particular localities.
THE TREPANG PROJECT

The above hierarchical framework was applied to guide and conduct a participatory research project with members of Australian Aboriginal communities about trepang. Trepang (or bêche-de-mer) is the edible product marketed after sea cucumbers are collected, boiled, smoked and dried to make the body wall firm (Harriott 1984:3). This section provides background information relevant to trepang research.

In past centuries, members of certain Aboriginal communities of northern Australia were involved in the harvesting of trepang species to supply Macassan traders, and their involvement is part of oral tradition in those areas. That fishery is considered to be Australia’s first export industry (NTDPIF 1994:2).

In 1992 the Northern Territory Department of Primary Industry & Fisheries (NTDPIF) issued six licences to fishers to re-develop the trepang industry. No licences were issued to Aboriginal people. Some Aboriginal communities expressed an interest in resuming trepang harvesting from their waters for commercial purposes. (Although technically incorrect, the term ‘trepang’ is commonly used to refer to both the product, and the species collected). The ability to harvest trepang was thought to present an opportunity for income generation and likely to contribute to their economic independence.

Very little relevant biological information was available to guide the development of a sustainable use strategy (Kerr et al. 1993:780). The trepang fishery has a history of overexploitation elsewhere in the world, probably due to poor management resulting in a legacy of ‘boom and bust’ cycles (NTDPIF 1994:2). The Northern Territory fishery was therefore opened under temporary, conservative management arrangements. Before further licences could be issued a sustainable use strategy had to be developed, in accordance with ecologically sustainable development principles adopted by the Commonwealth and the states and territories.

International commercial demand for the trepang species occurring in Northern Territory waters, Holothuria (Metriatyla) scabra Jaeger (known as Sandfish) is high
(NTDPIF 1994:3). It is considered a delicacy in many Asian nations. Australia is believed to have held some of the largest stocks of \textit{H. scabra} (pictured in Fig 1 in Appendix B), although very little survey and ecological work has been conducted on the species.

A trepang ecology research program was carried out and attempted to be collaborative, based on the research framework developed. In a sense, the trepang research project is nested within the ethnographic process, and data relevant to objectives of the ecological research project were collected at the same time as the data for this research project, which analyses the process of the participation and collaboration during the research. The ecological research project and its results are described in full in Appendix B. The techniques for data collection in the trepang research project adhered to standard biophysical science schedules of experimental design, replication and population modelling.

Development and management of a trepang fishery require knowledge of the standing stock before harvesting; how it is distributed in habitats; changes in the population as a result of harvesting; and size of individuals available for harvesting. These data are frequently determined from resource surveys and regular censusing (Shelley 1985:145, Harriott 1984:3–4). On the basis of this information the question then needs to be considered of whether populations are sufficiently large to provide a sustainable harvest, and at what rate of collection individuals should be harvested.

To provide the missing information, a proposal to research trepang was submitted to Environment Australia (EA) by the Director of the Wildlife Research Unit of the Parks & Wildlife Commission of the Northern Territory (PWCNT). The research was to assist with the development of a sustainable use strategy for the trepang resource. That research was to occur on the Cobourg Peninsula in the Northern Territory, with support of staff and vehicles from the National Parks unit of PWCNT.

In the original submission a number of objectives were proposed:
• Objective 1: to determine the distribution and abundance of trepang within the study area and characterise favoured habitats;
• Objective 2: to simulate basic population dynamics for trepang (using appropriate fisheries models);
• Objective 3: to measure the effects of harvests on local trepang populations within designated study sites;
• Objective 4: to provide biological advice on the management of trepang resources in the Cobourg region and other northern Australian waters.

The original budget proposed that an unspecified proportion of the funds be made available to fund a scholarship for a postgraduate student to undertake the research (see chapter 4). I spoke with the Director about some Aboriginal peoples’ interest in trepang research at another locality, (Maningrida in the Northern Territory). After that I became the designated postgraduate student, and the budget was renegotiated so that the original scholarship money could be expended on research at Maningrida, which became the second study area.

Manta tows — where a researcher is trawled behind a boat on a board which has steering controls — were proposed as a survey technique in the original proposal submitted to EA. This technique was however discarded because of safety factors (visible presence of saltwater crocodiles *Crocodylus porosus*) and because of the underestimates that it had produced elsewhere (see Appendix B). For this reason the development of a new technique, that of underwater camera survey, was necessary. At a later stage, after the trepang research project was audited in the field by an officer from EA, its objectives were renegotiated in recognition of the substantial work that had gone into developing this new technique. At that stage I suggested to EA (Environment Australia) that some of the generic processes for participatory research should be documented, and the officer concerned indicated that many people within EA would consider documentation of such processes a highly desirable objective. However, during further renegotiations about including this as an objective, another EA officer remarked that it was not interested in such information. When I told him that I would collect the information anyway, he then
suggested that the objective be included in the contract so that EA could have access to the findings. The objectives were eventually renegotiated as follows:

- **Objective 1:** to develop, evaluate, document and apply a suitable method for determining the distribution and abundance of trepang within the study areas, and characterise favoured habitat;
- **Objective 2:** to apply remote sensing techniques to identify suitable trepang habitat and provide habitat maps for the study areas, and areas outside them for which there was relevant imagery;
- **Objective 3:** to collate knowledge from traditional owners on trepang distribution and abundance, and document the collaborative process and its implications for resource management in the study areas;
- **Objective 4:** to employ available log-book data from commercial harvesters to draw inferences about harvest dynamics;
- **Objective 5:** to provide recommendations on further research and/or activities for a management strategy to sustainably harvest trepang.

Objective 3 is expanded as the aim of the research described and analysed in this thesis.

**STUDY AREA DESCRIPTIONS**

As part of the planning stage, described in the next chapters, two study areas were selected. The areas surveyed for trepang were the intertidal and shallow subtidal waters around Maningrida, in coastal Arnhem Land, and around Gurig National Park on the Cobourg Peninsula (Fig 2 in Appendix B). Both Aboriginal communities at these locations expressed their interest in being involved in a collaborative ecological research program about trepang. For some time, members of the Bawinanga Aboriginal Corporation (BAC) at Maningrida had been keen to inventory the stocks around their coastline in order to increase their knowledge base and decision-making power in relation to this resource. Traditional owners on the Cobourg Peninsula had been approached by a trepang licensee with a proposal to
pay traditional owners a fee for collecting and supplying trepang, and wished to know whether this proposal represented a feasible and equitable venture.

Maningrida is a community located adjacent to the mouth of the Liverpool River, approximately 380 km east-northeast of Darwin on the central northern coast of the Northern Territory (Fig 2 in Appendix B). Under the Commonwealth *Aboriginal Land Rights (Northern Territory) Act 1976* Aboriginal land is considered extend to the low water mark, thereby including the intertidal zone.

Gurig National Park is about 220 km northeast of Darwin on the Cobourg Peninsula (Fig 2 in Appendix B), and has a land area of around 2207 km² (PWCNT 1998:1). Cobourg Marine Park is declared over sea adjacent to Gurig National Park, from low water mark to identified boundaries based on coordinate points, as shown in the plan (PWCNT 1998). The intertidal zone and the islands surrounding the park are considered to be part of Gurig National Park (Foster 1997:2).

**Participants, roles and social structures**

*Maningrida*

Maningrida was established in 1957 as a government ‘settlement’. By 1972 there were approximately 1100 Aboriginal people and more than 150 non-Aboriginal staff and families living in Maningrida. Following the return of some people to their traditional homelands in the 1970s, Maningrida population stands at around 800 people in the dry season and around 1200 in the wet season. Clan groups belong to some 11 language groups — Eastern Kunwinjku (Kuninjku and Kune dialects), Dalabon, Rembarrnga, Gun-nartpa/Burarra, Gurr-goni, Djinang/Wurlaki, Ndjèbbana, Nakkara, Ganalpingu, Gupapuyngu and Kunbarlang — in an area that extends from Marrkolidjban in Kuninjku country in the west of the region, to Berriba in Dangbon country in the south, and as far as Yinangarnduwa, or Cape Stewart, in the eastern section (Danaja & Carew 2000).

The dominant language group of the Maningrida and Liverpool River region is Ndjebbana (spoken by the Kunibidji). To the east, the Marro people speak Nakkara and to the west the Warlang speak Kunbarlang. Gurrgoni and some Kunwinjku
speakers represent inland groups. More distant groups with long-term residential association include Maung, Rembarrnga, Dangbon, Djinang, Burrara and Gun-narntpa as well as a smaller number of families from further east. By the second decade of settlement Burrara people had attained a fairly dominant position at Maningrida in terms of jobs and of political power within the council; however, from the early 1970s the Kunibidji people began to reassert their traditional authority over their country, on which Maningrida is situated.

A number of formal administrative agencies provide some structures for interaction and relationships between the various community members. The town of Maningrida acts as a central locale for several local council and other activities encouraged by the Maningrida Progress Association (MPA). The town and its facilities are also important in facilitating visits with family, and in providing health and education services.

BAC, comprised of both Aboriginal and non-Aboriginal staff, was established in the 1970s to service some 25 homeland centres (Crerar 1998:6). Community and homelands representatives determine matters of policy through meetings, where a consensus must be reached for decisions to be implemented. BAC also provides essential services, health and education facilities and training opportunities. Databases maintained by staff include information from language dictionaries, and about arts and crafts. There is some internet and desktop publishing. Registers of clans, sites and outstations are maintained by BAC members. The organisation also aims to develop sustainable enterprises and manages an arts centre and a research office to foster associated initiatives for economic development.

Since the early 1980s BAC has supported and assisted the implementation of a community ranger program (Davies 2000). The activities in the program expanded following the appointment of a coordinator in 1994. This program was developed by BAC, in conjunction with other agencies, to manage the 10 000 km² region serviced by the organisation. Its objectives are to facilitate land and sea management using knowledge and practices of both Aboriginal and non-Aboriginal resource management traditions. Aboriginal cultural traditions are maximised and used in preference to outside traditions where possible. The aim of the project is to maintain
land, law, culture and people through traditional knowledge and practices as well as non-traditional approaches. BAC and the Northern Land Council (NLC) co-sponsor a Caring for Country program that operates in the area and has some 12 trainees from various homelands.

The program has had varying membership, usually with a structure of senior community rangers and junior community rangers. The community rangers are nominated as representatives of the various clan groups and associated estates. Membership is solely male, although attempts were made to involve women in the program through both training and the creation of a female ranger coordinator positions (see chapter 4). Although these attempts did not in fact facilitate female involvement there are aspirations to encourage and increase female involvement in the program in the future.

Carter and Yibarbuk (1997:291) describe activities of the community rangers, which include surveying and mapping locations, habitats and population densities of several fauna species. The rangers are also involved in control and monitoring of invasive species such as *Mimosa pigra* and other pest plants, and of feral pigs and cats. Law enforcement and regulation, school and community education, rock art documentation and protection, cultural tourism, species harvesting (such as crocodile eggs) and road rehabilitation and revegetation are other activities conducted under the community ranger program. Within this program BAC aims to implement initiatives that will simultaneously provide commercial income and environmental sustainability, because of the need to secure funding for continuation of the program

*Cobourg*

Traditional ownership of the area known in English as the Cobourg Peninsula is shared by four Aboriginal clan groups: the Algalda, Ngainjdjarag, Madjunbalmi and Muran. In the past Wurrgu, Gurig and Iwaidja languages were spoken; however Iwaidja, the language of the Muran clan, is the main language spoken today, although some Gurig is spoken by older people.
Gurig National Park was established under the Northern Territory *Cobourg Peninsula Aboriginal Land and Sanctuary Act 1981*, as part of the outcome of a negotiated settlement of a land claim. Title of the land is vested in the Cobourg Peninsula Sanctuary Land Trust and the park operates under co-management arrangements through the Cobourg Peninsula Sanctuary Board. The Act was later amended to the Northern Territory *Cobourg Peninsula Aboriginal Land, Sanctuary and Marine Park Act 1981* and recognises the right of traditional owners to use and occupy the park. Cobourg Marine Park was declared under the *Territory Parks and Wildlife Conservation Act 1979* (Foster 1997:2) and is managed by the Northern Territory government; it is therefore not subject to Board control, nor is ownership vested in the Cobourg Land Trust.

The Cobourg Peninsula Sanctuary Board (later renamed the Cobourg Peninsula Sanctuary and Marine Park Board, hereafter called the Cobourg Board) was established to facilitate joint management of the park for conservation purposes and as a homeland for traditional owners. The Board is comprised of eight members, four of whom are traditional owners from each clan, nominated by the NLC, and beneficiaries of the Trust.

The NLC is the statutory representative body established in the early 1970s during the Federal Government’s Aboriginal Land Rights Commission (the Woodward Inquiry) as explained by the NLC (1998). Under the *Aboriginal Land Rights (Northern Territory) Act 1976*, the NLC represents Northern Territory Aboriginal people and their respective regions. The area represented covers an area north of a line drawn from the Barkly Tablelands in the east to the Victoria River in the west; but excludes the area represented by the Tiwi Land Council (covering Bathurst and Melville Islands) and the Anindilyakwa Land Council, (covering Groote Eylandt and Bickerton Island).

The Northern Land Council is comprised of 78 elected representatives from Aboriginal communities from whom are chosen a Chairman, a Deputy Chairman and an Executive. Specific functions of land councils are defined in the Act, and further responsibilities are set out in other legislation, in particular the *Aboriginal
Land Act 1980 (NT) and the Native Title Act 1993 (Commonwealth). First and foremost, land councils remain representative bodies promoting Aboriginal rights.

The other four members of the Cobourg Board are government representatives. In the event of a tied vote the Chair of the Board, who must be a traditional owner, has a casting as well as a deliberative vote. When a difference of opinion between PWCNT and the Board arises, the difference is resolved by a Board determination, the conflict resolution mechanism specified in the Cobourg Act (PWCNT 1998:2).

Although Aboriginal people have formal control over decision-making through this provision of a casting vote, Foster (1997:11) analysed co-management interactions and activities over a ten-year period and concluded that in reality, translating formal responsibilities for decision-making into the practice of Aboriginal control has been difficult. His analysis suggested that informal powers are vested in the government in different ways: through their control of the information and expertise presented at the Board for management decisions; through ownership and management by PWCNT (then the Conservation Commission of the Northern Territory) of the process of preparing the first Plan of Management; and through PWCNT control of the operating and capital works budget (Foster 1997:13–15). The Gurig Association was established as a body intended to present a united Aboriginal voice, realise Aboriginal aspirations, increase negotiating strength and provide a mechanism for resolving internal conflict and decision-making (between clans and without the presence of outside agencies including PWNCT); however, views expressed by this community-based organisation have been frequently opposed by PWCNT.

Among other functions, the Board prepares plans of management and determines rights of access to parts of the park by people who are not members of the landowning groups. The first Plan of Management established joint management arrangements between traditional owners and PWCNT. The second Plan of Management (passed by the Board but still in draft form until reviewed by relevant stakeholders) provides the framework for management and development in the park. Management plans are to be updated and reproduced every five years.
The vision of the traditional owners articulated in the plan is to exercise traditional rights to control and manage the use and occupation of the park. The vision of the PWCNT is stated to be that of managing the park to maximise biodiversity preservation, cooperative management, and sustaining the park’s values for intergenerational equity (PWCNT 1998:iii).

Plan of Management objectives include training and, where necessary, improving the numeracy and literacy skills of rangers to fulfil the training needs of all rangers in the park (PWCNT 1998:49, 52). Aboriginal people are employed as PWCNT rangers and undertake western-style work programs.

With respect to research and monitoring the Board approves details prior to field work, including the purpose and significance of the project, areas to be visited, procedures to be adopted, equipment to be used, likely impacts, and project duration. The Board specifies restrictions on movements and activities of research personnel. A report on research and results must be submitted on completion of the project and a progress report can be requested by the Board to update research activity.

Facilities in the park include single person’s quarters for visiting officers/PWCNT staff and traditional owners.

**Biophysical characteristics of study areas**

Billyard (1995) and Ferns (1994) derived a preliminary regional classification for north Australian coasts, based on biophysical and structural properties. The Arnhem–Wessel Region (including the Maningrida area) has the Goomadeer, Liverpool, Blyth, Goyder and Buckingham Rivers as drainage systems and a mesotidal range of 3 m west of Castlereagh Bay. Annual median rainfall in the area is 1000–1200 mm with a mean annual runoff of 250–500 mm. In contrast, the Cobourg Region is categorised as having no major drainage systems, with a mesotidal range of 3 m. Annual median rainfall is 1200–1400 mm with a mean annual runoff of 500–1000 mm.

The low-gradient Northern Australian Continental Shelf (NACS), less than 200 m in depth, reaches to the New Guinea coastline in the Arafura Sea region (Ferns
Wave energy on the northern coast is usually low except during storms and tropical cyclone activity. Energy is dissipated by the NACS because the 20 m isobath occurs more than 10 km from the shore. During heavy rains river discharge increases, causing massive debouchment of fine sediments, and altering estuarine and coastal salinity.

Sediments of the inner shelf and coastal margins are not well known around the Arafura Shelf section; however, it appears that little recent sedimentation has occurred in the vicinity of the study areas (Ferns 1994:4). Around river mouths where river sediments mix and coagulate with seawaste, and in areas where water turbulence and current velocities are reduced, extensive areas of fine-grained anoxic saline substrate, or mud, occur (Davis 1985:298). This mud may be an extension of the mangrove substrate, which is typically richer in organic matter; however, ecosystem processes vary from river to river, depending on tidal and flood cycles.

Offshore regions have sediments comprising mainly muds and sandy muds (Billyard 1995), with tertiary alluvial surficial sediments in the Cobourg Region and quaternary sand and silt in the Arnhem–Wessel region. Saline muds beneath mangroves may extend for up to 13 km in Castlereagh Bay (east of Maningrida) at a 0.1 m low tide (Davis 1985:297).

Sandy beaches tend to occur in areas free from the deposition of mud (Davis 1985:297), although these are infrequent and narrow, typical of humid coastlines (Jennings 1965 in Ferns 1994:14). In these areas, sands are generally well sorted into ridges and troughs running parallel to the shoreline, and persist through tidal cycles because of the low wave energy. Dunes are typically chenier ridges.

Where the outflow from creeks combines with backflow from currents passing islands, muddy foreshores are found to the landward side of the islands while sandy beaches occur on the more exposed side. Islands further seaward are generally freer of estuarine deposition. Some reefs in the area hold the White Mangrove *Avicenna marina*; however, seaward islands and reefs are more commonly of coral nature (Davis 1985:298). Occasionally cliffs with rocky foreshores occur along the northern Australian coastline.
Although the Arafura Sea is an extension of the Indian Ocean, the input of Pacific-derived waters into northern Australia suggests that the region is essentially a convergence zone and should be referred to as Indo-Pacific (Ferns 1994:5). During the dry season (March to August) the dominance of easterly prevailing winds drives currents predominantly from east to west; however, during the North-West Monsoon currents flow from west to east (Ferns 1994:5).

Australian marine waters are amongst the most nutrient-poor in the world, receiving little input from sub-Antarctic waters, and being obscured from wind-induced upwellings of the equatorial Pacific and Atlantic Oceans by land masses and confined shallow seas (Ferns 1994:9). Coastal processes such as runoff and seasonality probably determine nutrient concentrations in the coastal zone. Nutrient concentrations can also rise rapidly around areas of high terrestrial runoff (Ferns 1994:14).

DEFINITIONS AND CONVENTIONS

In the remaining chapters of the thesis the following terminology is used:

Definitions used in the narratives

_Cobourg/Cobourg Peninsula:_ the study area including the intertidal and subtidal waters of Cobourg Marine Park as described in Appendix B, as well as the land base and land access through Gurig National Park also used during the conduct of both this research and the contractual research.

_Cobourg Board:_ members of the Cobourg Peninsula Sanctuary and Marine Park Board.

_Collaborators:_ a generic term used to denote all/any people/person from communities who worked with me during some or all of the contractual research. At first two young women were nominated to work by other community rangers on the contractual research. Later, acting on the advice of one key person from BAC, I approached a range of traditional owners at Maningrida about their interest in
working with me, largely because of difficulties experienced by the nominated community rangers in participating in the research.

*Community members:* Aboriginal people other than outside researchers, living permanently or temporarily within or adjacent to the study area and with interests in the contractual research.

*Community rangers:* Aboriginal people nominated to work in a position as ‘community ranger’ on programs directed to managing natural resources. In this research, the term refers generically to any person participating in the community ranger program, regardless of age, sex or position in that structure. Two young females were nominated by senior community members to initially be collaborators on the contractual trepang research. In this research, they are referred to as the ‘nominated community rangers’.

*Contractual research:* the research developed and conducted by a PWCNT officer to investigate trepang ecology.

*Country:* summarised from definitions by Rose (1996b in Suchet 1999:137) as an Aboriginal English term that is a multidimensional concept of the world consisting of people, animals, plants, Dreamings, underground, soils, waters, air and other entities, all of which have specific relationships in and through time and where life is given, received, lived in, and with.

*Djarribang gang:* the name given by one traditional owner at Maningrida to instances where she and her family accompanied me to her country to conduct work for the contractual research.

*Employment grant:* the Commonwealth DEETYA (Department of Employment, Education, Training and Youth Affairs) wages and training grant that was procured to employ three traditional owners at Cobourg Peninsula as collaborators on the contractual trepang research.
**External stakeholders:** institutions, including government agencies and universities, with an interest in the research. The only specific reference to the term is that of PWCNT.

**Final meeting/feedback results:** the last meeting at Maningrida where I verbally summarised to community rangers the findings of the contractual research and the report I had written about that research.

**First Cobourg Board meeting:** the first Board meeting during the research process (not the first meeting of the Cobourg Board). At this meeting I explained the contractual research and determined whether traditional owners wished to be involved.

**On country:** to be in a particular place where country is lived.

**Original objectives:** the original objectives written by the PWCNT officer in the contractual research submission to Environment Australia, as described above.

**Participation/participatory research:** a generic term to refer to all types of participatory research, as described in chapter 2.

**Partner community:** the members of a town or area where some of the local community members worked as collaborators on the contractual research project.

**Plan of Management:** either the first or second (draft) Gurig National Park Plan of Management as indicated in the text.

**Project coordinator:** the traditional owner employed at Cobourg through the DEETYA wages and training grant to help run the trepang project at that locality.

**PWCNT supervisor:** the author of the contractual research proposal submitted to Environment Australia. He was nominated in that proposal as a supervisor for the project; however, after subcontracting arrangements were finalised with Northern Territory University he suggested that I take responsibility for managing the project.
*Ranger coordinator*: the non-Aboriginal person employed at Maningrida to coordinate the community ranger program. He was employed during the latter stages of this research process and as such has a minor role in this particular research.

*Renegotiated objectives*: the objectives in the contractual research renegotiated by representatives from EA, PWCNT and NTU, as described above.

*Research protocols*: the guidelines produced by institutions such as the Centre for Aboriginal and Torres Strait Islander Participation, Research and Development (1995), CYLC (1995), the Batchelor College Research Program (1995) and NARU (undated) for working cross-culturally in research programs with Aboriginal people.

*Second Cobourg Board meeting*: the second Board meeting in this research process, when I explained further aspects of the trepang research and the DEETYA employment grant and received full Board endorsement for the work.

*This research*: the research conducted for this thesis; that is, the implementation and analysis of a participatory ecological research project (the contractual research) with Aboriginal people.

*Trepang team*: the name given by one traditional owner at Cobourg to me and the three traditional owners employed to work around the study area at Cobourg on the contractual research.

**Conventions used in presenting concepts and data:**

double quotation marks (“…..”) are used to identify a verbatim statement.

single quotation marks (‘…..’) are used to name a concept or add emphasis to a word or phrase.
CHAPTER 4: RESEARCH AT MANINGRIDA

This chapter discusses the results of applying the guiding framework described in chapter 3 and subsequently used in the Maningrida study. The chapter is presented in a narrative form, in terms of the component stages, principles and attributes specified in the framework. Results that predominated either quantitatively or qualitatively are expanded upon more fully than other results.

STAGE 1: PLANNING THE RESEARCH

**Principle 1: critically examine collaborative research recommendations**

During the period April 1995–July 1995, I became familiar with protocols for working with Aboriginal people. I reviewed the literature and institutional guidelines, and interviewed researchers by telephone to extract information that would guide this research. I also read international and Australian literature relating to the aspirations of indigenous people. I also read more general literature about community-based planning and management.

During this phase of research no study area had been selected, and the recommendations I examined were generally relevant to collaborative research with any Aboriginal community. For that reason this part of the analysis (described in this chapter and chapter five) is not distinguished by study area (i.e. Maningrida and Cobourg).

Critically examining collaborative research recommendations is not a principle explicitly identified in the literature and guidelines, or by the researchers contacted, but is a necessary background for a researcher inexperienced in working with Aboriginal people and wanting to pursue such work. The information about collaborative recommendations gathered during this phase was analysed, enabling me to summarise principles (below) describing various stages of the guiding framework. Principles developed during this initial part of the planning stage were subsequently used as components of the guiding framework during the research process. In other words, these principles took form after I became familiar with the available recommendations on collaborative research. Principles are presented in
the chronological order in which I envisaged they would probably occur during the research process. The guiding framework and results are shown in Appendix A.

**Principles identified as important for planning collaborative research**

(a) **Advance community aspirations**

This principle was derived from recommendations to ensure that there is local or community direction of the research (2 institutions and 3 literature sources), to allow local community members to determine the conduct of research (1 institution), to assess its progress (1 institution), and to ensure that decisions on the research design are made by local community members (1 institution).

(b) **Conduct negotiations**

This principle was derived from recommendations to negotiate joint objectives or joint research proposals including budgets, community resources, and timing of research (2 institutions, 3 literature sources and 1 telephone interview), and to ensure that the researcher explains his/her understanding of the aims and procedures (3 institutions and 2 literature sources).

(c) **Establish personal relationships**

Although only one literature source stressed the importance of establishing personal relationships with community members, that recommendation was strongly emphasised. This principle is deemed to be important during both planning and data collection (see below), especially if different people are involved with data collection. I thought that monitoring and management would be more likely to involve people already known, so that less time would be necessary for establishing relationships during the later research stages.

(d) **Allow flexibility and sufficient time for a collaborative style**

This principle was deemed to be important at all stages of the research project. It was derived from recommendations to ensure flexibility/accept changes in the research plan (3 institutions and 2 literature sources), to allow time for negotiations and/or other activities to occur (3 literature sources), and to ensure that collaboration
is equitable by not imposing an outsider’s agenda/culture and by sharing power (2 institutions, 2 literature sources and 1 telephone interview).

Since this principle is important at all stages of the research is not analysed separately for each stage. Instead it is kept in mind as an overriding key attribute of the research process and referred to in such terms, where appropriate.

Although the above principles are important at all stages of the research they are deemed to be most important when planning and gathering data. When making interpretations and recommendations about the research, the attributes of ensuring flexibility/accepting changes to the research plan were not as relevant, because at this point the project has been carried out, only thought processes about the research remaining. Therefore the tally of data sources recommending that flexibility and time be allowed for a collaborative style is amended from 13 to 8 in these stages (see Appendix A), deleting the recommendations to ensure flexibility/accept changes in the research plan (3 institutions and 2 literature sources).

*Principles identified as important for collaboration when gathering data*

(a) *Establish personal relationships*  
One literature source stressed the importance of establishing personal relationships with community members (see above).

(b) *Follow culturally appropriate procedures*  
Although this principle is important during all research stages, I inferred that it would be most relevant to the data collection stage, because it was during that stage that I would spend most time in the community. The principle was derived from recommendations to gain access permission from traditional owners (2 institutions and 1 literature source), to obtain consent for audio/video equipment and other materials or equipment to be used (1 institution), and to be aware of cultural differences (2 institutions and 1 literature source).
(c) Engage local people in the work
This principle was derived from recommendations to ensure that community members participate in the research (2 institutions and 4 literature sources), to make adequate payment for participation (3 institutions and 1 literature source), and to include training and demonstration as part of the work (2 institutions and 1 literature source).

(d) Interview appropriate people for relevant information
This principle was derived from recommendations to promote the validity of traditional ecological knowledge (TEK) in the research, including an emphasis on conveying the importance of this information to younger people in the community (2 literature sources), and to determine appropriate people of both sexes when gathering information (1 institution and 1 literature source). These suggestions imply that the owners of information should be sought and interviewed if possible.

(e) Delegate responsibilities
This principle was derived from recommendations to learn language or use interpreters (2 literature sources and 3 telephone contacts). I reasoned that since interpreters would need to take responsibility for questions and answers there might also be other opportunities and activities for which local people could take responsibility.

(f) Communicate with key persons
This principle was derived from recommendations to have Aboriginal community members as mentors/advisors (1 institution).

Principles identified as important for interpreting data and results

(a) Ask for community members’ interpretations
This principle was derived from recommendations from the data sources to include local interpretations (1 literature source), and to ensure that appropriate people of both sexes convey information (1 institution and 1 literature source).
(b) Explain your own interpretations
This principle was derived from recommendations to ensure feedback of results to the community (2 institutions and 1 telephone contact), and to explain how results will be used (2 institutions).

(c) Synthesise results sensitively
This principle was derived from recommendations to ensure that there is sensitivity to data collected, including restrictions on the dissemination of commercial and/or cultural information and ownership and co-authorship of data (3 institutions and 4 literature sources). I inferred that such restrictions would probably arise during the collation/synthesis of results. I also thought that results might need to be synthesised in order to present them in terms of consensus or of differing positions.

Principles identified as important for making recommendations from results

(a) Incorporate ideas from all sources
This principle was derived from recommendations that western researchers recognise traditional strategies (2 literature sources), and acknowledge the validity and significance of TEK in the research, including the importance of conveying this information to younger people in the community (2 literature sources).

(b) Ensure community approval of material for publication
This principle was derived from recommendations to ensure that a draft copy of the final report is sent to the community, before publication, for its approval, veto or amendment (4 institutions and 1 literature source).

(c) Ensure ongoing monitoring
This principle was derived from recommendations to select appropriate people of both sexes to convey information (1 institution and 1 literature source). It implied that there might also be a need to identify appropriate people to ensure ongoing monitoring after project completion.
(d) Ensure ongoing management

This principle was derived from recommendations to recognise traditional strategies (2 literature sources), and to select appropriate people of both sexes to convey information (1 institution and 1 literature source), implying that there are people in the community expected to take responsibility for management. Identifying traditional strategies and appropriate owners of that knowledge would help manage the resource beyond the life of the project.

Principle 2: approach potential partner communities

This principle was not explicit in any of the sources from which I sought guidance, but, was a necessary step if the entire research process was to be participatory. Having developed the framework, it was necessary to find a collaborating partner. The principles derived from the data sources described above would then be applied when working with the partner community.

As it happened, two communities eventually became partners in the collaborative research, but only the approach to one partner community, Maningrida, is described below. The conduct of subsequent principles at Maningrida constitutes the remainder of this chapter. The research process at the second partner community is described in chapter 5.

During telephone interviews that I conducted (described above), I was told that I should wait for an introduction to a potential partner community. However, the people I interviewed were unable to introduce me to a specific community and consequently I took the initiatives described below to locate one.

Initial telephone approach to communities via representative member of community organisation

Individuals whom I interviewed via telephone suggested six possible partner collaborating communities: BAC at Maningrida, Ngukurr Community Council in Ngukurr, Jawoyn Association at Katherine, Dhimurru Land Management Aboriginal Corporation at Nhulunbuy, Gurungu Council at Elliott, and Anangu Pitjantjatjara Land Management in central Australia.
In August 1995 I telephoned a representative of each organisation. I introduced myself and explained that I was interested in collaborative ecological research. I then explained my concepts of collaborative ecological research, particularly that we would work together. I also indicated broad research topics such as studying species, taxa or habitats. I then asked if the community in question was interested in being involved in a collaborative ecological research project. Representatives of four communities (Maningrida, Ngukurr, Jawoyn and Dhimurru) requested a letter from me to formalise the approach.

**Letter sent to communities to formalise approach**

After the telephone conversations, a letter was drafted (outlined below), and sent to each of the four communities. A copy is included in Appendix C.

In the letter I introduced myself, described my qualifications, and sought to learn the community’s level of interest by asking whether they would be interested in collaborative ecological research and if it would be useful. I pointed out how I thought collaborative ecological research could be of use: using both western and traditional knowledge systems; understanding fauna and land relationships; guiding activities for the future; benefiting community; benefiting land councils; conserving the resource base for the future; and improving knowledge of species, environmental impacts and/or management methods.

I was careful to indicate that the research ideas were still unformulated by offering a range of ideas for research including habitat requirements, interdependencies between species, changes in species abundance/distribution, Aboriginal land management practices and impacts on species, harvesting levels of species, and future predictions; by asking for ideas from community members; and by giving an assurance that I could adapt a research process to incorporate their suggestions.

I also mentioned specific principles that I would endeavour to follow throughout the research in order to ensure collaboration. These included project development with local community members and community rangers; feedback of results; development of future management strategies with local community members; payment for Aboriginal assistants; co-authorship of research; and alignment with
future plans of the community, such as biological surveys or use of remote sensing/GIS (Geographic Information System).

The principles were intended only to provide examples of interactions, since my intent was to be open to the form of participation that might develop. Key issues in the letter were:

- enquiring whether community members were interested in collaborative research, by describing concepts and benefits;
- ensuring that community representatives suggested their research priorities.

Asking for direction on the research topic appeared to be a way of initiating community involvement in planning the research.

*Receipt of response from communities*
One community ranger (from BAC) telephoned and offered me “a job”. Another member of BAC mentioned that their desire for me to work there was in part because I had “said all the right things”; yet another indicated it was good to see someone coming in and wanting to work with the people. A representative of one community (Jawoyn) was interested in collaboration, but his ideas were unformulated. A third representative (from Ngukurr) wanted to wait until he was advised as to the success of a funding application that would assist the research. A fourth representative (from Dhimurru) was interested in the concept but felt that the community was already overburdened with research activities.

*Participation in meetings to discuss potential research opportunity*
Representatives from BAC and Ngukurr asked to meet me to exchange ideas. At both meetings the community representative requested that I present my ideas, then presented some of his own thoughts or those of other community members.

The meeting with the BAC community ranger occurred in September 1995, while we were both attending a conference in Darwin. He said BAC could help with vehicles, boats, and other logistical requirements. After that meeting, the ranger
introduced me to other members of BAC attending the conference. One of the community members mentioned that the community was interested in research on trepang, and suggested that I explore that topic. He also mentioned that he was aware of a funding submission to support trepang research at another locality in the Northern Territory, and introduced me to the PWCNT officer who had prepared that submission.

Subsequently I spoke with the PWCNT officer, who told me that he had submitted a funding proposal to EA for trepang research at Cobourg Peninsula. He told me that the funding submission had provision for a Ph.D. candidate’s scholarship in the budget. I told him I was already supported by an Australian Postgraduate Award Scholarship and asked if he felt that the money set aside for a scholarship in the proposal could be renegotiated for research at Maningrida. He felt that this would be possible as it would generate more research results.

I later secured an assurance from EA that I could use money in the grant originally intended for a student scholarship to extend the scope of the research to Maningrida as well as the Cobourg Peninsula. The relevant parties (Environment Australia known as EA, and the Cobourg Board) agreed to this request, as the original funds available for research at Cobourg would not be affected.

The meeting with the representative from Ngukurr, also in September 1995, occurred at Batchelor College: he had invited me to have lunch there and meet some fellow students. After we both discussed our ideas (see above) he mentioned that he had recently applied for funds for a five-year community development program. He was uncertain, but hopeful, about receiving funds to assist that work. I told him I had been offered the opportunity at Maningrida and was keen to start as soon as possible. He invited me to visit his community and some of the places we had discussed (such as the wetlands near his home), regardless of whether I eventually undertook collaborative research with that community.

**Collaborative research agreed with partner community (including research topic)**

Although representatives from both communities expressed a firm interest in the project, it appeared that the research would be easier and more timely at Maningrida,
where a community ranger program was in place and BAC could provide vehicles, boats and other assistance as necessary. Maningrida representatives also had a firm research topic in place. The Ngukurr representative appeared to prefer to wait for news about possible funding and was unsure how long that would be. Time was an important consideration to me as some months of my Ph.D. candidature had already passed. I felt that the resources and infrastructure present at Maningrida would contribute critically to the feasibility of a collaborative project. I explained this to the Ngukurr representative and he indicated that he understood my decision.

I read as much as possible in the trepang literature; however I also telephoned the BAC representative to say that I had had no experience with marine invertebrates but would be prepared to research trepang if that was the community’s research priority and they wished to collaborate. The representative confirmed that trepang was their research priority and that BAC wished to collaborate with me on such a project.

**Principle 3: advance community aspirations**

Understanding community aspirations is important if outside researchers wish to avoid imposing a predetermined research agenda. While the research topic had already been decided, I felt it important to further understand community aspirations. I thought such understanding would be helpful in implementing the project and collaborating effectively. I also felt that it might be practically possible to incorporate community aspirations when designing the research timetable and activities. In this way tangible benefits from the research could become short-term incentives for partner communities to maintain their level of involvement in the research project.

Working toward understanding and incorporating community aspirations in the research process occurred over an extended period, some of which was concurrent with negotiating the research logistics (see Principle 4 below). For example, community aspirations were discussed at some of the meetings I initiated to negotiate the conduct of the project.
Community aspirations noted informally

During the period September 1995–May 1996 and on one occasion in June 1996 and one in June 1997 community aspirations were mentioned or discussed informally. Both generic and specific aspirations were mentioned. Generic aspirations related to a desire for greater female involvement in resource management, for local community involvement in research, for local employment and formalised training, and to “work together” (i.e. engage in collaborative research). Although such aspirations are mentioned generally in the literature, people at Maningrida added that they preferred training to occur in Maningrida rather than in Darwin. Specific aspirations mentioned were a desire to have a GIS at Maningrida, that people engage in fishing initiatives, and that rangers conduct resource surveys.

All the aspirations that I recorded were mentioned prior to the data gathering stage, except that during the data gathering stage one person mentioned her wish to be involved in GIS activity and another stressed that formalised training occur in Maningrida. Those comments reinforced comments made earlier in the research process.

On the final field trip to present research results I said it was unlikely that NTDPIF would issue more trepang licences. The new ranger coordinator said that on the basis of the research findings the community was now interested in working on trepang aquaculture (detailed below), which appeared to be a new aspiration stemming from the research.

After this last field trip I was telephoned by another BAC representative and offered a position of female ranger coordinator at Maningrida. The issues of trepang aquaculture and a female ranger coordinator were subjects that I had raised at various times during the research process, so it was apparent that appropriate ideas from outsiders can be incorporated into community aspirations.

Participation in meetings to discuss community aspirations

During the period January 1996–December 1996 I was frequently invited to attend or organise meetings about one or more of the community’s aspirations. I was called
“ranger” or appeared to have a marine researcher role in the eyes of people in the community, and my attendance at some meetings appeared to be related to this role. I was invited to meetings not directly related to the trepang research but to marine or other research issues (e.g. establishing a ranger research station, the North West Arnhem Marine Development Corporation, a joint crabbing venture, and an open day for institutional representatives).

Some meetings were related to trepang research; of those, most were about personnel and organising a training program for research assistants. This was because one of the aspirations mentioned and negotiated was that formal training for collaborators would be incorporated into the research program so that collaborators could gain recognition of qualifications from a western scientific standpoint.

I was involved in three other meetings — one with NTDPIF officers to discuss the potential for obtaining a special trepang licence. On two occasions I introduced other potential collaborating researchers to members of the community. One was proposed as a trainer for an on site Coxswain’s Course as part of the training program negotiated in this research, and the other was a potential Ph.D. candidate with a collaborative GIS research proposal.

As a result of my desire to work toward community aspirations, I invested time in attending all meetings to which I was invited because key persons from the community told me they thought I could learn about the people with whom I was working, and their culture. In addition I felt that attending those meetings would help demonstrate my commitment to the community and thus to establish good relationships with community members.

Participation in other activities related to community aspirations

I participated in activities other than the above meetings throughout the life of the research because I thought that my participation would demonstrate commitment to the community and help to build relationships with local people.

Again, I was invited to activities related to my role as ranger or marine research scientist. For example, I was invited to inspect the boat that BAC wished to
purchase for trepang research and for possible future fishing initiatives. I was also
invited to attend a conference to raise awareness about the community’s efforts and
interests in the research, and my advice was sought about a proposal for a grant for
an Aboriginal business initiative. I was asked to help find another Ph.D. student
who could take on a similar role to mine in undertaking a collaborative ecological
research program with the rangers. I was also asked to seek reference books to place
in the intended library at the research station, to obtain quotes for a dive course so
that rangers could receive accredited training, and to inspect the crocodile egg
incubator where the rangers had started incubating eggs they had harvested to sell as
hatchlings. Sometimes these requests appeared to be in the nature of a directive,
especially those from the senior community ranger.

Principle 4: conduct negotiations
Although this principle was initially related to negotiating the logistics of carrying
out the research, negotiations about changes to the research were also necessary.
This reflects the fact that an overriding key attribute is to allow flexibility in the
research process.

As mentioned above, some of the interactions that occurred while logistics were
being negotiated were concurrent with activities that focused on community
aspirations, or other phases in the research.

Regarding research direction and logistics
During the period November 1995–May 1996 two formal meetings were held. At
the first I was asked to explain the research to three senior community rangers, other
non-Aboriginal BAC representatives and one NLC officer. I explained how I
thought the research could be conducted. My descriptions of the process included
counting trepang in transects marked on the beach and during manta tows through
the water. One ranger then asked my requirements and I suggested a boat, a radio
for safety, and someone to accompany me and participate in the counting. The three
community rangers agreed to the research and my equipment requests, and discussed
with another BAC representative the possibility of using the HF radio belonging to
the school.
At the second meeting I proposed a research schedule, and further explained methods that could be used. By that stage a supervisor at NTDPIF had advised me not to use manta tows for safety reasons; and instead I proposed an underwater video camera. I also said there would be payment for people collaborating in the research. An NLC wetlands officer present at this meeting suggested that the research funds might not be sufficient for this, and offered to seek funding from the Commonwealth Employment Program for Aboriginal Natural & Cultural Resource Management (CEPANCRM) for collaborators. The rangers discussed the matter and then advised me that two young married female rangers would collaborate with me on the work and I was not present at their discussions about choice of collaborators. One senior ranger then requested a training component to provide formal qualifications (see previous section).

Subsequently I held talks with lecturers at the NTU Faculty of Aboriginal and Torres Strait Islander Studies, who eventually conducted a certificate course in resource management at Maningrida, continuing the NTU institutional linkages to the community. I was also later advised by that NLC officer that he had successfully procured CEPANCRM funding for collaborators.

Changes in research direction
Most negotiations during the research process were related to changes of the intended research direction and occurred frequently during data gathering, that is in June 1996, between May and August 1997, in November 1997 and in November 1998. Although many changes in direction occurred during the data gathering stage, in reality, the changes involved re-planning components of the research. For this reason they are included under the planning stage of the research framework. In addition, they are included at this point in the narrative because in the second study area (Cobourg), most changes in research direction occurred during the planning stage. In this way the flexibility in the research direction can be compared directly between the two study areas (see chapter 6).

Most of the changes to the research direction were related to personnel changes. I requested changes to personnel because collaborators nominated by the rangers were rarely available for various reasons (such as being prone to seasickness, or required
to look after their children). The senior ranger agreed to my suggestion that I might seek the collaboration of traditional owners (i.e. the senior men or women owning the estates where the surveys were to be conducted). He suggested that when the nominated collaborators were available, I might be accompanied by both traditional owners and nominated collaborators. On one occasion when it was urgent that data about trepang at a certain location be obtained and none of the identified collaborators were available, I asked the senior community ranger about the possibility of inviting a non-Aboriginal person to accompany me. He said there was no problem with my working with non-Aboriginal community members.

Sometimes senior community rangers were not available because of other work commitments and I was unable to seek their guidance about potential collaborators. I was, however, helped by an older woman who worked in the office at BAC. Although not a ranger, she knew appropriate traditional owners whom I should approach to visit country or to ask about their interest in accompanying me.

Sometimes changes in the research plans were related to the logistics of the field schedule, such as bad weather or changes to the research schedule at the other study area (Cobourg).

Other changes in the research direction that required negotiation involved financial arrangements. Thus when CEPANCRM funding was exhausted, I informed collaborators that I could no longer pay them. One collaborator replied that she would be prepared to volunteer, and her partner then did likewise. I added that sufficient time for hunting and fishing would occur during the excursions.

A significant change in research direction was initiated when I asked the senior community ranger if there would be any objection to amending the research objectives to include an analysis of collaborative interactions between outside researchers and Aboriginal people working on the project. He immediately said permission would be granted and signed an ethics clearance form on behalf of the community.
Principle 5: establish personal relationships

Formal meetings related to research
Between September 1995–May 1996 some relationships were established during the planning stage. They began at formal meetings where I endeavoured to talk informally with traditional owners. These relationships were built on, and new ones established, during the data gathering stage (see stage 2). Most of these relationships were informal in the sense that I was not living in the community at that stage and my contact with community members was irregular, occurring only at these formal meetings.

STAGE 2: DATA GATHERING

Data gathering about trepang occurred during June 1996, April–August 1997, November 1997, and November 1998 on 19 occasions (13 with traditional owners, 6 with nominated collaborators). Data gathering trips required a journey in a boat or vehicle to the sampling area. In addition, there were 10 occasions when we recorded TEK during unstructured interviews in Maningrida.

In July 1996 and during April and May 1997 I worked with both the nominated collaborators, and on four occasions with non-Aboriginal people from BAC. Most of that time was devoted to underwater camera trials. It was also a time when I was less sure of appropriate behaviour in the community than I was on subsequent occasions.

From June to August 1997, in November 1997 and in November 1998 I worked with traditional owners. On one of these occasions I worked with non-Aboriginal BAC staff because no Aboriginal people were available and I required some extra data before returning to Darwin.

Detailed observations were not recorded during trips with non-Aboriginal community-based people, although interactions with non-Aboriginal people are
noted in principle 6 (see below) because at the beginning these people were key contacts and their guidance in some matters was appropriate and useful.

**Principle 1: establish personal relationships (continues)**

Relationship-building during the data gathering stage at Maningrida eventuated in a number of differing contexts throughout the data gathering stage. I established relationships with people engaged in the trepang research as well as with other community members.

*Formal meetings unrelated to research*

During data gathering I also made efforts to strengthen my involvement with the community by attending meetings that were outside the scope of the trepang research. Two meetings occurred while I was temporarily resident in the community and the other eleven were invitations from the community while I was in Darwin. Because of my desire to establish and build relationships I expended finances and time to attend the meetings, believing that the expense was justified.

These meetings were additional to the planning meetings held with community rangers (described in stage 1 above), and occurred early in the data gathering process, presenting the opportunity to establish relationships with other traditional owners, particularly those who were not directly involved in the trepang research project. At each of the meetings I talked informally with those people present.

*During unplanned encounters and informal conversations*

Interaction in this category relates to unplanned encounters that were not directly related to or focused on research activities, but rather occurred because of my presence in the community. Most interactions were brief conversations; however, brief conversations were important because they reinforced a previous meeting or (in one case) presented an opportunity to meet someone and provide a basis for future interaction. This was important because some of the people I met informally became key people whom I subsequently approached for suggestions or guidance about other matters. Without such relationships collaboration in research would have been far more difficult.
Many of these relationships with community members were established through conversations that did not pertain to trepang research. Although I appeared to be perceived as occupying a role as ranger, the conversations were usually about topics such as family, living arrangements and everyday happenings. Conversations frequently occurred at the BAC office, which people used as an informal meeting place.

Conversations that I categorise as ‘in passing’ were with people I had met previously at the office or through trepang research, and generally occurred when I passed them while walking along the road. They tended to be greetings and brief chats, although occasionally they included longer conversations about trepang. On the last trip to discuss the research results (during the stage of interpreting results) I continued to have conversations ‘in passing’ with members of the community.

Sometimes I engaged in conversation because people were seeking another resident of the house where I stayed. These conversations occurred with people I had met previously. I used these opportunities to strengthen a relationship by further conversation (e.g. about trepang, family, or asking how to say words in the language of the person in question).

*During involvement in everyday activities*

I was sometimes asked to become involved with activities occurring in the community but not related to the trepang survey. These interactions again helped to strengthen relationships with community members and define my role in the community.

Many activities during which I established relationships with community members, particularly marine activities, appeared to stem from my role as ranger. They provided a means to meet new people or to further develop a relationship with someone I had already met. For example, I was asked to accompany another BAC member in a boat to pick up children from the school camp. Other examples of a ranger/researcher activity unrelated to marine or trepang research include being asked by a community member about the location of crocodile skins that the rangers had obtained recently from their harvesting trip. In this category of interaction I also
include being asked to introduce other potential research collaborators to the community.

I was also frequently asked to transport people, usually as a result of being at the office. These interactions involved using a car belonging to another BAC member for three airport trips to collect people I knew, and another occasion when I had access to a car temporarily. These presented opportunities for conversations. I was once stranded at the airport and asked people I did not know for a lift; this was an opportunity for conversation and initiating at least an informal relationship. On another occasion I was picked up by Maningrida Progress Association (MPA) workers I did not know while I was walking along the road. During my last visit to feedback results of the research, I talked informally with people; while sharing a lift in a vehicle from the ranger station to Maningrida, I spoke with the young ranger who was driving.

Collaborators came to my house at Maningrida or telephoned to ask me for favours (e.g. to see the doctor for them, to borrow fishing nets, or to approach a senior BAC member about a money advance so they could return home). I was also bestowed with favours (e.g. was invited to go to the dancing and told that I would be collected by someone).

*During trepang data gathering*

This category relates to relationships that were established while recording data about trepang. Specific instances of ‘counting’ trepang or interviewing somebody about trepang are only referred to here, and are detailed later in this chapter.

Gathering data about trepang was a major aspect of my role and I felt it was important to develop a good working relationship with collaborators during trepang surveys and related activities. It would also help me to understand, and be involved in, community members’ expectations of ‘collaborative work’.

The most frequent means of establishing relationships during this stage was through visits to people in their home. These visits were efforts to maintain the visibility of my presence in the community and to ensure smooth arrangements for a trepang
survey trip. The most common reason for a visit was to enquire whether the person I was visiting, usually someone I did not know, was interested in working with me. I explained my role and the research project, then asked if the person was interested in coming with me. The people I visited sometimes knew about the trepang boat and wanted to go out on it, sometimes to fish or to visit their country.

Sometimes I visited people I knew after I had been away from Maningrida for some time; as this enabled me to learn of important events that were occurring in the community (such as funerals).

Sometimes I visited to enquire about whether someone who had participated in the research had returned from Darwin, and once I visited a nominated collaborator who was frequently seasick (which helped to establish her future involvement in the work).

During field work people tried to teach me their language without any prompting from me, although I demonstrated my eagerness to learn. On one occasion I unconsciously said a word in Burrara, one of the dominant languages, and was surprised when the person accompanying me told me the word in his language, Nakkara, and told me to say it that way. We were on his country at that stage. I had initially approached a linguist about learning some language so that I could converse more easily with local people, and had included this activity in my research proposal, but the funding body had deadlines and objectives to be met so that time was a severe constraint on language learning.

Food gathering (fishing/hunting etc.) occurred on every survey trip. These activities are considered more fully later in this chapter. Opportunities to build relationships were a major component of the food gathering on only five occasions. On those occasions I was invited to sit down with collaborators during a survey trip and to have a meal. I thus learned that this is a congenial means to develop conversation and to gain understandings about the community and people involved. I also learned about assumptions that some non-Aboriginal people make about Aboriginal people, because a traditional owner told me of some cases — for example being thought by non-Aboriginal people to be intoxicated when sitting and talking in a family group.
on a beach in Darwin. People showed me the food they had collected to make the meal, explained words in their language, explained kinship relationships they had with other community members, and talked about their desire to do things “our way”.

On twelve occasions a formal TEK survey was conducted (analysed later in this chapter). When the conversation was conducted in English it was a good way of meeting people or reinforcing my presence in the community. I recorded two examples of establishing relationships during the TEK survey: during one interview an old man told me he had seen my face “in that upstairs house” and asked if he could come over for coffee. Another old man just wanted to chat about everyday happenings in the community as well as trepang.

On one occasion I was visited by a collaborator at my house, a man who brought his son and asked if they could watch the videotape of the seafloor that we had filmed. I tried to make them comfortable by offering them a drink, and hoped they would feel I was being friendly so that they would feel free to visit again. This interaction is distinct from the two occasions on which the nominated collaborators watched a seafloor videotape because on those occasions I suggested to them that watching the videotape to count trepang was part of their ‘training’ for university studies. The man who visited with his son was not enrolled in any formal study but came, I inferred, to see video pictures of the seabed of his country.

On one occasion I dropped at his home a ranger who was going to work with us the next day and whom I had not previously met. I asked where his country was and chatted with him. Although there were many cases when traditional owners showed or told me things about their country while we were out collecting data about trepang, in this case we were establishing relationships because we had not met previously.

Even on the last field trip to discuss research results I found I continued to establish relationships. For example, there were new, young rangers I had not met and I talked with them about their country while we worked together. I also inspected a spring with the husband of a traditional owner I visited. During this visit I had to
visit the traditional owners or drop people home. While these interactions are not strictly during data gathering, they are related to the trepang survey so are included in this category.

**Principle 2: follow culturally appropriate procedures**

When conducting the research on site, cultural considerations had high priority throughout the data gathering stage specified above. On many occasions during the research the Maningrida community made cultural considerations their first priority. For example, on some occasions I discovered that events such as clan meetings or ceremonial activities were occurring in the community and the field schedule had to be altered accordingly. At other times the research process necessitated a capacity to include events that were important to local people. Activities such as hunting or conducting a smoking ceremony occurred alongside the trepang survey. In the sections that follow I deal with cultural factors that facilitated the research process and those that to varying degrees constrained it.

**Facilitated collaborative research**

This section describes cultural considerations that facilitated, or did not prevent, the process of recording trepang data.

Seeking permission to have access to clan estates was extremely important. I called on traditional owners and explained the research and my role with BAC, then requested access to their estate. Not only was this an example of following the correct protocol; frequently the traditional owner also expressed a desire to accompany me. This helped with the trepang survey because I could not go out alone on a boat for both safety and logistical reasons.

Because I became aware of the need for access permission I built this into the sampling schedule on every occasion. Incorporating this activity as part of sampling facilitated future research in that area. Seeking permission often required sufficient time to drive to a number of places to locate a traditional owner, often learning that he or she was away (e.g. in Darwin, or at an outstation). Sometimes I approached a traditional owner but was then told to see another person in order to gain permission.
On the final data gathering trip the new ranger coordinator arranged access permission, which ensured that the research was completed quickly.

When accompanying me on the trepang survey, collaborators usually brought along groups of family and friends. This was a useful aspect of the collaboration because it increased the number of people locating trepang. (Because of the burrowing nature of trepang they are not easy to observe.) On one occasion a senior community ranger requested that I take a Croker Island resident with me because residents of the island wished to start up a community ranger program (in fact nothing came of this request).

Collaborators hunted, fished, and gathered food whenever possible during the survey, and while underway to a survey area. In fact, many people indicated their desire to accompany me in order to collect food such as oysters and mudcrab; this meant that collaborators were readily available and facilitated conduct of the research. While collaborators hunted, fished, or gathered food I usually counted trepang in transects; collaborators asked questions or gave me information that enhanced the collaboration, and looked out for trepang. While travelling in the boat, collaborators were involved in driving the boat, in using or watching the underwater video camera, or in providing information (see next section).

On two occasions I was told about the existence and approximate locality of a Dreaming site and asked not to go there. On another occasion an old man wanted to come out and show me a Dreaming place, but that trip did not eventuate. Apart from leading me to avoid the area, the information enhanced collaboration because of its importance for managing marine resources and ensuring that important cultural knowledge was conveyed to appropriate people.

On some occasions collaborators used the opportunity of participating in survey trips to perform some ceremonial duty. Twice a traditional owner came with me and performed a smoking ceremony prior to data gathering so that the research could occur at that place. I was also twice asked to take a guide with me because the traditional owner did not want me to get lost or have an accident.
Constrained collaborative research

The following descriptions present cultural considerations that constrained or temporarily prevented a research activity. Giving priority to those events rather than to research activity is a necessary aspect of collaborating with another culture.

Health and family obligations prevented data gathering when the nominated collaborators were ill or were required to give priority to family obligations. These obligations involved looking after children, visiting relations or friends, or acceding to a family request to stay home for personal reasons. These events all occurred in the initial part of the data gathering stage, when I was new to the community. As the research progressed I felt more able to question people about alternatives and had access to two key women who helped me find alternative collaborators for the survey (see later in this chapter).

Shortage of physical resources also constrained collaborative research. Although not strictly a cultural consideration, limited resources was a part of working in the community and as such, is included here. For example, on four occasions a boat or car I had previously arranged to use was required elsewhere, and on a further four occasions I had to borrow a car or equipment (e.g. oars for the boat), which caused delays to the schedule. When I first began the research I was unaware that I was expected to pick up people for work; not doing so meant that the research did not eventuate. On a further two occasions I was supposed to pick up personnel but did not have access to a vehicle, so that again the research did not eventuate.

Eight meetings organised in advance prevented data gathering because a collaborator wished to attend. Those meetings involved cultural responsibilities (e.g. attending a clan meeting or a meeting to discuss resource issues related to a particular clan’s totem) or community responsibilities (e.g. a community member negotiating with a visiting second-hand dealer, being interviewed by a cultural mapping researcher, or attending a training course). Frequently the same person was required for a number of community responsibilities simultaneously and was forced to choose between them.
As I became more familiar with the community I was able to accommodate changes to the research more easily, and found that data gathering needed to be modified but was not prevented by factors such as those described above. For example, I had planned on working with two collaborators but had to change them because one said she could not participate as the two were “poison cousins” and they could not do the same thing; I asked her advice as to whom to take instead. Changes to data collection plans also occurred because a traditional owner was involved in funeral ceremonies; but I worked with other collaborators, following the advice of the people I had initially approached.

Twice after demonstrating the use of a technical device or technique and then inviting a collaborator to use it (for example deploying the underwater camera) people present told me that in their culture they liked to watch first. I inferred this meant until they preferred to watch until they felt more comfortable with the operations, as I had already demonstrated the techniques. This constrained the rate of the trepang survey; I had initially assumed that collaborators would actively participate in western-based techniques after I demonstrated them.

**Principle 3: engage local people in data gathering**

The collaborators who were employed or volunteered during the data gathering phase of the project helped locate trepang by detecting trepang slide marks, and showing me potential localities, or they provided information about trepang location, or provided explanations for trepang absence.

The training component requested during project negotiations was taken over by another community member and an outside training institution, which freed me to plan activities, arrange for people to accompany me (which became necessary) and gather data for the trepang survey.

**During the trepang survey**

During the trepang survey traditional owners and nominated collaborators showed me where they had seen trepang on their country, or gave interpretations of field survey findings. Collaborators were also involved in the operation of the physical resources of the project. In particular they were engaged in driving the boat, helping
to deploy or haul in the underwater video equipment, and helping to prepare the
trawl net for deployment from the boat, including trying alternative options on the
boom — tied to the boat or around the capstan winch. When deploying the video
camera, I usually was on one side of the rope with a male collaborator on the other
side. On the last few attempts one man told me that he and another man would do it
for me (the sled and camera weighed 40 kg). When there were mechanical problems
with the boat all of us were involved in attempting to fix them. Nearly everyone
watched the on-board video of the seabed at some stage during a trip as most people
were eager to observe the seabed and see whether trepang were present.

During survey of intertidal areas, which involved transect walks at low tide, people
hunted for food while I tried to count trepang and estimate the area involved (by
pacing or tape measure). People called out to me or told me later when and where
they had located trepang, and I inspected those areas as well.

In the field collaborators offered interpretations about why we had not found trepang
where we had expected it would be; for example, that it was “deeper”, there was
“too much wind, him roll in the surf”, or it was “too rough”.

Planning survey and trepang matters
In this section I discuss occasions when I planned the trepang survey with local
people, rather than the actual conduct of the survey. These activities involved
organising trips out on the “trepang boat”, or in a vehicle, or planning to visit people
to learn about their knowledge of trepang.

At first I planned activities with the nominated collaborators the day before a boat
trip and did not confirm arrangements on the day of the trip. Planning with the
nominated collaborators was simply a matter of discussing plans for the following
day with them and asking what they thought about those plans, to which they
usually indicated that the plans were acceptable. Sometimes they simply asked me,
“How you want me today (or tomorrow)?” and I would respond by naming the
activities I thought would be appropriate and asking if that was okay, a proposal to
which they appeared to agree. However, of the twelve trips planned with the
nominated rangers, only six actually eventuated (three with both nominated collaborators and three with only one of the nominated collaborators).

On some occasions I planned activities for the training component of the project the day before and did not confirm the nominated collaborator’s availability on the day. On four of six occasions planned for training activities, the nominated rangers were in fact available for the training we had planned. On one of these occasions one of the rangers attended with a new person whom I had not previously met. This new person was to replace the previously nominated collaborator, who had gone to Darwin for family reasons and would not be working on the project any more.

On three occasions nominated collaborators and I planned to collect TEK in unstructured interviews on the day prior to the proposed interviews. I confirmed the availability of nominated rangers on the day of the interview and all those activities eventuated.

Planning the day before and confirming on the day of the trip appeared to be a successful strategy, because when overnight changes required rearrangement this could be done in the morning. I used this strategy most frequently with traditional owners because I adopted the procedure of re-confirming people’s availability later in the research process, i.e. after the nominated collaborators were no longer participating in surveys. Thus it is difficult to compare outcomes with earlier planning strategies that involved the nominated collaborators.

Planning a survey with traditional owners involved first visiting them, introducing myself and the research, and suggesting some plans to see if they wished to participate. If they agreed to participate in the planned activities, I would return to the office and arrange for the use of vehicles, inform previously nominated collaborators in case they wished to participate, work out tide times, contact other people that the traditional owner had suggested, and then return to inform collaborators that arrangements were complete. I would then arrange a time to collect them the next day. I visited traditional owners on the day of the trip to confirm arrangements for the day. After I adopted this strategy only once was a trip cancelled on the day. On that occasion the traditional owner was not able to be a
member of the survey party because he and his family had to attend a funeral; another collaborator, not attending the funeral, said it would not be good for him to accompany me alone and we cancelled the survey.

When working with the same people on consecutive days I usually arranged succeeding days verbally, then visited people at home or at the office on the day of the intended trip to check that they were still available.

On some occasions a trip was spontaneously organised for the day. All the planning occurred on that day because conditions were suitable and collaborators were available.

On my final data gathering trip I planned the boat trip with the new ranger coordinator, and he asked a ranger whether he could work with me. I then planned the day with that ranger. I did not re-confirm that trip on the day as we had arranged to leave early in the morning, which did not leave time for such a confirmation.

On two occasions when collaborating with traditional owners we planned visits with older people to record TEK. On both occasions we planned the interview the day before and I re-confirmed on the day. Both plans eventuated, and both times the traditional owner suggested that we ask for a car to drive to the house of the person in question; we organised the car together.

I also needed to find new combinations of collaborators on nine occasions, usually because previous collaborators were not available or because I was going to different country. I asked a non-Aboriginal BAC woman, and community rangers, to advise me about appropriate traditional owners to take. These people provided advice and usually accompanied me to visit the person suggested, if I did not know them, in order to plan the following day’s survey.

On one occasion I planned a meeting with community rangers to solicit their ideas for a book chapter on the collaborative process, but that meeting did not eventuate because other commitments prevented their attendance.
Formal training component

Training activities included watching the seabed video of the previous day and jointly interpreting it for trepang presence and recording data on a computer spreadsheet. I demonstrated to the nominated collaborators how to lay out a tape measure and count the number of trepang within a metre on either side of the tape. We took turns in this exercise. I asked if they had learnt the word ‘transect’ in their university course, and they said they had.

Report writing began after the Faculty of Aboriginal and Torres Strait Islander Studies (FATSIS) courses had been arranged to fulfill the formal training requirements of community members. Another BAC person who had recently commenced work as the senior ranger’s secretary was always present during those activities. That person explained to me that the FATSIS lecturers had suggested writing sentences first in “Maningrida English” and then in “science English”.

These interactions occurred with nominated collaborators, with whom formal training was part of the negotiated arrangement. After I began working with traditional owners rather than nominated collaborators I was not involved with any training, although the original assistants carried on their training outside of the trepang project.

Principle 4: interview appropriate people for relevant information

During May–August 1997, November 1997 and November 1998 I sought to record TEK about trepang held by appropriate people in Maningrida community or surrounding outstations. At times I also needed to seek general information.

TEK

I sought to elicit this information by way of unstructured interview on twelve occasions. Six of the people interviewed were recommended by an NLC anthropologist, two were recommended by a traditional owner, another two were recommended by the nominated collaborators and a BAC staff member also nominated two traditional owners.
A collaborator acted as interpreter, whom I asked to introduce me and to explain my role with BAC and the trepang research. At appropriate times I asked the questions listed in Table 2, in English. The interpreter then asked the interviewee and conveyed the responses (the answers are reported in Table 2 also). On one occasion the traditional owner who was acting as interpreter asked if she could ask her own questions in the appropriate Aboriginal language, so additional questions may have been asked in that interview and in the subsequent interview in which she was involved.

On the six occasions when an interpreter was not used, people tended to tell me what they knew after I told them about the project and my research role. The questions were asked at appropriate times during the conversation. Sometimes extra information was given in an answer and I then tried to elicit further knowledge using probing questions. That was often the most useful way to obtain information.

On some occasions I was not sure I had clearly communicated my question, or was unsure of the answer; and in those cases responses are not recorded. Answers given by a traditional owner acting as an interpreter were usually given in greater detail than those translated by the nominated collaborator.

Although I referred to Macassans frequently, in an attempt to elicit information that might have been orally transmitted about the Macassan trepangers, it was clear that many responses referred to the briefer periods of European/Japanese/Aboriginal trepang collection that occurred during the 1920s and 1930s.

Knowledge about trepang given at other times
Knowledge about trepang was also volunteered while we were in the field collecting trepang data, and during conversations in Maningrida. Every time I conducted trepang surveys with traditional owners they showed me where they had seen trepang or where others had told them they had seen trepang. A nominated collaborator also showed me where she had seen trepang. Sometimes people in town told me where they had seen trepang when they knew of my role in the research project. Once I told someone in Maningrida that I could not find trepang
Table 2: Questions and answers used during unstructured interviews about TEK — information provided that was not related to trepang is not recorded. (An earlier version of this table is presented in Appendix B). While some of the responses are not purely 'ecological', they are all of ecological relevance including distribution, abundance, habitats, seasonal and tidal changes, and so forth. The historical questions relate to Macassan movements in relation to trepang and thus to managing that resource. Questions about historical knowledge of Macassans were designed to facilitate further discussion about trepang ecology, and they include seasonality, or harvesting issues such as frequency, length, quantity and species. All responses have ecological relevance. The Macassan history is the vehicle for understanding these underlying issues. While the term 'traditional knowledge' would cover all this information, the questions are specifically designed to elicit ecological, and not just general, knowledge. Thus the term 'traditional ecological knowledge' is used rather than 'traditional knowledge' or 'indigenous knowledge' because it indicates that the exercise has been targeted toward specifically drawing out ecological knowledge.

Q. Where is your country?
A. Answers are summarised as: Nangak (1), Yirrkala (1), Nardelmuk (2), Yilan (2), Numaladja (2), Maningrida (1), Rolling Bay (1), Navy Landing (1), old barge landing (1).

Q: Do you know where there are trepang?
A. Ndjudda Pt (3), Gurundi (Liverpool River) (2), Karrdjarrama (2), Gurabu (Rolling Bay) (3), Junction Bay (2), King River (1), Milingimbi (2), Cape Stewart (2), False Pt (1), everywhere (1).

(Responses usually related to people’s country; for example, the two people from Yilan talked about Milingimbi and Cape Stewart, places that are close to their country. A couple of people had worked with trepang or were the descendants of people who had done so and were able to name places further afield than their country, for example King River.)
On some occasions this led to further questioning about what the habitat looked like at that place; responses were:
good place is seaweed, coral, reefs (1), seagrass, sand, rock (1), mud, rock (2), mud, rock a little bit, not sand (1), not rock, too hard (1), white always buried, brown on coral and reefs (1).

(There appeared to be a difference of opinion about the species we surveyed. Other species of trepang occur in Northern Territory waters but do not have commercial value. After I asked these questions I realised that most responses probably referred to all species of trepang and not just the species I was surveying, which did not occur on rock. I was confused because from the responses given it appeared that ‘white’ trepang to some people were ‘brown’ to others, while ‘brown’ trepang to some were ‘black’ to other people. For example, in the last response above I would have said “brown always buried, black on coral and reefs”.

Other information included:
not enough seaweed at Kupunga (1), no trepang at Rocky Point, Crab Creek, because reef but different sand — washed up too quick on the beach, no seaweed, coral, seagrass, just rocky reef, harder sand; they’re in behind where it’s sheltered (1), Ndjudda Pt, must be very low tide (1), Kardjarrama is calmer but Liverpool River, mud too deep near the mouth (1), Milimgimbi there is a Dreaming painting, circles for freshwater springs (submarine springs) (1), Kardjarrama mudflats (extensive with springwater and seagrass) (1).

Q: How much trepang is there?
A: Lots (4), big mobs (1), maybe same, maybe less now (1).

The last response was a follow-up question asking whether the interviewee thought it was the same today as it was a long time ago (he had answered “lots”).

Q: Are trepang there in the dry season or the wet season?
A: All year (7), don’t know (1).
Three people who had responded with the “all year” answer were then asked if trepang were there in the day or the night. Two respondents answered day and night and one said work did not occur at night because a “Mangadjarra” (Macassan) was eaten by a crocodile in the Liverpool River near West Point.

Q: What is the best tide for trepang?
A: Low (7).

Further questioning also gave answers:
At full moon the low tide is late and new moon low tide is in the morning (2). Neap tide is no good although sometimes dive to chest high on half moon (1). High tide dive, low tide collect (1).

Q: When did the Macassans come?
A: Don’t know (1), stories (1).

Q: How often did the Macassans come?
A: Don’t know (2), every year (1), during the mission every year, 3 or 4 years (1), Japanese in dry season, from March, sometimes wind (1).

(The final two responses probably refer to trepang collection during the 1930s when there was a mission on Goulburn Island and trepang collection on a small scale by a mixture of balanda — people of European descent —, Japanese and Aboriginal people, sometimes working in the same team.)

Q: How long did the Macassans stay in one place?
A: Don’t know (1), 5 days, sometimes 10 days (1), 2–3 months (2), lots of days (1), one week each place (1), worked together but Aboriginal people speared Japanese, said “go away” because Japanese never traded tobacco (1), worked every day and sometimes went back to “Malay” with trepang, come back empty, others stay 4 or 5 days to work (1).
Q: How much trepang did the Macassans take?
A: Don’t know (1), lots (1), 4–5 bags in one area (1), 11–12 bags took back, (demonstrated: shoulder height x 1.5 m wide) (1), 10–20 “garrung” (big bag), twice as big as a flour bag, over 3 months (2), worked morning to afternoon (1), took them in a big bag, nearly as big as a small man (drew size in the air), takes two people to carry the bag (1).

Q: What colour trepang did they take?
A: Black, brown (3), black, brown, white (1), black, brown, white, red (1), brown (2), no black (1), big ones (1).

Q: How many Macassans were there?
A: Don’t know (1), lots of boys (1), lots of Aboriginal people with 2 Japanese people before the war (1), 7–8 Mangadjarra/Malay at a time (1).

Q: Do you know of any animals that eat trepang?
A: mud crab (1), shark (1), porpoise (1), “Marrumbena”, big-headed turtle (loggerhead turtle) loves it, eats trepang and jellyfish (3), sometimes green turtle (1), barracuda eats baby ones (1), eats mud, sand, seaweed, cockles, shrimps, rot away and little bit of shell left (2).

(The last response refers to trepang diet rather than trepang predators).

Q: What things should we know if Aboriginal people want to collect trepang and sell them for money? (I sometimes said “manage trepang”)
A: use a stick to get the guts out, fill the flour drum with water on fire (1), mangrove root bark for boil, morning until lunch, hang out to dry (2), big pot boiling on island, leave until lunch (1), no waste of trepang or money, need to do it properly and boil with special mangrove that the respondent would show us (1), worked at night with paperbark branches and fire to make torch, hold the torch up high and
collect trepang, other people collect trepang in the day time (1), no good walking or
diving because of sea wasp (1), they breed all the time, “that’s nature’s way” (1), the
Macassans left the smaller ones to breed (1), the Macassans took all of them in the
one place (1), the Macassans took medium and large ones, not small ones (1), leave
some big ones there (1), no sacred sites/spiritually important areas, “all clear” (1).

Other information that emerged from the interviews included:
wet season, strong winds, cyclone, waves bring trepang to the beach/shore, tidal
waves (1), wind is okay but floating, rolling (1), they move very slow, on sand and
rocks, slower than a snail (1), after a few days in the sun they are dead (1), taste like
bailer shell (1), taste like rubber (1), brown ones taste better, like bailer, white takes
longer to cook (1), good idea for employment (1).

and he said that maybe there was too much wind. Interpretations about trepang
absence given in the field are described later in this chapter.

In Maningrida I was told by a collaborator that old people sometimes ate trepang.
There had been a cyclone once and people couldn’t get to the shop, nor obtain fish
or wallaby, and the bush tucker boat couldn’t take food to them so they ate trepang.
This information was also volunteered by another man during field work.

Other types of information
I also sought knowledge from local people about other matters, such as finding
appropriate collaborators for the trepang survey, finding the right person to obtain
access permission, and local assistance with the training program through a local
person’s demonstration of how to use ‘e-mail’ software to nominated collaborators.

Principle 5: delegate responsibilities
Throughout the data gathering stage at Maningrida responsibilities were delegated
by either party.

Related to the trepang survey
I sometimes asked if collaborators wished to carry out a technical activity that was
part of the western-based research. At other times I demonstrated what I knew to
them about survey techniques or technical matters. At yet other times people needed or wanted to show or tell me something about their knowledge or about skills they had. These interactions are considered a necessary part of collaborative research because they demonstrate two-way interactions, and because of the individual skills brought to the research project by different collaborators. These were fairly straightforward ways in which everyone was involved in the research.

During data gathering local people drove the car, drove the boat, or organised lunches, and one person asked for other work to do when she realised she was unable to participate in surveys because of seasickness. Generally I asked other people if they wished to drive the boat or car, because although people perceived my role to be that of ‘ranger’ with BAC, I wished them to realise that I was the outsider in the situation. However, people sometimes told me what needed to be organised, for example lunches for collaborators.

I asked key persons I met for help to locate people with traditional knowledge about trepang and for assistance in finding appropriate people to work as collaborators or to gain access permission. Access permission on the final data gathering trip was arranged by the new ranger coordinator. Although I prompted these interactions through a question, they are recorded because they constituted ways in which local people directed and guided me.

A collaborator who acted as an interpreter asked her own questions and on one occasion asked me to take a book with pictures of trepang to the interview so that she could show people which trepang species we were surveying. While these interactions are detailed in the TEK section, they are a pertinent example of a collaborator taking responsibility for some of the work by initiating a technique in the process of recording information about TEK, and of a context in which I took a dependent and subsidiary role.

Often a local person picked up collaborators or arranged other people to work. This does not include the many times when extra numbers of family or friends, for whom arrangements had not been made in advance, participated in field trips.
On the final data gathering trip the new ranger coordinator arranged for a ranger to drive the boat. After the survey, I discussed washing the boat with the ranger/skipper and he told me he would do it in the morning. The next morning I saw him at the office and he told me he had thought I was going to pick him up so he could wash the boat. I apologised as I thought the new ranger coordinator had arranged to do that. I asked him whether he or I should do it now as it was getting late and he asked me to do it. He was working nearby and from time to time checked with me to confirm that the task was progressing satisfactorily. I then asked him where he wanted me to store some of the equipment, and he gave directions. These interactions are further instances which show that decision-making during the project was not unilateral but might be initiated by any collaborator.

Other
Delegation of responsibilities related to matters other than the trepang survey. Interactions included a non-Aboriginal BAC member assuming responsibility for supervising the training/report writing. He had been employed as a secretary for the senior community ranger and I assumed he was carrying out instructions from the senior ranger. I encouraged people collaborating on the trepang project to make their financial claims for work hours. In an incident not directly related to the trepang research I drove a collaborator to the clinic but encouraged him to talk to the doctor, even though he had asked me to do so on his behalf. On another occasion I did not collaborate with local people because the nominated collaborators said they wanted to write their own report for a conference without my input. I later found that this request had been largely influenced by the senior ranger’s secretary, who was living at the outstation of one of the rangers, and who often informed me that the nominated collaborators were not available for work. I later discovered that the paper had been rejected, and also that the senior ranger's secretary had been removed from the position for various reasons.

In late 1995 I invited the senior community ranger to write and speak about the trepang survey and the community ranger program at Maningrida with me at a conference in Brisbane.
On the final trip to Maningrida to discuss the research results one of the rangers said he would ask the ranger coordinator if he could drive us to see some collaborators who had previously participated in the trepang survey. Previously I had always arranged a car from other BAC staff and thus had taken responsibility for organising a vehicle, but on this occasion he demonstrated the initiative and responsibility for getting us there.

**Principle 6: communicate with key persons**

On many occasions throughout the data gathering stage I was unsure about precisely how to proceed with the research and found it necessary or useful to seek guidance.

*Community ranger*

Community rangers were key contact people. The senior community ranger was the person who informed me that the community wished collaborative research to occur and offered me the opportunity. He was also the person with whom I liaised to arrange field schedules, make requests, help find a skipper, find alternative collaborators, find traditional owners for access permission, and obtain input to a book chapter on collaborative research.

When changes to the project seemed to be required, I checked the appropriateness of my suggestions with the senior community ranger or other rangers involved in helping to facilitate the research. I also interacted with the nominated collaborators; — for example, I asked them who appropriate skippers might be, who was the appropriate traditional owner for access permission, and the appropriateness of plans I suggested. Sometimes I asked them to let others know about those plans. This was an attempt to continue working in a way the community considered desirable. Toward this end on one occasion I left a note with the senior ranger suggesting that we meet to discuss personnel problems.

During the planning stages, I sometimes asked community rangers questions about changes in research direction and these are discussed in stage 1 above.
Ranger/project coordinator

In the process of organising the final data gathering trip I communicated with the new ranger coordinator to arrange the field schedule, find a collaborator/skipper, and gain access permission. Because I was unsure of his role I told him I had previously discussed such matters with the senior community ranger, and he assured me that he was the correct point of contact in future.

Non-Aboriginal BAC/PWCNT staff

Non-Aboriginal BAC members also acted as liaison contacts in various ways. Thus one initially conveyed the research topic to me; subsequently others located skippers and new collaborators, arranged the field schedule, and provided technological or equipment advice.

After the project was completed I kept in touch with two non-Aboriginal members of BAC who had been supportive during my time at Maningrida. This was useful because one of them subsequently contacted me for advice about trepang (see stage 4 below).

Other Aboriginal persons

One woman, a BAC member, played an important role in arranging combinations of collaborators and suggesting appropriate people to consult for access permission. Although I interacted with her only five times about these matters, she made suggestions that led a range of people to become involved in the research in various ways. This woman initially approached me in informal conversation at the BAC office, and we then had conversations on other occasions.

STAGE 3: INTERPRETING RESULTS

Principle 1: ask for community members’ interpretations

In what follows I describe the context of interaction in which local people gave their interpretations of the research results. Much of the information was given throughout the data gathering stage, that is, in June 1996, April–August 1997, November 1997 and November 1998. I also visited Maningrida in April 1999 to present my research interpretations during a meeting.
Trepang presence/absence

At Maningrida, people mostly offered suggestions about the results of our survey while we were in the field. On one occasion a traditional owner said there was “too much surf”; on another one said the sea was “too rough”; and on yet another occasion two traditional owners who accompanied me on a survey kept saying “it must be here”, although we failed to find any trepang. Upon our return to Maningrida after one survey a woman enquired about the survey and the next day called out to tell me that “the old man” said it “should have been there” (where we looked). She then suggested “maybe trepang don’t like it here anymore”. There was an opportunistic element to gathering these data because I realised that it might not be possible to locate people at a later stage when I planned a formal feedback of the research results, because this would occur on only one visit (and often people are away).

On one occasion a community member said he thought trepang must come out when “it’s calmer”. He said this during a survey when we found no trepang and explained that he thought that must be the case because the sea was calm when some people located trepang at Karrdjarama. He had looked for trepang at the same place earlier in the year when it was windy, and found nothing.

Sometimes I directly asked or prompted a community member about his or her interpretations of trepang by making a comment such as, “We couldn’t find any trepang today”. On two occasions different people said that “maybe there was too much wind” and that trepang was “deeper”.

Other matters
Community members also gave suggestions about other matters related to the trepang survey. I would sometimes check the appropriateness of changes to the research schedule or to personnel participating in the trepang study, and sometimes offered suggestions about a better approach. I then recorded the comments of those who responded. For example, when discussing personnel difficulties, a senior community ranger told me that the nominated collaborators didn’t always participate because they had babies to look after; he also said that the sex of accompanying staff
from the community was “up to the skipper”. On another occasion I told him that I had been informed that old people sometimes ate trepang, and he suggested that old people must have been shown how to eat trepang by the Macassans. On different occasions a BAC representative and BAC mechanics gave me technical and mechanical suggestions regarding the use of the camera sled and how to haul the trawl net up to the boat, the speed at which to trawl, etc.

On a number of occasions I had made an inference about some matter related to the research, and wanted to test my inference, so I asked questions. For example, I asked participants why some people hadn’t arrived to participate in the trepang survey, enquiring whether they had other things to do; I also asked whether seasickness was a problem for someone (I was told that both inferences were correct). I also asked one of the nominated rangers if she didn’t like the work but she indicated there were other, personal difficulties (which I was aware of). I checked whether the reason I had been asked to question another, rather than the interpreter asking the question, was because the interpreter was a ‘poison cousin’ to that person (a correct interpretation). Some children told me they didn’t have to go to school on a particular day and I asked if that was because they were participating in the trepang survey with their family; the children confirmed that interpretation.

**Principle 2: explain your own interpretations**

**Trepang report**

In April 1999 I requested a final meeting with community rangers at Maningrida. At that meeting I went through the draft final report I had written about the trepang project as a way to present my results/interpretations. I had expected people to correct or offer extra interpretations in that meeting, but nobody did. The ranger coordinator said that BAC had tried everything and now wanted to try aquaculture. He told me they were putting together a research proposal and hoping to find an interested student to help with the work. Two other traditional owners I visited knew about oyster aquaculture, which was also being planned with another scientist, and confirmed that aquaculture would be worth trying. I told people to let the ranger coordinator know if they or their families wanted anything extra included in the trepang report.
I also visited two individual traditional owners and went through the report, asking them to let the rangers know if they wanted me to change anything in it. They said they were interested in aquaculture.

**Principle 3: synthesise results sensitively**

*Attempt to synthesise results*

At the final meeting in April 1999 I had intended to synthesise results because I thought I would be able to include the comments made there. However, contacted me with anything further to add to the report. People appeared to accept my interpretations and had started thinking about aquaculture.

Synthesis probably occurred during data gathering in the field. As mentioned above, collaborators often offered their interpretations and I would note these, sometimes concurring or remaining unsure of my own interpretations at the time.

**STAGE 4: MAKING RECOMMENDATIONS FROM THE RESEARCH**

**Principle 1: incorporate ideas from all sources**

*Ideas given during TEK survey*

During the data gathering stage some management recommendations were provided in response to the questions I asked during the interviews about TEK. They included a recommendation that in future trepang should be harvested in a manner that minimised waste of trepang and money. (Waste occurred in the 1970s when the community attempted to establish a trepang enterprise but the product was rejected because of its low quality.) The person in question suggested that he would show people how to boil and cook trepang properly, and how to use a special mangrove wood to smoke the flesh so that there was no waste.

Other recommendations came from an old man who wanted to show his way of trepang collection: apparently in the old days, because trepang are more abundant at night, people worked together at night with paperbark torches held above their
heads. Other persons said that the Macassans left smaller trepang, and some large ones to breed. People also said that during a wet season strong winds/cyclones generate large waves that float/roll the trepang to the shore; information useful for data gathering or for monitoring purposes.

After trepang survey/results feedback

On my final visit to present results in April 1999 the ranger coordinator informed me of community interest in trepang aquaculture, as did two other traditional owners not present at the actual meeting. The ranger coordinator also suggested that the trepang report I provided was a good working document, containing baseline information for future work to build on. He then suggested that trepang monitoring continue and that data be incorporated into the GIS the rangers were establishing in conjunction with another Ph.D. student.

Principle 2: ensure community approval of material for publication

Literature sent for approval

In February 1996 a senior community ranger and myself attended a conference and gave a joint presentation about the forthcoming research, which was subsequently published in the proceedings of that conference. I wrote some sections for the paper and the senior community ranger added his own sections.

I was obliged to provide progress reports and a final report to the funding agency via PWCNT. One of the progress reports had locations of verified and potential trepang habitat presented in the form of a map. As I was concerned that this may violate confidentiality arrangements I sent the progress report through to BAC. I sent a letter explaining that I was under contract to provide this information, but felt that it would be kept not to disclosed to any other interested party, because there were confidentiality clauses in our contract with the contracting agency. Furthermore, as the report was not to be published I did not feel that there was any problem with maintaining confidentiality.
I showed the final report with an executive summary to rangers. I also attempted to secure publication of a discussion paper about collaboration, using examples from the Maningrida study area, but PWCNT would not support its publication.

*Receipt of response*

Prior to its publication a BAC representative read and approved the conference paper. He had been nominated to act on behalf of the organisation to coordinate matters other than fieldwork with the university.

The same BAC officer read the progress report and approved of forwarding it to the contracting agency. He mentioned that the data corresponded to locations of Macassan boiling pots, i.e. the data that were easily accessible to the public.

Rangers had no comments on the final product. The ranger coordinator stated that it would be good baseline information to show other funding agencies, and I understood that the information was suitable to forward. He suggested that the report be kept in the library and the executive summary at the ranger station.

Although the discussion paper was not published, the same BAC officer read and approved its potential publication.

**Principle 3: ensure ongoing monitoring**

*Through existing activities*

The entire research process was an opportunity for local people to establish or to continue monitoring through existing mechanisms. Involving local people in the survey, and as much as possible in other aspects of the research, established a basis for future monitoring of the resource because local people visiting the area could report observable changes in the resource base to community rangers or BAC members.

On the final visit the ranger coordinator suggested the data I provided could be input to the GIS as baseline data, and updated with further monitoring of trepang changes at various localities. Continued monitoring of the resource would therefore create an
opportunity for the community to influence harvest levels, should they notice local declines from harvesting or from natural perturbations. The rangers had previously attempted to undertake enforcement matters by investigating the activities of trepangers on their country using the ranger boat. Rangers had undertaken a Coxswain’s Course to further their enforcement and marine aspirations.

**Principle 4: ensure ongoing management**

*Initiation of management strategies*
Throughout the research process BAC members made plans for natural resource management activities. They constructed a ranger station/research laboratory and accommodation, and investigated natural resource management activities that would generate income, e.g. crocodile harvesting. There was a need for the ranger program to be self-funding and for income to be raised to continue the life of the ranger program. In relation to marine issues, members twice attended a North West Arnhem Marine Development Corporation meeting and after these the senior ranger mentioned the need for a third meeting. In this way resource management was an attempt to coordinate regional initiatives with other communities (for example, trepang collection by neighbouring communities under the one licence was suggested).

BAC members telephoned to offer me work as a female ranger coordinator. This was an attempt to help women become involved in managing their natural resources.

They also kept in touch with me after the project was effectively finished. A BAC representative telephoned me for advice five months after my last visit. On this occasion he asked if I could think about ways to prevent commercial fishers taking their trepang, because some had recently harvested a large amount from their waters. He thought BAC should express concerns about environmental impacts from such a large operation. I telephoned back after a few days and told him that the commercial fishers could not have used the maps in my report because I reported nil or low densities of trepang where they were fishing. I said it would be appropriate to mention their concern at the amount of trepang being harvested in that area, given the uncertainty of the fishery dynamics, which my modelling had shown. However,
at this stage, it would be up to NTDPIF to impose any bans/regulations on commercial fishing activities and this would not stop fishers taking trepang again when stocks were restored, and as often as they could in future years. I suggested that according to my notes people were interested in trepang aquaculture, so it would be preferable to collect trepang as brood stock for an aquaculture venture. Trepang could be collected before they reached harvestable size so that way they would not be taken by commercial fishers. I thought it might be possible to get some protection order for the purposes of collecting them for brood stock, or even to explore the idea of a sea lease. The BAC representative said that the ranger coordinator had been talking about aquaculture and it was a good idea. I remarked that I was not clear about this advice and it would need to be explored further; however, the BAC representative thanked me.
CHAPTER 5: RESEARCH AT COBOURG

This chapter discusses the results of applying the guiding framework described in chapter 3 and subsequently used in the Cobourg study. The chapter is presented in a narrative form, in terms of the component stages, principles and attributes specified in the framework. Results that predominated either quantitatively or qualitatively are expanded upon more fully than other results.

STAGE 1: PLANNING THE RESEARCH

Principle 1: critically examine collaborative research recommendations:
Understanding and critically examining collaborative research protocols involved the same activities and chronological period (from April 1995 — July 1995) as described in chapter 4 for the research at Maningrida. For this reason principle 1 is not re-presented for the Cobourg study area.

Principle 2: approach potential communities:
As with the Maningrida case study, principle 2 was not explicitly recommended from any of the sources from which I sought guidance, but, if the entire process was to be collaborative, was clearly a necessary step in this research process.

I had already identified a collaborating partner community (Maningrida), but elected to work also at Cobourg because of the events in the research process described below.

Existing research proposal/funding
During the initial meeting with the BAC community ranger at a conference in September 1995, I was introduced to a PWCNT officer attending the conference, who had submitted a proposal for (contractual) trepang research on and around the Cobourg Peninsula. The officer told me that a commercial fisher had approached the Cobourg Board with a proposal to pay traditional owners at Cobourg $2 per trepang collected. He had thought that offer might not represent an equitable return to traditional owners and had submitted a two-year research proposal that would provide information useful for responding to the proposal. The contractual research
had been endorsed by the Cobourg Board and I eventually conducted the research after renegotiating the work at both study areas (see chapter 3).

Soon afterward I attended a meeting with officers from the PWCNT and the Northern Territory Department of Primary Industry and Fisheries to further discuss aspects and requirements of the contractual research. One officer suggested I attend a Cobourg Board meeting and I encouraged his suggestion as I felt it would be a good opportunity to meet traditional owners and explain the contractual research plan. I was informed by a government officer present that a visit would be appropriate and that someone would invite me to a Cobourg Board meeting.

Research agreed
My decision to undertake work at Cobourg was largely made because of the financial benefits available to the Maningrida partner community with whom I had already accepted work. To access research funds for Maningrida it was desirable to conduct the contractual research project at both localities. I conveyed that information to the representative of BAC, who indicated that they had no concerns about my working at both localities.

The PWCNT officer told me that PWCNT was prepared to subcontract the work to me so I conveyed this information to my supervisor at NTU. I began the work at Cobourg in December 1995 and a contract for NTU to subcontract the work from PWCNT was signed in August 1996.

Principle 3: advance community aspirations
The contractual research proposal had been written for the Cobourg study area and submitted to the funding agency before I became involved in research. I was involved in no consultations with traditional owners or representatives of the Gurig Association to plan the project, and was unsure of community members’ aspirations at that time. The PWCNT officer who had submitted the proposal was nominated as a supervisor for the project, but after I began the contractual research under the subcontracting arrangements he told me to manage the research.
The proposal, as written, envisaged that I work with PWCNT rangers and have access to PWCNT vehicles and boats. On the first data gathering trip to Cobourg in December 1995 I worked with one Aboriginal PWCNT ranger, but on two subsequent trips in May 1996 I worked only with non-Aboriginal rangers. No Aboriginal person was employed in the position of PWCNT ranger. By the end of this third data gathering trip I had undertaken very little data collection and the senior PWCNT ranger indicated that there were a number of problems with implementing the research, including a lack of ranger staff to help with the project.

After the third field trip I returned to Darwin and telephoned the senior ranger at Cobourg to enquire whether I could make arrangements to bring other people to Cobourg as assistants. He told me they would need to be PWCNT staff to drive the boat, and to ask the PWCNT Assistant Director to supply an extra ranger. I conveyed this information to the supervisor in PWCNT, who said he would arrange everything. I telephoned him again some weeks later and he informed me there were difficulties with arranging personnel to accompany me, and that this was not the first time research had been difficult to implement in the park.

Community aspirations noted informally
During those first three field trips I had limited contact with traditional owners, and no means by which I could secure access to them. I therefore asked an NLC marine native title officer about community members’ aspirations at Cobourg. He informed me that he was aware that community members were interested in fishing initiatives that had the potential to generate income, and that they wished to have employment and greater involvement in activities in the park. I asked if it would be possible to determine whether community members were interested in working collaboratively on the research with me, and he suggested I attend a Cobourg Board meeting to discuss the idea.

He arranged my attendance at the next Cobourg Board meeting (December 1996) where I explained the research plan and also how local people were collaborating on the research at Maningrida. I enquired whether local people at Cobourg aspired to have that kind of involvement with trepang research. The Director of PWCNT talked with traditional owners present about my suggestion. At the end of the
discussion I was advised by one traditional owner that local people wished to be involved in the research. I suggested that I could seek an employment grant and was directed to do so by some of the Cobourg Board members present.

I then sought funding opportunities for employing local people on the contractual research project and eventually received verbal support from an officer of DEETYA for a wages and training grant. Conditions of the grant specified by the DEETYA officer were that I would supply $10,000 from the trepang grant as seeding funds and DEETYA would provide the balance for a six-month employment contract with three collaborators. Prior to beginning the survey and receiving funds from PWCNT under subcontracting arrangements, I had submitted a budget to PWCNT where I specified that $10,000 of the grant would be used to employ and train local people; this had been approved.

The DEETYA officer then contacted the NLC representative for the Cobourg Board, who was also the marine native title officer, and asked him to be involved in administering and implementing the wages and training grant at Cobourg. I was asked by the DEETYA officer to finalise the grant with the marine native title officer of the NLC. Between December 1996 and September 1997 I attended a number of meetings with traditional owners of the area and the NLC officer to arrange the details of the employment grant. At the meetings, traditional owners nominated all collaborators, based on one representative for each clan estate. At these meetings some aspirations were mentioned to me by traditional owners, including their desire for local involvement/employment in activities in the park and for formalised training opportunities.

One traditional owner, a representative of the Muran clan, was to undertake the role of project coordinator at Cobourg, as he had considerable experience and qualifications suitable to this role, including a previous position as an Executive Member of the NLC. Other than employment, I was also to arrange appropriate training for the employees so that the grant would provide not simply short-term work but a chance for local people to gain skills potentially in demand for future research activity within the park.
Other than these aspirations articulated at informal meetings, most aspirations were informally mentioned between September and November 1997, when the trepang team was formed and was conducting trepang research at Cobourg. Although these aspirations were mentioned during data gathering stages they are included here as part of planning the research so that a parallel with the Maningrida study area can be presented (in the next chapter). Aspirations mentioned during data gathering about the trepang survey were: a desire for the involvement of local women in activities in the park; a wish to independently undertake data collection for research projects; the need for better housing and infrastructure; and the desire that visiting researchers work with local people. On one occasion when discussing the desire for local people to carry out the contractual research program independently of me, a traditional owner discussed a number of additional research and monitoring ideas he had previously formulated for future research activity in the park.

**Participation in meetings to discuss community aspirations**

Between January 1997 and September 1997 I participated in formal meetings to discuss community aspirations. All were related to arranging personnel and the training component of the DEETYA wages and training grant.

One meeting was held for clan representatives to nominate collaborators for the trepang research program. I also had meetings with representatives of the Northern Territory Industry and Training Advisory Board (ITAB), FATSIS, and Northern Territory Fishing Industry Council (NTFIC) trainers to discuss alternatives for the formalised training component of the grant. I presented some alternatives to traditional owners, who informed me that a Coxswain’s Course would best meet their aspirations to be involved in park activities because they would then be permitted to drive the PWCNT boat stationed at PWCNT headquarters at Cobourg.

**Participation in other activities related to community aspirations**

Between January 1997 and September 1997 I was also involved in activities, other than meetings, related to community aspirations. These activities were also associated with arranging the DEETYA wages and training grant.
I contacted several funding bodies to enquire about potential funding opportunities and wrote a formal letter of request to DEETYA. A DEETYA officer informed me that my request was supported by his senior officers and asked that I supply more specific details about the work, collaborators, etc. for formal endorsement by the Department.

I held discussions about employment conditions with personnel from the university and arranged responsibilities for managing/administering the grant with the university and NLC staff. The NLC officer suggested that NTU act as employer; the NLC would ensure that traditional owner interests were protected, and I would be the project manager. The employment contract would be between NTU and the individuals nominated as collaborators.

Further to the meetings described above, I conducted telephone discussions with a number of potential trainers including the Northern Territory ITAB coordinator, and with Active Fishers (commercial trainers registered with NTFIC). Of these, the commercial trainers and their course were eventually chosen by traditional owners and DEETYA as the most suitable because they had already developed a Coxswain’s Course for Aboriginal people at another locality. This course was to be delivered on site with competency-based rather than written assessment.

**Principle 4: conduct negotiations**

*Regarding research direction and logistics*

Two formal meetings were used to negotiate the research direction and logistics. Both of these meetings occurred after the original data collection with PWCNT officers had started and before receipt of the grant to employ local Aboriginal people as collaborators. However, because in reality they involved planning participatory aspects to the contractual research (rather than planning the contractual research itself) they are presented here.

Although at the end of 1995 I had expressed a desire to speak with traditional owners at a Board meeting about the research direction and logistics, I did not receive an invitation to do so until I discussed this need with an NLC officer in
December 1996. At this meeting I sought traditional owners’ level of interest in involvement with the trepang research, and also used the opportunity to present the research plan.

After this meeting a number of difficulties arose in relation to the wages and training grant (described below) and some discussions with PWCNT were held informally. I was eventually invited by the PWCNT supervisor to clarify details about this grant to the Cobourg Board at another meeting (in September 1997). I also asked his advice about paying older people for passing on to me their knowledge about trepang, because PWCNT had retained some of the money from EA as payment for supplying that knowledge. He told me to organise those people at the Cobourg Board meeting and to submit a list of names to him at the end of the research; PWCNT would arrange payment.

Apart from the informal discussions with the NLC and PWCNT officers mentioned above, I went with the NLC marine native title officer to informally visit the nominated collaborators, who were temporarily staying in Darwin, to obtain their signatures on the employment contract with NTU.

Changes in research direction
Most negotiations at Cobourg were related to changes in the intended contractual research rather than to negotiating the initial project as discussed above. These negotiations occurred well into the data gathering stage — that is, after the first three unsuccessful field trips with PWCNT officers. Changes in research direction are considered to be a phase of re-planning the research rather than a stage of gathering data, and so are included here.

Changes to the personnel, availability of resources, and research objectives were important characteristics of the process at this stage. Other less substantive changes were related to financial matters, the field schedule, accommodation and training.

Directions to change collaborators nominated for the trepang team were given to me by traditional owners. These changes occurred for a number of reasons: one senior traditional owner desired a family member to be on the trepang team, another
collaborator developed “poison feet” and had to be replaced, and yet another was replaced because the substitute collaborator had a son to financially support. One traditional owner from the Algalda clan advised the NLC officer that he did not want a particular Muran representative, who had been nominated as the project coordinator, coming to his country. However, the NLC officer explained to that traditional owner that the three members of the team were representatives of the Algalda, Madjunbalmi and Muran clans where the survey was to occur, and that the person had been nominated by all clan representatives at a previous meeting. The traditional owner was apparently satisfied with those arrangements.

PWCNT officers also attempted to advise about changing the personnel selected for the trepang team. However, different individuals within PWCNT frequently conveyed conflicting information or non-committal responses, which impeded the logistics of carrying out the contractual work. This is illustrated by one observation of the PWCNT supervisor, who conveyed to me his impressions that there were “too many people involved” in the contractual trepang research, which was “making things hard”.

After the traditional owner left the meeting described above (where the NLC officer explained the need to represent clans from country on which the trepang survey would occur), PWCNT officers told me that some clans did not want the Muran collaborator on their country. A traditional owner from Madjunbalmi clan then mentioned his dissatisfaction with the Muran representative, nominated as the project coordinator, although he had originally nominated this person to the team at the formal meeting. Afterwards I was told by a different, more senior traditional owner of Madjunbalmi clan that the Muran representative was allowed everywhere. The PWCNT Assistant Director then advised me that the project coordinator was not from Muran country, nor was he the Muran clan’s preferred representative on the Cobourg Board. I questioned an NLC resource manager later about his advice to me. He contradicted the PWCNT officers on the basis of anthropological evidence and assured me that the project coordinator was indeed from Muran country and the clan’s nominated representative on the Cobourg Board.
Later, at the second Cobourg Board meeting, a young Aboriginal man employed at that time as a PWCNT ranger, yet again broached the issue that the Muran collaborator would not be allowed on his father’s country. (His father was the Madjumbalmi traditional owner who had reversed his support for the Muran collaborator to act in the role project coordinator). At that point during the meeting, Aboriginal people held discussions in isolation from non-Aboriginal people and later came back to the meeting with a unanimous decision that the contractual trepang research would continue, as planned, with the collaborators nominated. This statement was passed as a Cobourg Board resolution.

The initial reasons for changes in personnel were I was told by PWCNT rangers that there were not enough of them to help with the contractual research. For that reason I procured the DEETYA employment grant and told them this would reduce the project burden on them and help alleviate their staff shortages. I also stated that the grant had the potential to provide benefits to traditional owners for future activities in the park, in accordance with the Plan of Management. I was later invited (in writing) by the PWCNT supervisor to speak about the research and employment grant at the second Cobourg Board meeting. There I explained the process of team member nomination described above, and how NLC assistance with choosing trepang team collaborators had come about at the request of the funding agency. I was informed by the Director of PWCNT that I should not have been invited to the meeting nor involved with the people chosen on the trepang team, and that the NLC should not have been involved either, regardless of their statutory role in representing traditional owners of the area.

Changes to researcher access to the PWCNT boat was the major limitation for the contractual research. These difficulties with resources meant that several changes to the proposed field schedule (both in locations visited and type of data collected) required immediate attention.

Although the original funding submission specified that the PWCNT boat would be supplied for the research, I was told by two PWCNT officials (the supervisor and the Assistant Director) that the boat was not available for research in the Muran clan area. When I repeated the words to the Assistant Director and asked for his
confirmation of my interpretation he said that it would be available for that clan area. I was then told by various PWCNT officers that the boat was available but would have to fit in with other research priorities as they arose. Later I telephoned from Darwin to confirm a field trip and the boat availability, and was told that the boat was currently available on the dates I had proposed, but they could not guarantee it would still be available when I arrived there. Finally I was told that it would be available but not for trainers involved with the training component of the employment grant. After traditional owners unanimously supported the trepang research and the team members nominated, the PWCNT Director made a statement to everyone present that the boat would be available “as promised”.

The boat was provided for the first day of survey by the trepang team, which was conducted on Muran clan estate. A non-Aboriginal PWCNT ranger drove the boat to Muran country. During that day the PWCNT ranger informed me that the boat was leaking and required constant draining. He mentioned that it did not have enough carrying capacity to carry simultaneously the trepang team and himself, and further, that its fuel range was insufficient to get me to areas designated for trepang survey in the contractual research proposal. Because neither a boat trailer, nor a car to trailer the boat by road, was supplied with the boat we were unable to trailer the boat to these areas as an alternative strategy. Additionally the depth sounder I had requested, in writing, to provide depth data specifically mentioned in the contractual research proposal, had not been supplied.

After that day’s survey the boat was recalled by the senior ranger for repairs. I suggested paying a traditional owner to hire his private boat, which was larger. The senior ranger asked if I had sufficient money in the budget to pay that person. I explained that my budget had been committed and approved through the PWCNT supervisor much earlier in the research process, and that because PWCNT had agreed to provide a boat I had made no provisions for hiring a traditional owner’s boat at that time. I later telephoned the senior ranger and suggested that PWCNT supply fuel for the survey and a little extra money for wear and tear on the boat as an alternative to hiring the traditional owner’s boat. He agreed to this suggestion.
After the survey in Muran country was completed I returned to Darwin to arrange a field trip to the next clan estate. I telephoned the PWCNT senior ranger and was informed that the leaking area in the boat had been welded, and that the boat now had the carrying capacity for everyone because it had been equipped with a larger fuel tank. I was told that the trepang team would now be able to travel to all those areas specified in the contractual research proposal. He added that the Commission was “keen to support the research as much as possible”. After this conversation the PWCNT boat was never used again because the trepang team were asked by the Director to leave the park (see below).

A large number of changes in project direction were associated with renegotiating objectives of the contractual research proposal. One of the primary sampling techniques proposed in the contractual research proposal was dangerous and ineffective. For this reason it was necessary to develop a new technique (an underwater video camera — see Appendix B). As detailed in chapter 3, an EA officer audited the project in the field and noted the substantial work involved in developing this alternative technique. She suggested that the research objectives be renegotiated to reflect the substantial work I had already undertaken in developing the technique. I told her there appeared to be difficulties with implementing the contractual research at Cobourg, probably related to staff shortages, and she said EA would be satisfied if the research continued at Maningrida only, given the additional work required in involved in conducting the research collaboratively at the study area.

I questioned the PWCNT supervisor about the possibility of withdrawing from Cobourg as a study area because of the logistical difficulties in implementing the research there. PWCNT officers were adamant that some component of the research be conducted at Cobourg to keep traditional owners happy. I then suggested to a supervisor at NTU that the research continue at Cobourg, but that the survey be limited to fewer areas. I visited the project coordinator at his home on two occasions in relation to these matters. He supported the suggestions, which meant that the arrangements now appeared to be suitable to the traditional owners, PWCNT and my supervisor at the university.
Having spoken with traditional owners who wished the research to continue at Cobourg, I urged that the research continue at both localities, with reduced survey site demands. However, I argued that the new underwater camera method developed should be included as an objective. These renegotiated objectives were accepted by representatives of NTU, PWCNT and EA at a teleconference. I was asked to provide a written statement of the renegotiated objectives to representatives of the three agencies. I sent this to EA and received a reply within a few days with suggested wording changes. I forwarded these changes to PWCNT, but the objectives were not accepted in writing until after all field work was completed.

Later, after difficulties with arranging the collaborators for the employment grant arose (as detailed above) there were attempts by two PWCNT officers to renegotiate arrangements so that Cobourg would no longer be a study area for the contractual research. However, they altered their position and accepted Cobourg as a study area after I pointed out the history of broken promises to Aboriginal people and that the employment contracts had been signed between collaborators and NTU.

Other changes in the research objectives involved negotiations between me and the project coordinator to obtain his permission to record the collaborative research process. He gave me oral permission, but preferred not to sign any statements until he saw what I had written. He asked if I could understand why and I replied that I did. I recorded the data with his oral agreement.

Attempts to change the field schedule occurred because PWCNT officers requested me to return to Maningrida, and to change the survey starting date at Cobourg until after the second Cobourg Board meeting. However, because I had already arranged that the employment grant would take effect prior to that date, I felt that these suggestions were unacceptable.

On another occasion I was told by the PWCNT Assistant Director that Muran clan area should not be included in the field work survey as there were no trepang on that country. After I informed him that information I had from literature sources suggested the contrary and that I would like to survey the area, he did not respond; in the end the survey did eventuate.
Once trepang team members suggested that I visit an area I had not proposed for survey because of logistical difficulties in other places. This was a minor change and the field work plan was readily altered.

Financial arrangements also appeared to be subject to change, and I needed to settle concerns of PWCNT officers. The original budget I submitted to PWCNT had been approved with a $10 000 provision for the employment of community members. At the second Board meeting the PWCNT Director expressed dissatisfaction that I had spent money from the budget to employ community members when the Cobourg Board had not seen the submission. He also asked why I had not submitted the funding application through PWCNT. I explained that no other expenditure submissions had been endorsed by the Cobourg Board (including purchase on an underwater video camera for $11 000) or had previously been required to pass through PWCNT channels.

Other changes to arrangements were associated with accommodation and required substantial re-negotiation. After finishing the survey on Muran country and moving to the next clan estate where PWCNT headquarters and accommodation facilities were located, I was telephoned by the Assistant Director of PWCNT. He informed me that my role in the research at Cobourg was over and my contract was to be withdrawn because I had accommodated collaborators in PWCNT accommodation. I explained that the ranger had placed us in that accommodation when we arrived. The Assistant Director then stated that the recent Cobourg Board resolution had banned traditional owners from PWCNT accommodation. I denied that this was so, telling him that I had written the exact words of the resolution in my notebook; after which the Assistant Director then stated he had told me and the NLC officer in an earlier telephone call that traditional owners would not be allowed PWCNT accommodation. I denied that he had said this to me in an earlier telephone call, but the issue was apparently not open to discussion. Furthermore, since the trepang team members were employees of the university it was also an issue of accommodation for university staff. After that the trepang contract was withdrawn.
As I wished to continue the research I obtained signed statements from traditional owners who also desired that the research continue on their country. We agreed that the research would continue, without the support of PWCNT if necessary. An out-of-session Board paper was prepared by the NLC representative of the Cobourg Board with a resolution endorsing the research, and instructing PWCNT to reinstate the trepang team under contract, release funds, permit accommodation for the research team and supply the boat, fuel, oil and equipment required. The NLC officer also sent a letter to PWCNT asking for confirmation that the research contract had been withdrawn on the grounds that traditional owners had been accommodated in PWCNT accommodation. After this, the Assistant Director reinstated the contract, but forwarded to NTU a number of terms and conditions he wished to see implemented in the research. These included caveats that I was not to provide publicity about the project, nor to talk directly with the funding agency.

Changes to training arrangements became significant matters for renegotiation during the research. The Cobourg Board had directed me to seek an employment grant, and I procured funding of which training was a component, because employment and training was also an objective of the Plan of Management, a point recognised by DEETYA. I participated in informal meetings at the home of the project coordinator to discuss alternative training component possibilities that would satisfy DEETYA requirements. I presented various options to him for training. He informed me that traditional owners wanted to undertake a diving course, but at the second of these informal meetings he advised me that community members preferred a Coxswain’s Course to be delivered on site with practical assessment. They thought this would be more useful because they required such accreditation to drive PWCNT boats.

PWCNT officers of the Cobourg Board became dissatisfied with the training component arranged, and changed or attempted to change it. They suggested that PWCNT should train collaborators, but I asserted that because I had expended university time in procuring the grant, and the money had been granted to the university, it was appropriate that the university advise and manage the grant. Furthermore both the university and other industry-certified trainers arranged had more appropriate credentials for delivering the Coxswain’s Course training.
At this point government agents from DEETYA cancelled the money for the training component just before the course began. They told me they had been told by PWCNT personnel that there were no permanent employment prospects for traditional owners in the park and therefore the Commonwealth Employment Service did not want to risk its money. DEETYA had originally wanted to fund the training because it appeared to be in line with Cobourg aims and objectives. I then had to renegotiate with the officer from DEETYA alternative suggestions for the time set aside for training; it appeared to be agreeable to anything which would incur only limited expense. Some suggestions I made were to bring collaborators to NTU for a short course; that collaborators work for the Gurig Association; or that they visit Maningrida to work with the community rangers there. In the end, I used the practical demonstrations of western science techniques as training.

**Principle 5: establish personal relationships**

*Formal meetings related to research*

Between December 1996 and September 1997 I had six opportunities for meeting traditional owners and interacting with them. These interactions occurred through meetings related to the research. They occurred at Cobourg Board meetings, at the meeting to organise representatives for the wages and training grant, and at the informal meetings at the home of the project coordinator. These meetings provided the context for getting to know community members to a limited extent, prior to much closer involvement with them during the data gathering stage.

**STAGE 2: DATA GATHERING**

Data gathering at Cobourg occurred during December 1995, May 1996, and between September and November 1997. During December 1995 the PWCNT Aboriginal ranger accompanied me on two boat trips to survey areas for trepang presence. Two further field trips were made during May 1996 and on these occasions I was accompanied by non-Aboriginal PWCNT officers to survey trepang and conduct underwater camera trials (see Appendix B). Interactions involving the field trips with PWCNT officers are not recorded in detail. I spent around 20 days in the field
during these periods but conducted only around 16 hours of work with PWCNT rangers.

After those data gathering trips, which I deemed largely unsuccessful, I procured the DEETYA employment grant to employ local people on the contractual research. The final 30 days of field work (between September and November 1997) were carried out by the trepang team. On one of those occasions a non-Aboriginal PWCNT officer accompanied the trepang team because he had driven the PWCNT boat to that clan estate for use on the survey.

**Principle 1: establish personal relationships (continues)**

*Formal meetings unrelated to research*
In September 1997, during data gathering by the trepang team, a special meeting was called at Cobourg to propose changes to the Cobourg Peninsula Aboriginal Land, Sanctuary & Marine Park Act. The Chairman of the NLC flew in to advise traditional owners to keep the act unchanged, or they would risk losing power. Members of the trepang team needed to attend this meeting, and I accompanied them. I used this opportunity to talk informally and establish some relationships with other traditional owners present at the meeting.

*During unplanned encounters and informal conversations*
Between September and November 1997 I lived with the three other members of the trepang team on a day-to-day basis throughout the period of each field trip. These trips usually lasted between one and three weeks, during which I was totally dependent on them for transport and everyday living arrangements. In many ways the entire phase of gathering data during this time was one of establishing relationships between members of the trepang team and myself.

Most of the time during the data collection stage at Cobourg was devoted to the contractual research, and there were few unplanned encounters or interactions with other community representatives that were useful for establishing relationships. Members of the trepang team met and talked with two Aboriginal people on the road to the airport, and I also interacted informally with them. However, on one occasion
in the early research stage during data gathering with PWCNT rangers I was introduced to a senior traditional owner in the ranger station by a PWCNT ranger.

Other than these instances, relationships developed through unplanned encounters and informal conversations, mainly when eating meals. They occurred during breakfast, or when having drinks and eating dinner around the campfire at night after a work or rest day, or after driving to a new study area. At night, team members seemed to enjoy the opportunity to sit and talk about the incidents of the day or other matters. On two occasions the same person pointed out that the team were “workers” and deserved a knock-off drink. The most frequent conversation topics related to family, incidents which had occurred when team members had been employed as PWCNT rangers, and their perceived inequitable treatment of Aboriginal clans by PWCNT. Other topics included their country, the challenges of Aboriginal law, accommodation issues, Gurig Association problems, tourism in the park, and plans for other research in the park. Although these topics came up on other occasions, the context of having drinks after work provided greater opportunity to discuss them at length. Once we were visited at night by members of a neighbouring clan.

*During involvement in everyday activities*

On the first data gathering trip (in December 1995) the Aboriginal PWCNT ranger employed at the time accompanied me. After the trepang survey was over he suggested that we visit Victoria Settlement and I indicated that I was keen to learn anything he wanted to show me. He showed me around and told me the history of the area, and I felt that we had initiated a good working rapport.

On the second data gathering trip (May 1996), I briefly took up a role as marine ranger. I had been informed by PWCNT rangers that staff shortage was making it difficult for them to help me with the contractual research and with supplying the boat, so that nobody could accompany me for survey. I offered to help rangers so that it would be possible to take the boat out the following day. I felt that this would ease any difficulties and help to establish a good working relationship with PWCNT. I then became engaged in ranger duties including emptying bins, pruning trees and painting signs. However, the desired outcome of finishing ranger duties and then
having a PWCNT ranger accompany me was not forthcoming after I had been participating in these tasks for a day and a half. I then explained I had other work I needed to do and no longer participated in PWCNT ranger duties.

After formation of the trepang team between September 1997 and November 1997 I had brief interactions with some Aboriginal people because of their need for transport. These interactions took place because one member of the trepang team drove community members to or from the airport, and as a passenger I was able to chat informally with community members I had not met previously.

On another occasion I telephoned a senior traditional owner from Darwin to confirm that the trepang team could move to his country for survey. After he consented to my request, he asked a favour of me: that I bring him some cigarettes from Darwin. I complied with the request as a means of establishing a relationship with him, although because he was away when we got to his country I never gave him the cigarettes.

Another time I arrived at Croker Island airport and team members met me there in the boat. While we waited for high tide to leave the island we stayed at the home of the father of one member of the trepang team. I was able to chat with other family members present at the house. Both times I was invited to a meal with the rest of the family.

_During trepang data gathering_

During the first trepang survey in December 1995, while working with the PWCNT Aboriginal ranger I asked him many questions about his country. He answered the questions and then pointed out additional things about his country that were not in response to questions from me. This was as a means of establishing rapport with him, because at that stage I had not met any other Aboriginal people of the area and did not yet know that I would later secure the employment grant.

After the employment grant was received I lived with the three other trepang team members. Because of this arrangement, particular instances of establishing relationships during the trepang survey were not as evident as if I had worked with
different collaborators at varying times. I did not have a need to constantly seek new collaborators, and was not as concerned with establishing relationships with unknown people as I had been at Maningrida.

However, relationships were reinforced rather than new relationships established, and these are included here. A useful opportunity to reinforce relationships appeared to be during lunches while on the survey or on a rest day, when we engaged in other work such as hunting for food, burning country, or repairing houses. Team members brought the food they had caught or collected and cooked it over a fire. We ate together and discussed observations we had made.

I learnt some of the commonly spoken Iwaidja words (e.g. those for boat, fish, water). When I initiated a question to clarify language or a word spoken, I sometimes said the word. I was helped immediately with further explanation, new words, or pronunciation. Although I did not initiate requests about language often, I found it useful to listen to language when it was spoken in order to pick up common words. I felt that this helped to show team members that I was interested in learning from and listening to them. The number of times Iwaidja was spoken in interactions with me is not recorded, so is presented as a ‘large number’.

I was in constant contact with the project coordinator and did not need to visit potential collaborators for everyday enquiries about their involvement in, and planning for, the trepang survey. However, on the day before data gathering began with the trepang team I made a conscious attempt to establish a relationship with one team member. The NLC native title marine officer had come to Cobourg to help start the contractual research with the trepang team, prior to his attendance at a Cobourg Board meeting. He drove me to Gumeragi, where the particular team member was camping. I encouraged that team member to come over to the outstation on Muran country and camp with the other members of the team. While there I also spoke with two senior members of the clan at their home. They remembered me from the first Cobourg Board meeting I had attended and made some jokes with me about collecting trepang. This visit to Gumeragi was useful for establishing relationships both with a collaborator and with two non-collaborators.
Collecting data about trepang using unstructured interviews with owners of traditional knowledge did not occur in a planned or formal sense, and there were no visits to people specifically for this purpose. However, collecting TEK about trepang occurred in an opportunistic way — usually as a result of interacting with someone. I talked to some people (identified by the Cobourg Board as appropriate to interview) who were present in a house where I was staying, but their English was limited and interacting in these conversations was limited to brief question and answer interactions. However, the attempt to discuss trepang was probably a means with which to reinforce my presence and to demonstrate a wish to collaborate with Aboriginal people of the area. Another older man had very good English and during my conversations with him about his knowledge of trepang we seemed to establish a good relationship. I was staying in his house and he later initiated conversations with me to find out whether I had found any trepang, to offer me food, to make me feel comfortable in his house, or to give me information about other marine resources.

Once a traditional owner at whose home I was staying, who was not a member of the trepang team, sat down with some of his family and the trepang team and watched the video we had made that day. This interaction is presented as an attribute of establishing relationships during the trepang survey because it was a chance for me to interact with other community members. (On the other occasions when the team watched the video it more appropriately characterises the ‘training’ attribute of engaging people in the research, presented later in this chapter.)

Relationships were established with 11 additional people by their presence in a house where I was temporarily staying. These people usually required transport to or from nearby Croker Island, or sometimes simply came on the entire field trip for company. I was also invited on some hunting expeditions with these additional people in the house and these also were opportunities for building relationships.

Some interactions with collaborators are included here because the relationships contrasted with everyday interactions. I was told twice that I was doing things the “right way, with us”. This seemed to be encouragement to continue the collaborative research. After PWCNT had not allowed the team accommodation at
the park headquarters and withdrew the trepang contract, one team member told me “they’re always doing this to my people” and I felt that he trusted me enough to say this. Once, around the campfire, another team member conveyed his ideas for research in the park. I felt that this would have required some trust on his part that I would not steal his research ideas. I also felt that his discussions with me were an indication of encouragement to continue collaborative work. Another time I was told in confidence about some of the social problems at Cobourg, including alcohol-related issues and non-equity in resource allocation for clans, particularly the preferential treatment of one clan. One member complained to me about continually using his private vehicle for the research while receiving no help from PWCNT, and then mentioned that he didn’t like other people driving his vehicle. He told me about his son-in-law, his medical problems, and about the competing pressures he had faced when working for the Gurig Association. He also told me about people he didn’t trust and gave reasons for this emotion. A visitor in a house where I was staying told me that that person and PWCNT were always fighting.

Other interactions that contrasted with everyday relationships were being welcomed to an old man’s house, and later being thanked by the owner for staying there. The welcome and thanks encouraged me and I hoped that it also encouraged other team members who were not members of that clan. That same old man tried to help us obtain accommodation at the PWCNT headquarters after we left his country, explaining that everything was “cleared now” because all traditional owners had signed the out-of-session Board paper, although we were refused accommodation by PWCNT a second time.

The project coordinator and I talked about components of this research. I explained what I thought about a collaborative research process and enquired about his thoughts on how collaborative work should be carried out. I also talked to him about ethics clearance for recording the process of collaborative work, as discussed above.

**Principle 2: follow culturally appropriate procedures**

Cultural considerations that facilitated or constrained collaborative research are recorded for the survey with the trepang team, which occurred between September
and November 1997. Cultural considerations did not appear to be an issue prior to working with the trepang team.

**Facilitated collaborative research**

Interactions that facilitated collaborative research related to arranging access permission, the presence of others, hunting and gathering food, and sacred areas on the country surveyed.

The project coordinator arranged the visit to his country and also visited other traditional owners before we surveyed their country. I had contacted one of these traditional owners by telephone prior to the visit so that he would know we were coming, but the project coordinator also went to see him when we arrived there. After PWCNT withdrew the contractual research contract, I sought access permission from traditional owners and obtained signed letters from them so that I could continue to visit their country for trepang research (detailed above). One clan area was represented by the project coordinator and he told me I did not need a signed letter because he would always be with me.

On three occasions extra people travelled with us in the vehicle to obtain a lift between Cobourg and Darwin, but those people did not participate in the trepang survey. Twice someone came along to stay at the outstation for the duration of the field work, but did not participate in the survey. On another occasion the same person did help with the survey. As well as participating in the trepang survey, people wanting lifts and those wishing to stay at the outstation facilitated the research because their involvement generated wider awareness of it.

Hunting and food collection occurred every time we conducted a trepang survey. On three occasions I was told that other members of the team wanted to “check” out the country. On two of those occasions they told me this was country they had not previously explored, and once collaborators told me they had been there previously. There were probably additional times when people checked out their country, but I was not made explicitly aware of it. Hunting and collecting food, and presumably checking out the country, were also substantial features of rest days, or days when logistical problems prevented trepang survey.
I was twice told about a site of importance, which was useful to this and future research. On one of those occasions I was told I could go there but not to collect oysters. I never collected food unless invited to by the people I was with, so was surprised at this comment (although the old man who told me had not been with me during the survey and so was unaware of my habits). The rest of the team was close by and should have heard his comments. The other occasion when information was given about an important site was when one person simply said there was “a site” in a particular bay I was interested in visiting. I thought he meant a Macassan site and said that it wasn’t recorded in a book I had. I then asked if it was the site that a senior man had told me about. He asked me what the senior man had said and I replied that he told us to go to “that pocket, Ernie and Lorna’s, and Copeland Island.” He then said to me “Oh you mean Macassan site!”, so I realised he had been talking about a sacred/Dreaming site.

*Constrained collaborative research*

Health and family issues and the lack of physical resources largely constrained the work. Health issues included illness among team members. Although there were sufficient people to continue working when a team member was ill, we were constrained in that less work for the contractual research occurred. Other times the work did not continue because of alcohol-related problems. Family issues included the inability of a team member to come to Cobourg from Croker Island because he later told the project coordinator that his family was sick. Other family issues that took precedence over the contractual research were a visit by one team member’s wife, and the need to attend funerals. Data gathering was constrained, but not prevented due to the availability of other people: however, it had to be substantially modified. On one occasion a team member needed to discuss with another Aboriginal person problems which had arisen in the Gurig Association. Because of the need to coincide data collection and tide times, even minor delays to the planned schedule, such as visiting the person in question, constrained research by limiting the time available or completely preventing the trepang survey for that day.

Physical constraints to the research concerned the equipment needed for the contractual research, and the lack of physical resources at the outstations where we
stayed. Technical problems arose with the equipment and the camera. Once a team member fixed a problem (he was a qualified electrician) and once I returned to Darwin to have the camera repaired. On eight occasions we spent a day packing and cleaning at one location, moving and then setting up at an outstation at another locality, or packing and cleaning the outstation where we stayed prior to returning to Darwin. On two more occasions we could not survey trepang because we were not allowed accommodation by PWCNT staff (detailed above). This meant days spent packing, moving and unpacking had been in vain. A couple of times we needed to telephone ahead to an outstation to make alternative arrangements for the trepang survey. Both times we had to wait for the high tide, take the boat to an area where there was a telephone and make the call. By this time the tide was usually receding again so that it was necessary to return the boat to the outstation where we were staying while there was sufficient water depth; as a result trepang survey was impossible. In reality a lack of boat ramps and channels through mudflats at outstations, of telephones and other resources probably prevented our investing more time surveying trepang.

The need to repair generators also prevented data gathering on three occasions because team members needed to spend time making repairs so that the refrigerator, food, lights and general living arrangements were suitable. Another time it was necessary to take the boat to and from Croker Island to find a more skilled generator technician. He was not available and we had to wait again the following day for that person to arrive from Croker Island. On yet another occasion the team was made aware that the road gang was in the vicinity and spent a day driving to find them to request that they make a dump and remove a tree blocking the road. These are general living and maintenance arrangements that take precedence over research activity.

Other constraints on the research were human resources, meetings, necessary general maintenance work and conducting clan public relations. Human resource issues were mainly related to the unavailability of persons for the contractual research. Eight times during the initial data gathering trips (before formulation of the trepang team) PWCNT rangers informed me that they had too much other work or that no-one was available to help with the contractual research. Once the trepang
team searched for a senior traditional owner to provide TEK about trepang but after taking the boat over to find her we were informed that she was in Darwin (for unknown reasons).

Meetings of the Cobourg Board and another special meeting called to discuss proposed changes to the Cobourg Peninsula Aboriginal Land, Sanctuary & Marine Park Act prevented data gathering because all team members wished to attend. One member needed time to prepare for a Cobourg Board meeting and meticulously read minutes, discussed agenda items he felt would be raised at length with the relevant NLC officer, and prepared his input to the meeting.

General maintenance work that was needed on one clan estate was also incorporated into the research program. While on the country of one team member we burnt around his house to keep the country clean. He also required other work around his house, such as removing rotten boards from a house whose construction had never been completed.

After the second Cobourg Board meeting and all aspects of the research were endorsed, the project coordinator felt there was a need to spend time engaging in public relations with the senior traditional owner of the clan estate we wished to survey next. He spent one day driving to visit that person, and told me later he had discussed problems that had previously caused tension between them. After he returned he told me that everything was “all right now”. One other interaction occurred that demonstrated good relations between clans: while staying at an outstation one team member received a telephone call that someone had bogged a truck. We drove about an hour each way to remove the truck from the bogged area and transport the driver to the outstation where we were staying.

**Principle 3: engage local people in data gathering**

This section relates to local people engaged in the trepang surveys, conducted during December 1995, and May 1996, and between September and November 1997.
During the trepang survey

Results showed that a major role played by local people in the western research activities involved technical aspects of the work. Members of the trepang team took the role of skipper for the boat. After I demonstrated the use of equipment to the project coordinator he then demonstrated equipment use to other members of the team when they came onboard. After that, team members other than myself lowered and retrieved the camera on every occasion, which was extremely heavy work. My role was to take the GPS (Global Positioning System) coordinate readings at the start and finish of every transect, and also to take a sediment sample from the sled on which the underwater camera was mounted. Nearly everyone watched the onboard video of the seabed.

During boat transects the boat owner skippered the boat, the other two people stood and pointed out trepang on each side of the boat and I recorded GPS readings, obtained sediment samples, and verbally kept the tally of trepang observed.

When trepang transects were walked in the intertidal zone, I conducted the survey on my own and other team members hunted and collected food, but called out to me if they located trepang. Twice they encountered a very dense area of trepang and came back and told me they had counted them. I asked them the area involved and they demonstrated the approximate distance on the ground.

One team member repaired the camera and technical equipment as necessary.

During the trepang survey, team members and other people who sometimes accompanied us offered interpretations as to why we could not find trepang where expected. One time we found only sub-adult trepang, and a team member suggested that the trepang must be have been cleaned out by commercial fishers because an old man had seen them in that locality collecting trepang the previous year. Another time after we had failed to locate trepang a young man who was accompanying us on a survey remarked that he had seen them at another locality washed up on the beach after cyclones.
Planning survey and trepang matters

Arrangements for the trepang survey needed to be planned. At first I tried to plan a field schedule in advance; however, the schedule mostly was not appropriate because of other priorities such as cultural considerations or general living arrangements, which took precedence over the contractual research.

All members of the trepang team planned activities the night before a survey. This interaction was facilitated because we lived together, and it was a relatively easy matter to organise activities together. However, changes to the daily plans were often necessary because of the weather, tide, vehicles, equipment, meetings, or other necessary activities. Once plans were changed because the person we sought for knowledge about trepang was not home. Even during the day’s activities plans were frequently re-arranged. Usually the project coordinator decided the day’s activities, although sometimes he asked what I wanted first and then made a decision. He had asked early in the data gathering stage if the schedule would be flexible.

Other planning matters attended to by local people were related to equipment and resources. After the underwater camera failed team members discussed plans for my return to Darwin for repair work and then my return to the outstation. This involved coordinating tide times with aeroplane flights in advance because communication was difficult once I departed. Another time the project coordinator had to return to Darwin and suggested I go to Maningrida for two weeks. He suggested that he could drop me at a convenient area and the BAC ranger boat could pick me up. Team members then planned implementation of the contractual research independently of me. It was also necessary to plan the travel of collaborators to outstations after they had returned to their country during rest breaks. On two occasions I tried to arrange collaborators’ travel, as did the project coordinator on a further four occasions.

Physical resources that required substantial planning mainly related to obtaining the PWCNT boat and obtaining accommodation in areas other than the project coordinator’s country. Before formation of the trepang team I planned and tried to organise use of the PWCNT boat on some 20 occasions. Again after the second Cobourg Board meeting, when the contractual research had been fully endorsed,
various team members twice planned and organised use of the boat and rangers to work on the research. In one case these plans were successful.

When planning accommodation at the PWCNT ranger station headquarters the head ranger asked when we were arriving at that area and we advised him of our intentions, but could provide only an approximate timeframe. We arrived one day later than expected and reported to the ranger on duty that we were there for the trepang survey, but two days later we were asked to leave. On a later occasion we planned to use accommodation at the ranger headquarters because the chairperson of the Cobourg Board confirmed that accommodation had been approved. The project coordinator was unable to speak to any rangers at the time we were near a telephone, so he left a message that we would be coming. However when we arrived the senior ranger told us we were not allowed to stay.

Accommodation at the Araru outstation required planning twice. Although I had telephoned the senior traditional owner and told the project coordinator he was expecting us, the project coordinator felt it necessary to follow up with a personal visit. A day had to be set aside for this to visit and to conduct the clan relationship activities. The project coordinator planned the timetable and took a letter with him asking for permission for me to be on his land. He also took with him items such as food and hunting equipment.

Other physical resources that required planning were fuel, and moving team members’ personal equipment such as the depth sounder belonging to the project coordinator, located in another boat he owned. Planning and implementing strategies to obtain and move these resources frequently took the greater part of a day because of the distances involved.

Another specific trepang matter that required attention was my need to obtain clearance for all members of the trepang team to visit all clan estates. As noted earlier at the second Cobourg Board meeting we formally obtained clearance for all collaborators to visit all clan areas. I also received clearance informally from a senior man on another occasion. However, on another two occasions it was necessary for an individual to approach the senior person and ask for access to clan
areas at some time in the future. This was less presumptuous than turning up the day before or on the day of a planned survey and asking the traditional owner for permission to survey the country.

Another time I asked for permission from one team member to survey an area on my own, because the other team members were having a nap after lunch and it was low tide. The team member said it would be fine for me to walk on the mudflats. However, later when he and the other team members came to look for me and to catch some fish, they said they hadn’t realised I would walk so close to the water’s edge; they asked that I not to go on my own again because they were concerned that I might become victim to a crocodile.

On two occasions we advised the manager of a pearling company, leasing the land in one clan estate, that we wished to survey in that area. This appeared to be a courtesy matter as Aboriginal people had granted the lease to that person and made it clear to me they were the owners of the land.

Formal training component
Training was a requisite component of the employment grant. The formal training component was initially planned to be an on site Coxswains Course, developed with industry partners, but this was cancelled by government personnel after the second Cobourg Board meeting that endorsed all aspects of the contractual research, including the employment and training.

Training was eventually incorporated as part of the contractual research in a practical applied demonstration manner. In this way it was not set aside as different from the activities in which we were engaged on a day-to-day basis.

A practical demonstration of camera and boat transects was given to team members. As mentioned above I demonstrated the camera technique to the project coordinator, who in turn demonstrated it to other team members. On the days when we used the underwater camera, we all watched the videos we had filmed together, at night after work.
During boat transects I explained the need to keep the boat travelling in a straight line, approximating a transect, and showed team members the GPS readings which I recorded. One team member said he already knew about GPS locations from training with NORFORCE (part of the Royal Australian Army). I also explained to team members about counting trepang at one arm’s distance on either side of the boat. They called out when they located an individual trepang and I verbally kept the tally. Although I did not explain the concept of the intertidal walks, team members came back to me with a tally of trepang and an estimate of the area counted. They may have watched me previously or had prior knowledge of this concept. At times the project coordinator had articulated scientific research proposals to me informally over dinner, discussing the concepts of ‘variables’ and marking out areas with star pickets for ‘control’ which suggests he had a high understanding of the western scientific principles of survey procedures.

Another time I had forgotten to obtain a sediment sample or “bottom type” which was the phrase I used. One team member reminded me to “get some mud”. I had previously explained that I would test this back in a laboratory to determine the “bottom type”. These reminders by team members suggested that formal training was not necessary and that practical, on site training by demonstration was useful.

**Principle 4: interview appropriate people for relevant information**

Between September and November 1997 knowledge about trepang was sought from appropriate people, identified by Aboriginal representatives at the second Cobourg Board meeting.

**TEK**

Traditional knowledge about trepang was sought from knowledge owners on four occasions using unstructured interview techniques. On one of these occasions the project coordinator visited a traditional owner for permission to survey in that area. He asked her for further information and informed me of some localities where she had recently seen trepang. This person was nominated by the Cobourg Board members at the second Cobourg Board meeting as appropriate to interview. After that meeting I approached her about visiting to ask her what she knew about trepang, but she indicated that she never saw it.
On other occasions I attempted to ask two old men the questions listed in Table 2 but these men were difficult to understand and I recorded only brief information about where they had seen trepang.

On another occasion I sat down and asked another old man some of those questions. He told me there had been large amounts of trepang “out the front” of his outstation and also large amounts of seaweed but since a cyclone struck the area both had been absent. The project coordinator then asked if it was Cyclone Tracy or another cyclone but the old man seemed confused and did not answer.

The same old man said that as a little boy Aboriginal people worked with trepang for a Japanese man. He said they would collect “6 or 4 hessian bags” then boil them the next day in an enclosed area. They would smoke them all day and night in a large pot with a particular mangrove wood that made the trepang “strong”. The trepang was placed on a net above the fire. He said we would need a 44-gallon drum to do this today. They would again boil the trepang one week later.

I asked him if he knew any stories about the Macassans and he told me they would travel along from bay to bay. He said people would walk or dive for trepang and sometimes spear trepang from a canoe. Sometimes children swimming would collect trepang. I asked him if old people from his country ate trepang and he thought the old people in Gove might do so.

Knowledge about trepang given at other times
Most information was not obtained from attempts to conduct a TEK interview, but at other stages in the process. Usually this information was given out on country, or when talking with traditional owners at an outstation. For example, once a young man who accompanied the team on a survey told team members where he had seen trepang, without prompting. He also offered interpretations about trepang absence in an area we had surveyed, explaining that he had seen them washed up on the beach after cyclones. Once the project coordinator asked a senior traditional owner for appropriate places to hunt for trepang because he was unsure. Once a traditional owner enquired of me whether the team had found any trepang that day. He seemed
a little concerned because he had told us that trepang were at the locality we had surveyed but thought that commercial fishers may have harvested them.

Three additional times an old man I interviewed volunteered extra information. I was staying at this man’s house for about a week and this information was provided during that period of time. Information he provided included mention of trepang at yet another locality before Cyclone Tracy. After that cyclone the area filled with mud in which he would sink up to his knees when walking, and trepang were absent. Another time I asked him whether he had seen trepang in the southern section of the park. I showed him a map I had with me and he explained in great detail the environmental conditions in each bay around the southern section of the peninsula. Most of the bays contained turbid water. He indicated that these would be suitable to survey during weather conditions with little wind “like now”. There was also lots of reef there. Another time, after team members found no trepang in an area he had suggested, he said, “maybe they take them all away”. Then he said to go at low tide (in that bay we had used the camera that day during high tide because low tide was at 7.30 p.m.).

Sometimes I found it easier to ask only one or two questions rather than attempt a formal interview. For example, when interviewing the two old men with whom I had experienced some difficulties communicating (see above), I simply asked whether they knew where the trepang was and they suggested some areas. This information was obtained when sitting around a campfire eating a meal together, while they were visiting the outstation where the team was temporarily staying. I introduced the topic by explaining the work the team was engaged in, although they may have already had some understanding of this from other team members. I also opportunistically used two other occasions to ask people attending meetings whether they knew where trepang could be found.

Other types of information
A meeting was a formal mechanism used to obtain knowledge about appropriate people to interview. For example, the second Cobourg Board meeting was the forum for obtaining a list of names of people with whom to collaborate, and of appropriate people from whom to seek knowledge. However, at times team
members advised me during the survey about other appropriate knowledge owners we should speak with.

Other types of information were given to me in a variety of circumstances, but mostly in an informal way as the need arose. For example, I asked the project coordinator during a lunch break his thoughts about the process of conducting collaborative research, rather than using the interview context. I sought team members’ impressions of the collaborative research process by first offering my interpretations about “working together”, to which people often added their own thoughts.

**Principle 5: delegate responsibilities**

Responsibilities for aspects of the contractual research were delegated among trepang team members between September and November 1997.

*Related to the trepang survey*

Most delegation emanated from the person employed as project coordinator. He took a leading organisational role and usually undertook aspects of the work or delegated to team members including me. He took on the responsibility for coordinating and encouraging collaborators and non-team members, organising trips to and from the study area, and arranging food, clothes and other items for the field trips. He arranged access permission and/or public relations with other clan representatives.

He usually drove his private boat and car, but when he was unable to do so delegated the responsibility to another team member. He demonstrated western scientific survey techniques to other team members after I showed them to him. He repaired equipment such as the camera and generator. He also asked that I leave the equipment with the rest of the team when I went to Darwin so they could continue data collection themselves, but I was advised that this was not possible as the equipment legally belonged to EA.

There were numerous everyday delegations by this person. Because I did not record every delegation they are recorded in Appendix A as simply a ‘large number’. For
example he delegated tasks such as cleaning the boat, refuelling the generator, preparing food for the night and arranging accommodation at Black Point for team members. He also arranged responsibilities for collecting data for the contractual research. For example, he would tell a team member to collect a sediment sample when required.

I checked most things I was unsure about with the project coordinator. For example, at a meeting I was told by a traditional owner that he wished to replace one of the collaborators nominated for the trepang team. I was concerned because the Cobourg Board had approved a different person so I informed the project coordinator, knowing he could initiate the appropriate action. I also sought his advice about the best strategy for repairing equipment, and his thoughts on recording ethnographic data about the research process. The project coordinator also asked me if he could provide some comments on a book chapter I was writing about the collaborative research process at Maningrida.

Occasionally someone other than the project coordinator also delegated work. A PWCNT ranger was transporting a team member and myself to the airport so I could return to Darwin. He informed me that PWCNT would probably pay for the fuel if we used the project coordinator’s boat. Since I was returning to Darwin I suggested to the other team member on the boat, who was returning to the outstation where the project coordinator was, to pass that information on to the project coordinator.

The NLC took a role in relation to the trepang employment and training grant, as requested by the funding body. It arranged the paperwork when collaborators were changed, and lobbied PWCNT to supply the boat for the project. I tried to delegate the training component of this grant to accredited trainers, but this part of the training grant was terminated at the last minute, as noted above.

Other
The project coordinator once asked me to approach the head ranger about staying at PWCNT accommodation that night because he had chest pains and wished to be near the airport.
**Principle 6: communicate with key persons**

Instances where I needed to liaise with key persons about aspects of the research occurred on all data gathering field trips, that is in December 1995 and May 1996, and between September and November 1997.

*Non-Aboriginal PWCNT staff*

The greatest number of liaisons were with non-Aboriginal people including PWCNT staff, NLC representatives and DEETYA representatives before the trepang team had been formed. Most involved planning of the research.

PWCNT staff were consulted to arrange six field trips and the field schedule proposed for the trepang team. I spoke with staff early in the research process because there appeared to be logistical difficulties with the research due to lack of staff, which they confirmed. They were consulted about renegotiating project objectives, and about paying the project coordinator for use of his boat when difficulties arose over supply of the PWCNT boat. I also spoke with a PWCNT ranger to request accommodation for myself on the first data gathering trips, and later after the trepang team was formed.

During the first three data gathering trips, before the trepang team was formed, I networked with PWCNT to ask for a boat/ranger approximately twenty times before the first Cobourg Board meeting and twice after the second Cobourg Board meeting. However, PWCNT officers assisted with the sledge design in that time.

NLC officers were key contacts for advice about employment of traditional owners, and conveyed information about or assisted with organising the field schedule, the boat and accommodation. DEETYA representatives were necessary liaison persons for arranging the employment grant, but they also conveyed to me some concerns they had because they had received complaints from PWCNT personnel about the employment grant and the training program.

*Project coordinator*

Once I received notification that DEETYA would fund the employment grant for traditional owners, the project coordinator became the key contact person for liaison
and organised all matters related to the contractual research. He was involved with the day-to-day planning for trepang data collection (see above). He was involved with renegotiating project objectives, discussing training options, and requesting permission to record the process. I informed him of a change of collaborator on the employment grant, given to me by another traditional owner at the second Cobourg Board meeting, in case he needed to let other clans know. I discussed with him the possibility of using his boat on the research when there appeared to be difficulties over use of the PWCNT boat. On four occasions he tried to arrange collaborators when they had not arrived as expected. I discussed my interpretations of collaborative research with him and I convinced him about the importance of surveying a nearby area, after which he carried out a “P.R.” (public relations) trip to visit the traditional owner of that area. He suggested that I visit Maningrida because he would not be available at a time we had previously planned. He volunteered information to me regarding alcohol problems in one clan area that he felt would affect the work schedule. He also made suggestions including extending the survey to Croker Island, speaking to a person there about trepang knowledge, and other research ideas he had for the park.

Other Aboriginal persons

Other important people with whom I interacted at times were traditional owners present at the two Cobourg Board meetings. At a prior meeting with traditional owners I discussed employment of traditional owners on the project, and requested the names of appropriate people to interview.

STAGE 3: INTERPRETING RESULTS

Team members and other non-team members gave interpretations about the results of the trepang survey during the data gathering period described earlier.

Principle 1: ask for community members’ interpretations

Trepang presence/absence

Interpretations about trepang were given in the field, at home after a survey, or informally during visits to a locality, rather than during a formal process of
collecting people’s interpretations about the trepang research results. Once during a
trepang survey I commented that there were not many trepang at that locality and the
project coordinator remarked that commercial fishers must have taken it all away
because an old man had seen them collecting there the previous year. While talking
about a survey where no trepang had been found, one person said he saw large
numbers on a beach after a cyclone. Another time after finding no trepang in an area
an old man mentioned that commercial fishermen must have taken trepang away
from that area. Once when I gave an old man a lift from his home he told me there
used to be large numbers of trepang at one locality but that the cyclone had filled the
area up with mud and trepang were no longer present.

Other matters
People also gave interpretations about other matters during the process of data
gathering. These interpretations are included to suit the guiding framework
developed. Once I asked the project coordinator about his thoughts on the
collaborative research process. I asked whether researchers should work together in
the sense that we conduct some western research activities and some activities
Aboriginal people desired, such as checking out country, hunting etc. and he agreed
that that would be useful. Another time the project coordinator provided his
interpretations on mechanical difficulties with the equipment: he said that problems
with the underwater camera were because the camera was upside down in its casing
(although this was incorrect). Another time the project coordinator offered his
interpretations about the political situation at the park and said there was something
going on in another clan estate because PWCNT was paying for the funeral plane for
members of that clan. Another time the project coordinator interpreted the weather
conditions and their effect on the trepang survey, suggesting that we would get stuck
in the boat in the shallow water because the wind would die down.

Principle 2: explain your own interpretations

During the trepang survey
I did not have the opportunity to formally present the results of the contractual
research as I had been asked twice to leave the park, and had been told that I should
not have come to the second Cobourg Board meeting. I did not wish to pursue
another meeting with the Cobourg Board to present the results of the survey, so gave preliminary interpretations in the field during the data gathering period described earlier. For example, I remarked that commercial fishermen must have been at the locality we were surveying because trepang were all less than harvest size. Another example of offering my interpretations during the trepang survey was when I concluded that the water was too shallow for filming because the onboard monitor showed it to be murky, probably from tidal movement at the time.

**Principle 3: synthesise results sensitively**

*Attempt to synthesise results*

No attempt was made to seek different interpretations and synthesise these in a formal sense because I did not wish to request another visit to the park (see above).

**STAGE 4: MAKING RECOMMENDATIONS FROM THE RESEARCH**

**Principle 1: incorporate ideas from all sources**

Recommendations were given during the data gathering period described earlier.

*Ideas given during TEK survey*

No formal questions about trepang management or research recommendations were asked during the TEK interviews, and consequently no interpretations were offered at them. This is largely because I could communicate effectively with only one person, and at the time of the interview I did not have my notes with me. The interview emerged when he told me some things about trepang he felt I should know, and so I followed up with further questions. I did not specifically ask about management recommendations.

*After trepang survey/results feedback*

Sometimes after a trepang survey some recommendations were given by team members. The project coordinator suggested that we establish a plot and monitor it for trepang abundance at different lunar phases. He also suggested that we conduct research to supply trepang as broodstock rather than continue to commercially
harvest the resource. He mentioned a desire to research mudcrab stocks as a future research project.

**Principle 2: ensure community approval of material for publication**

*Literature sent for approval*

In October 1998 I sent a progress report to the Aboriginal PWCNT ranger at Black Point ranger station, asking that it be passed on to the project coordinator and other clan representatives.

I also mentioned to an NLC officer that it would be desirable to have the project coordinator read a newsletter article intended for publication and provide comment.

*Receipt of response*

I heard nothing from the project coordinator by the date I had specified, so forwarded the progress report to PWCNT. A few months later an NLC officer was communicating with the project coordinator about trepang and mentioned my progress report. (I had asked the NLC officer for an address to which to send the progress report as the project coordinator had moved permanently to Cobourg). The project coordinator asked the NLC officer to let me know that he had never seen any progress report, and the NLC officer complied. By that stage it was too late to incorporate any comments/changes the project coordinator wished to make.

When the project coordinator visited the NLC officer on another matter, he added his input to the newsletter article I had written.

**Principle 3: ensure ongoing monitoring**

*Through existing activities*

There were no existing mechanisms through which a trepang monitoring program or other resource monitoring activities could be established or continued. Although the Cobourg Board was a formal structure through which research proposals could be endorsed, nothing appeared to be in place to encourage or support traditional owners to undertake resource monitoring activity other than through any PWCNT ranger
vacancy. PWCNT may have been able to offer technical advice and support to monitoring activities, but staff numbers had not changed during this research period, suggesting that staff shortages were still a problem for park management and therefore for assisting Aboriginal people in such work.

*Unfulfilled desires*

Quite clearly the technical/mechanical competence of the trepang team and the scientific understanding of the project coordinator suggested that it would be within the ability of local people to conduct research and monitoring, if adequately resourced. For example, when I mentioned that the team could establish a control plot for monitoring purposes at one of the locations we had surveyed the project coordinator questioned this suggestion — he said team members could not control variables like sediments and nutrients — demonstrating his understanding of western science. It was clear that the other team members were interested in conducting the research because twice the project coordinator suggested I leave the camera with them so they could do the research themselves. Once when I forgot to get a sediment sample a trepang team worker reminded me to “get some mud”, showing that team members were aware of the procedures involved for the western-based sampling techniques.

**Principle 4: ensure ongoing management**

*Initiation of management strategies*

No new management strategies for trepang were recommended by local people, because of political difficulties concerning my return to the park and Board meetings and because of difficulties with correspondence and communication with team members. Since management of the park was supposed to be conducted under the auspices of the Cobourg Board, and my recommendations used for informed decision-making and management by all stakeholders, I hoped that the final trepang report I submitted to PWCNT would be adequately discussed at a Cobourg Board meeting in my absence. At the time of writing this thesis I remain unsure of the reactions of Cobourg traditional owners to the contractual research report.
CHAPTER 6: COMPARISON OF THE RESEARCH PROCESS AT THE TWO STUDY AREAS

The case studies in the preceding chapters were presented according to the methodological approach outlined in chapter 3, which was developed to guide the participatory research process. While the same framework and its component principles were applied at each locality, certain attributes and characteristics of the principles varied between the study areas.

The narratives in chapters 4 and 5 describe many obstacles to the collaborative research paradigm becoming dominant. This chapter summarises the similarities and differences in the research at the two study areas, based on the results presented in preceding chapters. Similarities and differences are discussed with respect to each principle and to the component attributes found to be qualitatively or quantitatively dominant in characterising that principle.

The research was designed to collaborate directly with Aboriginal people in two study areas. The many indirect interactions with government personnel at Cobourg, where it is clear that government organizations are still driven by the western ideology, is perhaps the major difference between the two study areas. Elements of government presence intruded into many areas of the research and coresearchers were forced to deal with these added complications. Despite the point of view of the agency often being counterproductive to the work, interactions with the agency were necessary, and so impacted on the degree and quality of participation that eventuated during the process. These instances are expanded and described according to the guiding framework, and combined with other research findings, to interpret and present key concluding points for collaborative research processes.

Further detail is presented by discussing some fundamental features in the analysis of collaboration: the level, or degree, of participation that occurred, and the structures and mechanisms that aided or impeded participation. The level of participation is assessed by referring to the classification scheme proposed by Biggs (1989 in Okali et al. 1994:20–21), described in chapter 2, and by describing the roles of stakeholders during the process. Participatory ‘structures’ refers to organisations,
constitutions, constructions or arrangements that were part of the research process, and participatory ‘mechanisms’ refers to methods, systems or procedures used in the process. Together, these similarities and differences, and their fundamental features, are used to provide important interpretations about the collaborative research process.

The research style is dynamic rather than linear. As with all approaches where hypotheses are continually refined over time, theory and results from other research need to be added to clarify why certain results may have appeared, and to assist in the interpretations and conclusions that are drawn. By combining the results of past research findings with results and interpretations in this research, the conclusions and key points generated are of greater validity. This style of research also reflects one of the key themes reiterated in past research of this nature - the need for flexibility in the process.

STAGE 1: PLANNING THE RESEARCH

Principle 1: critically examine collaborative research recommendations

Similarities and differences in the study areas
This research derived principles and developed a guiding framework for the research process for both study areas. Constructing guiding principles initially involved undertaking another principle, one not explicitly mentioned by the data sources: that of understanding and critically examining research recommendations for collaborative work. It was necessary to obtain and comprehend these recommendations and their implications for cross-cultural research before other principles could be developed, and thus constructing the principles was integral to the research process.

Research recommendations were obtained from relevant data sources (institutional guidelines, the literature, and telephone interviews). Some protocols exist in printed form and are readily available from many research and educational institutions, government institutions, Aboriginal organisations and land councils (e.g. ATSIC

Other recommendations were obtained from Australian literature sources, which helped to set the Australian context in this research. Those few ecological research programs in which Aboriginal people participated during the entire research process provided important advice for achieving desired outcomes for both parties (e.g. Reid et al. 1992a, Baker & Muitjulu 1992, Walsh 1995). Such previous applications provided background observations and interpretations for deriving the principles used in this study.

Telephone interviews were also extremely useful for both generic and specific information. In particular, professionals with working experience in the region or community in which this research was conducted provided important contextual detail and past profiles of the study area.

When summarising research protocols, the characteristic attributes of recommendations became the basis of subsequent principles in the guiding framework. Thus the principle of understanding protocols to derive a guiding framework was duplicated for both localities because it was a necessary prerequisite to further progress. Because this component of the research process was developmental in nature, occurring prior to negotiating study areas, there were no differences related to study area.

In developing a participatory research project elsewhere, the principles derived in this project may require amending; creating new principles may even be necessary, particularly as further participatory research is conducted and new results publicly disseminated. This is because though generic themes can be found, site-specific differences occur (White et al. 1994c:107). Thus the principle of understanding recommendations and deriving a framework offers a guide to establishing a collaborative project, but specific details may not be the same for collaborative research with other communities, or in other circumstances.
Participation, roles, structures and mechanisms

While understanding recommendations for collaborative work is not a participatory activity, the implications and effects of observing this principle, or failing to do so, will fundamentally decide project success or failure. In fact, appropriate implementation of research is argued to be more important than the project itself, because without the appropriate framework in place the research may not be viable at all (Dale 1996:110). That observation is endorsed by the findings of this research, illustrated by the two occasions on which a BAC member confirmed to me that organisation’s reasons for collaborating with me: he said it was interested because I explicitly expressed an understanding of the appropriate protocols to follow in my initial approach to the organisation.

This principle is the responsibility of the novice, and sometimes the experienced, community-based researcher, as part of their obligation and role in the participatory process. Appropriate behaviours and conduct, not previously recognised or comprehended by me, were sometimes conveyed to me by community members at later stages. Community members therefore had a role in furthering my understanding about working with Aboriginal people. However, I suggest that this two-way interaction was facilitated through firstly demonstrating a firm commitment to working to those protocols of which I was already aware.

Since I was enrolled in Ph.D. research prior to securing the contracted trepang research, I used early stages of my candidature to read and comprehend appropriate recommendations. Had I not been in receipt of an independent scholarship for the research it would have been more difficult to find adequate time for this activity. Further, justifying the necessity of this work to superiors, whose focus is to supervise contractual research based on a primarily biophysical data collection agenda, would not have been an easy task.

Analysis

Becoming familiar with protocols was a necessary principle to guide the research approach and to instruct a novice western researcher in appropriate attitudes and actions during the process. It was of paramount importance, because an appropriate attitude and work ethic set the foundation for the working relationship.
Birckhead et al. (1996:127, 128) and Dale (1996:113) suggest that future western researchers work within a more politically informed research culture, because research has frequently supported the political and social orders that marginalise indigenous people. They maintain that researchers need to understand protocols for working with an Aboriginal community to avoid negative impacts from research on a potential partner community, which have occurred in the past.

However, I suggest that understanding research recommendations is an activity that needs to be undertaken with motives beyond that of avoiding the negative impacts and power differentials that research frequently creates. It is possible that a researcher might demonstrate commitment to an equitable research process for the sake of principle but never delve beyond a mere adherence to protocol, and thus never take advantage of the full potential learning opportunities that are presented. Becoming familiar with cross-cultural research recommendations merely lays the foundation for understanding another cultural system where values and practices differ vastly from that in which most western researchers operate.

Demonstrating and acknowledging these principles is primarily the role of the outside researcher. However, obtaining an informed understanding is lengthy and should ideally occur over extended periods, because the researcher should observe this principle with an enquiring mind, keeping in mind the protocols to follow but with an additional aim of understanding the foundation to them. This requires that the research go beyond a mere demonstration of the rhetoric of principles, and achieve mutual regard for each cultural value system. In this way, the benefits of the increased knowledge gained by western researchers about alternative understandings of participation, resource management, or issues relating to another culture, are potentially one of the great advantages of a truly participatory approach.

All too often, however, the knowledge generated in participatory research is limited or subsidiary to biophysical knowledge, a point illustrated in Dale and Bellamy (1998:86) in their critique of CYPLUS. There are very few mechanisms for two-way learning and institutional learning in current resource management projects,
limiting the scope of participatory research to western-based biophysical research only, which can hardly be considered participatory.

Claridge and Claridge (1997:3, 30–32) suggest that one of the factors necessary for sustainable collaborative management in Australia is that of a supportive cultural and bureaucratic environment, and this factor is probably equally as important in collaborative research. Achieving cultural and bureaucratic support requires that groups or agencies in positions of superordinate power (such as political, bureaucratic and industry groups) respect local values, approaches and contributions instead of using risk averse, familiar and easily controlled approaches.

To engender the desired respect for local values, approaches and contributions, bureaucracies could allow their researchers time to gain skills in collaborative research. This would require time for researchers to become familiar with protocols for working with Aboriginal people, perhaps in the manner presented in this research, or through other mechanisms such as cross-cultural awareness activities (preferably conducted by the community, or simply through spending time in a community. Buhat (1994:37) describe a case where a researcher in the Philippines first lived in a community for a year to gain acceptance as a partner in a community fisheries management project. Incorporating adequate time for researchers to become familiar with recommendations and conduct their research accordingly requires a reduction in the biophysical data collection expectations of sponsors and funding agencies, in deference to following appropriate processes.

Environmental management would be enhanced by institutional support for researchers to engage in such activity. Respect for alternative cultural value systems and practices requires that funding institutions and partner agencies incorporate mechanisms into their research programs and submissions that allow time for staff to understand the protocols for working with indigenous groups. It also requires supporting staff to be open to the multiple knowledges not recognised due to perpetuation of Eurocentric epistemologies, that exist in relation to resource management, as iterated by Suchet (1999).
Key point: Both individuals and institutions need to understand protocols for working with Aboriginal people and accept that following these are crucial to furthering participatory ecological research and respect for an alternative intellectual tradition.

Principle 2: approach potential communities

Similarities and differences in the case studies
A major difference between the two study areas in this research project began at the outset, when approaching the respective communities about collaborative research.

Walsh (1995:102) advises that an appropriate starting point for collaboration is simply to find out whether Aboriginal people are involved or want to be involved. At Maningrida I followed that advice by sending a letter to determine whether community members were interested in exploring a collaborative research project. In reply I was offered “a job” by the community by the senior community ranger.

However, at Cobourg I did not determine the level of interest from Aboriginal people about collaboration until well into the data gathering stage, because I was undertaking a research project as written by a PWCNT officer and endorsed by the Cobourg Board. That project had no explicit aim to work in a participatory manner with members of the community, so I did not approach the community about this initially, nor were there mechanisms to canvass support for participatory research within the project. Instead, PWCNT rangers, boats and vehicles were stipulated on the research proposal as in-kind support and assistance for the project (with a subsequent condition that a PWCNT officer must be present when using a PWCNT boat). Community members did not have input to my selection as the researcher on the project.

At Cobourg I first followed the intended research arrangements, but much later in the research process, after unsuccessful data gathering trips, I initiated an approach to community-based Aboriginal members about their interest in participating in the project. Following that step, I attempted to carry out the research process in a manner similar to that at Maningrida.
Participation, roles, structures and mechanisms

The two studies describe the alternative ways in which a collaborative research project with a partner community may be initiated. At Maningrida, the level of participation during the approach about participatory research was collaborative, because although contact with an outsider researcher was not initiated from within the community, the research topic was formulated by community members. At Cobourg the degree of participation at the initial stage was contractual because the funding agency hired me as a researcher and the services of PWCNT through contractual and subcontractual arrangements. Much later in the research process I approached traditional owners about their involvement in the research, but because the topic and methods were predetermined, participation could be regarded as contractual in the sense that I merely asked traditional owners whether they wished to work on the project.

Letters and formal meetings were mechanisms used to approach the community at Maningrida, assisted by the structure and infrastructure of BAC.

The community at Cobourg was approached about the research proposal through the Cobourg Board, as detailed in chapter 5. This structure has its own mechanisms for information sharing between stakeholders (see chapter 3). My eventual approach to the community about participatory research also occurred through a Board meeting, and the Board endorsed increased participation by traditional owners. The Board members involved in this structure directed me to seek an employment grant to assist participation.

Analysis

An approach to community members to consider the possibility of participatory research can take a number of forms. Traditional owners and community rangers, for example, might have expressed an idea that generated a research question and then contacted a researcher or academic institution, which would be an example of collegiate participation (see chapter 2). Or scientists might wish to work collaboratively with a community in order to gain greater insight to the processes involved, and ask if the community is interested, as in my case. Or government
agencies and funding bodies with an interest in environmental research might be required to adhere to particular ethical protocols in working with indigenous people. This latter scenario might entail any level of participation; however, if the bureaucratic motives for participation are built on regulatory necessity, there is a danger that the process will tend toward lower degrees of participation such as contractual or consultative research.

A community-initiated approach to research is the ideal, where provision of outside advice and contact with the relevant partners emanates under community control. A further important issue is that participation needs to occur from the planning stage, that is, at the outset of the research. However, the research on which this thesis is based showed that, depending on circumstances, participation may be initiated whenever possible during the process, and that this is preferable to maintaining merely passive participation. This implies that as understanding, trust, contact, interest, or other circumstances change, community members may wish to alter their level of participation, and the project should be flexible enough to accommodate changes in the degree of local involvement. The important finding in this research is that the two fundamentally divergent management structures involved both indicated in-principle support for community members’ participation in the research, even though the approach was initiated at differing stages in the process. However, practical outcomes of community participation were different in many respects at the two sites.

At both localities mechanisms for stakeholders to meet and consider participation were mainly via formal channels and occurred through the various institutional and community-based structures. A useful mechanism that funding agencies and bureaucracies may wish to adopt is to make it easier for coordinators within communities to initiate and approach partner agencies about research. Claridge and Claridge (1997:3, 33) suggest that adequate organisational structures with mechanisms to create links between constituents are important components of collaborative activities.

I suggest that these links are needed simply to help stakeholders and researchers approach or be approached about involvement in participatory research. It is
important that the facilitator be involved with the community, i.e. live or spend ample time in the community, and understand the local context. Suchet (1999) reiterates that cultural transmission and maintenance systems need to be built on to protect local interests. Locally appropriate structures should be used to discuss new initiatives, rather than undermining these by establishing new organisational structures.

Field workers need to understand local politics, history, group dynamics and community values, all of which can be helpful for initial approaches about participatory research. Some positions to facilitate participatory research now appear to be resourced by organisations such as the Indigenous Land Corporation where field workers and liaison officers are employed to make the approaches between community representatives and potential partner agencies.

Outside field workers need to delegate responsibilities and act as objective facilitators and resource persons. They are trusted and credible agents of change and the community is dependent on their fulfillment of that role. Such contacts would require skills in bridging the worldviews of at least two cultures. Whether the best person is a local person or an outside person living in the community would be determined by the community, and probably varies with local politics. It may also be necessary that further on-ground workers in community development, or extension officers, be schooled in non-Eurocentric paradigms to understand the differing approaches, and to expand their roles in environmental research.

**Key point:** Active community participation is desirable for research, regardless of the point at which it was initiated. Field workers could be funded to help establish effective participatory research approaches, and are important because of their grasp of local contextual information and credibility with community members.

**Principle 3: advance community aspirations**

*Similarities and differences in the study areas*

Community members in both study areas held similar aspirations. Both communities expressed a desire for greater female involvement in resource
management activities, local employment, fishing initiatives, on site formalised training and participatory activities with non-Aboriginal resource managers. At both study areas the research topic represented the community’s desire to establish sustainable fishing initiatives. At both localities I also invested a substantial proportion of my time organising a training component within the research program and organising appropriate personnel to conduct accredited training.

While aspirations were similar at the study areas, the principle of using the research to advance aspirations differed. At Maningrida aspirations other than the trepang initiative were mostly raised during the planning stages of the research, because I established acquaintances with community members at this point. As such, I had the opportunity to incorporate some of the additional aspirations mentioned into the research program at an early stage.

At Cobourg I had no contact with community members during the early stages of the research and could not elicit further community aspirations of my own accord, until there was an agreement to work in a participatory way. I had several meetings with traditional owners to discuss aspirations, which mainly related to aspirations that could be met by western-based training programs, because training was a condition of securing an employment grant. After formation of the trepang team I had greater contact with community-based members and at that stage became aware of other aspirations, some of which were incorporated into the research. However, I did not provide opportunities for benefits such as links to outside researchers for GIS activity, as I might have done had I known of their aspirations at an earlier stage.

Another difference between the study areas was that at the time of the final field trip at Maningrida (to present results to community members), trepang aspirations had advanced toward a more specific goal — that of investigating the feasibility of trepang aquaculture. At Cobourg I was not able to learn of aspirations of the community after my submission of a final report of the contractual research to PWCNT, and thus cannot comment on any changes in community aspirations as a result of the research findings. The progression of community aspirations at Maningrida from that of harvesting wild stocks of trepang toward setting up an aquaculture venture suggests that the project may have been useful to answer
people’s questions about harvesting wild trepang stocks. From those results community members then reformulated aspirations for that resource. However, this occurred during the process rather than as a segregated ‘results interpretation’ phase of the project (see later), thus emulating an action research methodology based on reflection about the research findings during the research process.

**Participation, roles, structures and mechanisms**

My role varied significantly at the study areas. At Maningrida I was assigned a broad role in the community, that of ranger or marine scientist. This role increased my understanding of community aspirations. Through it I was subsequently involved in formal meetings arranged by BAC. These meetings related to realising community aspirations (e.g. the proposal for a joint crabbing venture). I was also involved in other activities related to community aspirations (e.g. obtaining appropriate ecological books for the ranger station, advising on economic initiatives, providing assistance with the school camp). This role increased my exposure to people and their aspirations. I was also given additional information probably because I was perceived as a ranger. The structure of BAC enhanced perception of that role since I was easily absorbed as a “ranger”, and the organisation offered resource assistance by way of boats and vehicles.

Community members expressed to me the value of my understanding more about the community through involvement in community activities such as meetings or school camps. There were expectations that I become involved at a level beyond that of a contractual researcher. Community members directed me where to use my skills in the community. In this sense, the mode of participation during the phase of working toward community aspirations was a collegiate one.

At Cobourg I was merely a trepang researcher. I had a narrow role, that of the trepang contractual research, and of securing the related employment/training funds to enable local people to participate. The only meetings and activities to advance community aspirations that were additional to the contractual research were related to obtaining the wages and training grant. Those related activities were mainly meetings and telephone conversations with government officers, and were arranged
by myself. The level of participation under this principle reflected a contractual mode of participation.

Mechanisms used within the Cobourg Board structure were formal, in contrast to requests for my participation at Maningrida, which were usually informal requests about which I was at liberty to make judgements on the appropriateness of my participation. However, at Cobourg informal mechanisms, usually chats with the project coordinator after work with the trepang team was underway, were the optimal way for me to obtain additional information about community aspirations. Those interactions occurred following extended contact with the project coordinator.

Analysis

There was support from both communities for further participatory research and for western-based accredited training opportunities. This is probably the result of the impacts on local communities of global market economies and modernising lifestyles.

However, the potential impact of such change is the loss of cultural wealth that is linked to biodiversity (CBIK 2000) not to mention heightened despair and anxiety, youth suicide, alcoholism, violence and social dislocation. Community members repeatedly indicated a desire for young people and outsiders to learn ‘their way’. Since Aboriginal stakeholders appear to be prepared to undertake western-based training programs, there is no recognition of the need for reciprocal training based on Aboriginal intellectual traditions, so that the concept of equitable participation is challenged by most training that is eventually implemented on the ground. Aboriginal people acknowledge the benefit that can accrue through education in western-based systems, but institutions have not yet come an equal distance in acknowledging the benefits of Aboriginal-based knowledge and education. The ways in which indigenous people relate to habitats and resources is little understood by western scientists and institutions, generating gaps in linking cultural and biodiversity processes (CBIK 2000), and for this reason alone, if not for cultural survival, training in this area should be embraced. There are also many benefits to western society from Aboriginal value systems and worldviews, which much of western society has yet to appreciate.
Much personal investment is made by Aboriginal educators during the research process to train outside researchers about some of their values, knowledge and practices, but learning can sometimes be lost because of limited timeframes or divergent agendas. Often withdrawal from the community by the outside researcher occurs far too early, so that opportunities to strengthen the learning process are lost. Components of training programs could be devised and delivered by community members to help trainees to ground themselves in the practices of both knowledge systems. For example, in University and TAFE courses, elders could be part of instructional learning for students, while back in their communities they teach children, rangers and outside researchers. Sections could be built into western courses that encourage students to learn from Aboriginal tradition.

The differences in the stage at which aspirations were understood during the research process are important. Aspirations established during planning can be used in participatory programs to provide indicators of project success, as well as providing tangible benefits for increasing participation and therefore management (White et al. 1994c:115, 116). When research begins with community members informing the researcher of aspirations, the tendency for outside agents either to drive change or to misunderstand community perceptions about research outcomes is reduced. Research that begins in this way is more likely to succeed (Dale 1996:123), not just because community priorities are advanced, but through extra benefits of community interest, ownership and control of the research, tangible benefits to community members during the project, and clearer direction for outside researchers. Establishing aspirations at the start helps to establish process indicators against which the project can be evaluated. Links to future activities are also an important consideration so that the impetus gathered during the project can continue beyond the life of the project.

However, Suchet (1999:275, 276) suggests that the concept of aspirations is not necessarily universally appropriate because it suggests that aspirations can be interpreted and articulated by outside researchers, and further, aspirations are not static. Walsh (1995:88) stresses the need for flexibility of research plans, developed in conjunction with local people as their needs require. Flexibility and local
development of research plans mean that rigid objectives may need to be revised, not merely at the start of the research process, but again at various stages during the process, emulating an action research style. Pursuing a research objective that is found, for example, to provide no new knowledge or results to Aboriginal people, or to be too technocratic for participation, or that simply does not answer questions community members wish to know, cannot be considered conducive to participation and probably will not produce a sustainable project. Therefore there is a need to continually review and revise a project.

Berkes (1999) stresses that adaptive management processes (described below) are the western-based resource management approaches most closely aligned to and communicable with indigenous knowledge systems. In research guided by adaptive management processes, ecological processes and ecosystem uncertainty are stressed, while humans are quintessentially a component of the ecosystem to be studied. In this way the human use of resources is managed rather than simply the resource. Adaptive management is characterised by ‘learning by doing’, that is, trial and error with feedback learning.

A community role, rather than the role of a contracted worker, also enhanced participation. It increased my understanding of aspirations, information, knowledge and contextual data. In addition to making it possible to understand aspirations and values, that role favoured satisfactory conduct of the contractual research with a variety of traditional owners on different clan estates, and interpretation of other information about the research process. The community role appeared to fulfil community expectations about what constitutes participation — that is, people appeared to desire that I learn about their culture and practices rather than simply conduct research on trepang. A consequence of this finding is the need to understand the concept of participation from the point of view of community members, which would be a useful subject of future research.

Providing mechanisms and adequate time for community members to consider future strategies based on the research is an important part of the process — probably more so than in non-participatory research. In purely western-based research programs, a typical function of a researcher is to apply for and undertake
further research and management, based on previous work. However, equity in this function is also required at the community level if participation is to be active rather than passive. Thus funding for a field worker or coordinator position may be required so that community individuals and agencies can articulate aspirations and submit proposals to funding agencies based on existing knowledge, ideas and methods. This occurs in organisations such as Greening Australia, where farmers write their own funding proposals, assisted by facilitators. However, institutional support for such extension-oriented professionals who have a role and credibility within Aboriginal communities appears to be less enthusiastic than for corresponding roles within farming communities.

**Key points:** Education and training opportunities can emanate from both intellectual traditions. The research style most suited to participatory research appears to be that of action research, with adaptive management systems probably best suiting management of the resource. A community role heightens understanding of factors relevant to the research and to the community, and can thus help to promote equity in participation. Institutional support for such community roles would enhance participatory resource management.

**Principle 4: conduct negotiations**

**Similarities and differences at the two study areas**

Negotiating the research project was vastly different between the two study areas. After I met relevant people from Maningrida and we agreed on the research topic, community members were made aware of the objectives of the contractual trepang project. Two formal meetings were held with community rangers, additional personnel present (non-Aboriginal BAC staff at the first, an NLC wetlands officer at the second) and myself. The first meeting was devoted to explaining the trepang research design and techniques I had in mind to achieve the objectives of the contractual trepang project, and I obtained community direction and input about my suggestions. Community members asked what equipment I desired for the research and said they would make arrangements to obtain it. At the second meeting I explained some changes to the techniques I had proposed. Community members nominated two young women to work with me and they also informed me that they
wished to have a component to the research, which would provide accredited training for collaborators.

At Cobourg I did not have the opportunity to negotiate with the community about the research process until well into the data gathering stage, after three largely unsuccessful field trips. This interaction was also via two Board meetings. At the first meeting I determined that local people wished to be involved in the research, and was directed to seek an employment grant. At that meeting I also used the opportunity to explain the research plan with a view to obtaining community members’ direction and input. At the second meeting I was required to seek formal Board endorsement for the employment and training funds I had secured, because despite substantial on-ground work with traditional owners about the employment and training grant, a number of dissatisfactions had been expressed to me via PWCNT officers. At this meeting a dispute arose between the single Aboriginal ranger employed by PWCNT and a traditional owner. The traditional owner suggested that the issue be decided in the absence of non-Aboriginal people, after which the remainder of the Board were informed of the unanimous community members’ decision to support the research in its entirety and as proposed to the Board.

At both localities, negotiating changes to the research direction was a more substantial component of the research process than negotiating the initial project. This reflects the importance of one of the key principles, that of allowing flexibility in the research at all stages. Most changes occurred during the data gathering phase at both localities, but in reality the changes were most closely related to planning, and, as such, are presented here as a characteristic of the planning stage.

Negotiating changes to the research program was a far greater component of the overall process at Cobourng than at Maningrida. At Maningrida most of the changes to the research direction were related to changes in personnel. This was an unanticipated aspect of the research, but I became aware of the fact that community-based researchers were required to attend other cultural and community activities, and that research projects had low priority in community life in relation to other more pressing issues. Personnel changes were not insurmountable, nor did they
feature significantly in the life of the research program. Nor were changes to the field schedule, financial arrangements, and research objectives major difficulties. Changes usually involved discussing an alternative approach with an appropriate liaison contact person (see principle 6), working with another person, or waiting until another time. As those changes occurred during the data gathering stage, when the time I spent with members of the community increased, alterations to personnel became easier as a result of my familiarity with the people and community matters and as appropriate procedures improved.

At Cobourg most changes were related to personnel, resource availability and research objectives. However, different individuals within PWCNT frequently conveyed conflicting information or non-committal responses when I discussed changes. Their responses impeded or completely prevented maintaining the logistics necessary to carry out the work. Although the changes in direction occurred during the data gathering stage, they usually required re-planning of intended aspects of the work, or a rethinking of the project direction, albeit at times only temporarily, based on different information. The changes may be summarised as: altered arrangements for vehicles and boats due to PWCNT staff shortages and inability to deliver in-kind support; incorrect advice from PWCNT officers about kinship relations, the project coordinator, and at times, the project coordinator’s access to other clan estates; incorrect advice about trepang distribution and abundance; imprecision in advice from PWCNT officers about whether I should work in the Cobourg area; repeated explanations on my part to PWCNT officers, and at times, to traditional owners, about the nomination procedure and reasons for selecting the trepang team resulting in difficulties with employing local people; shifting support of the formalised training by DEETYA/CES officers; termination of my contract and park access by a PWCNT officer (because I had used accommodation originally offered as in-kind support on the project for the benefit of other members of the trepang team); arranging a judgement on trepang research via an out-of-session Board resolution (the legal mechanism for resolving disputes between PWCNT and the Board) as to whether the research was supported; and, finally, participation in discussions about team park access and contract, which were eventually support under revised terms and conditions (after the data gathering stage was finished). Non-flexibility in approach on the part of PWCNT officers was a source of the difficulties with
renegotiation, as they did not want the original research objectives altered to reflect the changes suggested by other stakeholders such as EA and NTU.

During data gathering activities with the trepang team changes to personnel and the field schedule did not involve insurmountable difficulties, because the team discussed alternative arrangements on a day-to-day basis as problems arose.

**Participation, roles, structures and mechanisms**

During negotiations, levels of participation at Maningrida were fairly equitable, with both parties specifying terms and conditions from the outset. This occurred mainly through BAC and meetings, whereas later changes were incorporated through informal mechanisms such as key contact people (see principle 6). At meetings I was always invited to detail my ideas first, after which community members indicated their requirements of me during the project. This is collegiate interaction because community members directed the meeting including the order of speaking. Changes to the research direction usually involved my informing the senior community ranger of a problem and either he or I suggesting an alternative approach.

At Cobourg I did not receive any community prompts about my intentions for the research: I simply carried out the work I was contracted to deliver. When I was changing the focus of the research direction toward participation, I prompted the community and they indicated their desires for participation — a move toward a consultative approach. Participation was negotiated through the formal channels of the Board.

After that step almost all other negotiations about changes of the research direction at Cobourg involved another external stakeholder, i.e. PWCNT, although many changes were directions rather than negotiations. I often argued against its suggestions, which resulted in two-way communication but in a strained rather than conciliatory atmosphere. I eventually resorted to the formal conflict resolution mechanism contained in the Cobourg Peninsula Aboriginal Land and Sanctuary Act. Changes were negotiated through discussions and meetings with personnel in external agencies, and through the Board.
The changes in the day-to-day activities at Cobourg that occurred during the data gathering stage were negotiated informally through discussions with the project coordinator and other members of the trepang team. Changes to personnel were collegiate, with traditional owners informing me of field work arrangements and who would constitute the trepang team.

**Analysis**

Negotiating changes to the project was far more substantial than negotiating the project itself. This again reflects the key characteristic of the need to retain flexibility during the process, again probably best suited to an action research methodology.

The research project was negotiated at the start at Maningrida but not at Cobourg. Changes to the project were more substantial at Cobourg. Negotiating changes at Cobourg also involved an external stakeholder, which impeded the project. Eventually differences in renegotiations were resolved through formal channels for dispute resolution.

Claridge and Claridge (1997:3) suggest that mechanisms for conflict resolution need to be part of the negotiated arrangements and of the process itself. Collaborative arrangements with Aboriginal people frequently require the negotiation of a research agreement where stakeholder roles, objectives, feedback mechanisms and other details are specified. This is because of the emerging issues regarding ownership of research by Aboriginal individuals and groups, a principal consideration when undertaking research with Aboriginal people. These issues are governed by recent research and developments in the legal sphere relating to Aboriginal rights, including ownership of knowledge and resources. Agreements are now a typical requirement when undertaking partnerships with Aboriginal people and representative agencies. Simply articulating the research agreement may lead to a more complete understanding of the perceptions of the work from the point of view of all stakeholders. However, the act of signing a form may be intimidating for many people, who prefer verbal consent/agreements (Suchet 1999:25); this needs to
be kept in mind, and the agreement probably needs to be carefully articulated by a trusted intermediary.

I received a written reference from a BAC representative who explicitly stated his pleasure that in the course of my work I had always sought advice when unsure of directions to take. I conducted the work in the same way at Cobourg, always seeking advice, but was unsuccessful in many respects, again probably because of the agenda of the external government stakeholder. For this reason, a research agreement would have been more useful at Cobourg.

At the United Nations Conference on Environment and Development in Rio de Janeiro (1992), Australia was signatory to Agenda 21 and the Convention on Biological Diversity. Although this instrument is not legally binding, domestic institutions have expressed commitment in principle to protecting indigenous intellectual and cultural property and the right to preserve customary systems and practices.

In Australia, the National Strategy for the Conservation of Australia’s Biological Diversity has attempted to reflect some of those commitments. It proposes that the use of traditional biological knowledge in scientific and public domains must occur under the control of traditional knowledge owners. That strategy suggests developing collaborative arrangements to safeguard traditional knowledge, taking into account existing intellectual property rights. (It also recommends royalties from any commercial developments in relation to that knowledge.) Bennett (1996:5–9) suggests that intellectual property is subsumed within selected provisions of the Native Title Act 1993, which protect customary use of biological resources in accordance with traditional laws and customs. Together with current international commitments, there is a strong argument for ensuring that research should in no way produce results that could diminish the enjoyment and exercise of Aboriginal rights. If it did diminish those rights the Commonwealth may be exposed to the need to provide compensation, and would continue the history of grave injustices related to usurping or impairing commercially beneficial rights of indigenous people.
Dale (1996:113–116) suggests that the failure of many projects involving Aboriginal communities is related either to the negotiation process or to technical factors. Negotiation with Aboriginal communities and about following protocols may be a complex process and may be constrained by social, cultural, historical or political considerations, with the possibility of misunderstandings. However, the important point is that negotiation should basically require finding and conferring with the appropriate people to obtain their opinion or advice, and should analyse benefits and losses to check that circumstances are equitable in the negotiation process (Walsh 1995:102, Birchkead et al. 1996:131).

As Suchet (1999:107) claims, traditional power structures and systems, including spiritual authority, can be ignored and subsumed by imposed formal authority structures, and would probably be ignored in the co-management models imposed at Cobourg. Indigenous groups have to negotiate on Eurocentric terms that reimpose colonial domination in these contexts. Not only must they accept working within an external paradigm but they also have to give ground on fundamental points. Suchet (1999:290) suggests that negotiation should be between knowledges and explains that even the concept and practice of the negotiation process are dominated by western experts who bring their own interpretations and set agendas to the process. Community needs for resources, including financial and human resources, bring an added element of one-sided power to the negotiation. Negotiation also requires compromise to achieve outcomes for both parties, but when one party holds a position of superior power, it may be necessary to recognise that those stakeholders, rather than indigenous people, need to give ground. In this way cultural and epistemological diversity can be retained through multiple knowledge approaches rather than retaining a singular western approach to research, perpetuating non-participatory research.

On an everyday basis, (i.e. changes in the data gathering arrangements) negotiations are probably much easier, and key community contact people who act as channels can be useful for negotiating details of the project or changes in direction. In the research process presented here everyday changes were easily accommodated, probably because community decision-making mechanisms were used in relation to everyday changes in the project and I was informed of the outcomes of decisions.
Key points: A research agreement is useful so that all parties are clear about the work from the start. Conflicts can be avoided by regular review and mechanisms by which parties may alter the work. Agreements should recognise the knowledge contribution of both parties, work with existing structures and resources, and recognise imbalances in the terms of reference of the work.

Principle 5: establish personal relationships

Similarities and differences
During the planning stages at both study localities I did not have substantial contact with community members in the field, and relationships at that stage were established through meetings. At both localities those meetings were related to the trepang research: planning, negotiating or arranging some aspect of the research.

At Maningrida these events occurred at the outset of the research; at Cobourg they occurred after the first three field trips (prior to formulation of the trepang team) and during the data gathering stage, but in reality were a stage of ‘re-planning’ the research.

Participation, roles, structures and mechanisms
All interactions were probably collaborative in nature, because they simply involved each party conversing with the other in an informal sense, about general interest matters unrelated to trepang research. Most interactions were initiated by me as I sought to engage in conversation with local people.

Engaging in informal conversation was a simple but an important technique to establish relationships and demonstrate a commitment to working with community members, and more importantly, to demonstrate the ability to listen attentively to people. These are mechanisms that almost any researcher would use in an everyday work situation in an effort to bring a human element to the workplace environment and to elicit general information.
Analysis

In the initial planning stages meetings provided the opportunity to informally establish relationships with some individuals. Time and care need to be invested to establish good relationships because these interactions demonstrate an interest in and commitment to the community and its constituents. Acute listening and observation skills are important tools for an outsider researcher.

Listening to information provided voluntarily, rather than listening to answers given in response to a question, can generate very different types of information, particularly something not thought of by the outside researcher. Berkes (1999:xiv) mentions the importance of obtaining and processing information that is volunteered rather than given in response to prompted questions. He found that when undertaking activities at the request of elders his learning experience was different because views of life, spirituality, relations with missionaries, animal population cycles and so on were transmitted; information about which he would never have thought to ask.

In her analysis of Aboriginal English and its implications for communication in the legal domain, Eades (1992:28, 33) also mentions the importance of people volunteering information. It is a feature of Aboriginal communication that speakers hint at what they are trying to find out about, and information is sought as part of a two-way exchange. Silence, and waiting until people are ready to give information, are central to Aboriginal ways of interacting so outside researchers attempting to elicit information using one-sided questions (e.g. why, what happened) are usually unsuccessful. Furthermore, direct questioning is also frequently inappropriate. This may be because of gratuitous concurrence, discussed by Eades (1992:51) and other culturally inappropriate communication techniques she discusses, such as insufficient time to think. (Gratuitous concurrence is when the speaker agrees with whatever is asked, often not in agreement but as a peacemaking gesture, or because the question has not been understood.) Understanding of Aboriginal communication strategies is important to establishing relationships.

Key points: It can be more important to listen and observe than to ask questions; thus participant observation is a most useful data collection technique. It is also
important to understand, recognise, and respect, Aboriginal communication strategies.

**STAGE 2: DATA GATHERING**

**Principle 1: establish personal relationships (continues)**

*Similarities and differences*
During the data gathering stage at Maningrida I established relationships with a range of community members. Those relationships were established during extended visits and constituted a significant component of the data gathering stage. Encountering a broad range of people was probably facilitated by attending meetings unrelated to trepang research, engaging in conversation with people at the BAC office, or in passing, or when people came to my residence. My perceived role as a marine ranger also provided opportunity to establish relationships with people during everyday community activities. For example I was asked to transport children in the trepang boat to and from the school camp conducted by elders. I was also asked for lifts and other small favours (which were reciprocated) probably as a result of extended periods living in the community and gaining familiarity with people.

At Cobourg I had much less contact with members of the community, being mainly restricted to contact with members of the trepang team, or, less frequently, with a traditional owner at whose house I was temporarily located. Those relationships were built mostly during informal conversation while eating meals together, or at the outstation where I was staying before or after work.

At both localities, establishing relationships during trepang surveys constituted a relatively large proportion of relationship-building interactions. Those interactions mainly occurred while eating meals around a campfire during a lunch break, and during attempts to speak the local language, usually in relation to a physical resource (such as fish) that we were observing.
Some relationships were established when seeking knowledge about trepang for the survey from people at their homes. At Maningrida a relatively large number of interactions involved visits to people at their homes to seek their presence on a boat trip; other times I visited people with whom I interacted while attempting to collect TEK about trepang.

At Cobourg I noted several conversations which I interpreted as two-way attempts to foster encouragement in the research and/or build a sense of trust between team members.

**Participation, roles, structures and mechanisms**

At Maningrida, participation was collaborative during the establishment of relationships because people often told or taught me information and vice versa, and because we interacted in a two-way relationship typical of a workplace, such as eating a meal together. Such two-way communication is an important interaction technique, as mentioned above (Eades 1992:28). Attempts to learn language were important.

Relationships were probably facilitated through community members’ acceptance of me as part of the BAC organisation, and subsequently through a variety of mechanisms such as my role as ranger, as well as everyday happenings such as visits at home, passing someone in the road or seeing someone at the office. This recognition was confirmed by the comment of one old man whom I went to interview that he had seen my face around; others knew of the “trepang boat”.

At Cobourg, relationships were established through the wages and training grant I had secured, which allowed the trepang team to organise field trips and spend extended time together as a team. Had this grant not been secured, it would have been very difficult to establish and continue relationships with traditional owners of the area.

At both areas, the processes involved personal commitment and regular contact at a number of levels over an extended period. Knowing someone personally, sharing
experiences, and engaging in relaxed times are important ground-working techniques, as mentioned by Walsh (1995:103).

Frequently information is conveyed over time. Data collected in this way will ensure that misunderstandings do not occur or information is not incomplete, giving the interpretations of the outsider researcher a higher degree of integrity. In order for the participatory process to be effective, outside researchers should not be hurried or working to a deadline with little knowledge of the community (Walsh 1995:97, Birckhead et al. 1996:129), but should take time and make a specific effort to that end. White et al. (1994c:119) say that community-based management systems need time to evolve, a decade probably being the minimal commitment. Again trust in the relationship, and allowing silence and thinking time in interpersonal interactions as mentioned by Eades (1992:34, 46) are important. Information is frequently divulged at a stage when trust has been built between interacting parties.

Analysis
At both localities relationships were built, most particularly with the people who accompanied me on the survey for the contractual research. The context of surveying on people’s country was an important mechanism for establishing relationships and building information about a range of relevant factors.

A role in the community was also a useful means on which to build relationships, mostly with previously introduced community members. The range of people with whom I established relationships was far greater at Maningrida than at Cobourg, probably because of my role in the Maningrida community, my collaboration with a broad cross-section of the community, my visible presence in town, and the variety of mechanisms by which people generally come to know each other, such as through conversations at meeting places. At Cobourg the team initiated the employment grant as a structure through which community members and the outside researcher could have a continued relationship.

Relationship-building requires adequate time to develop so that the relationship is both harmonious and beneficial. For this reason establishing relationships may
require the greatest effort on the part of the researcher in terms of time required. One of the best mechanisms is to live in the community and have a community role so that people can become acquainted with each other in a variety of contexts over time. Furthermore, unless a role is assigned to the outside researcher, there is a chance that participation will not be achieved on the terms of the partner stakeholders, who will probably have completely different expectations about the position description of a collaborative researcher. Another useful mechanism for relationship-building is an attempt to learn the local language.

Again these considerations need to be dealt with by funding agencies and potential partner agencies so that adequate time is built into research timetables to allow relationships to evolve. This means that biophysical data collected for an outside funding agency may be reduced in favour of relationship-building activities. In reality, such activities generate learning opportunities and create the potential for the outside researcher to gather other types of information that provide long-term benefits to all parties.

Key point: Trips to country, an understanding of communication strategies, interest in local languages, and a community role are part of relationship-building activities. These require considerable investments of time, for which both individual and institutional recognition and support need to be forthcoming. It is also important to understand collaborators’ views of participation, a concept requiring considerable effort in further research if that research is to be truly participatory.

Principle 2: follow culturally appropriate procedures

Similarities and differences
It was important to acknowledge that for collaborators, cultural obligations and community concerns continue, and it was therefore necessary that the research did not adversely impact on community members by impinging on those activities. Cultural and community obligations that facilitated the research were similar at both study areas. These included the need to seek access permission from traditional owners of country where we planned to survey trepang, the opportunity to hunt and
gather food, and sometimes the need to conduct other cultural obligations such as a smoking ceremony or burning the country.

These obligations did not prevent the survey; rather, people were engaged in concurrent activities as I conducted trepang counts using western-based research techniques. Collaborators appeared to watch my activities at times, but carried out their own self-directed activities. Survey trips appeared to be opportunities for people they may not otherwise have had to get out to country. This interpretation is reinforced by people’s comments, when I invited them to accompany me, that they wanted to collect food, check out the country, or perform a ceremonial duty.

Often people brought family or friends, which may have been an extra incentive for joining the trepang survey. This inference is illustrated by the comments of community members that extra people came for company or to be with a relation (either to learn from or spend time with that person).

Health and family issues and physical resources constrained the survey at both localities. At Maningrida, the need to attend some meetings also constrained the survey. At Cobourg the lack of human resources, the need to incorporate other work (such as burning country or removing rotten house planks) while on country, and the need to conduct public relations between clans were factors that prevented survey for the contractual research. While these factors constrained data collection for the survey, they enhanced the research because additional learning opportunities about local history and politics or other contextual data were generated.

Participation, roles, structures and mechanisms
Collaborators and I appeared to have separate roles in relation to the requirements of conducting the research. I usually asked for access permission from a traditional owner. During the surveys community members hunted and collected food, performed cultural duties, and managed country using their locally specific strategies. We were always together in the vicinity of the area under survey, but acted in separate roles during the research (see next section). People directed me to keep away from certain places, or to the appropriate behaviours expected of me, such as not collecting a particular resource (oyster) at a certain place. Their
direction of me suggests that the principle of incorporating cultural concerns occurred collegiately. Since cultural considerations arise from the community members, there is no other participatory level at which these activities can occur. Community members must direct the outside researcher in culturally appropriate behaviour, usually expressed simply via the means of oral communication.

It was also important to recognise the aims and methodologies of the differing stakeholders, expressed through the techniques adopted and through the lack of importance placed on the contractual research by the various collaborators. In other words, my aims and objectives were to collect data for the contractual research and to understand participatory research using western-based philosophies and methodologies; the collaborators appeared to be concerned with managing country, pursuing livelihood strategies, finding out about non-indigenous approaches to resource management, and conducting their own resource management practices, all of which are related to their cultural duty of care for the ecosystem and governed by cultural considerations and relationships.

In order to collect data about collaborative research I required a technique that facilitated my learning. Participant observation techniques were most useful because they did not require direct questioning. Eades (1992) advises that direct questioning should not be used because such techniques do not respect privacy, may put people ‘on the spot’ and do not recognise two-way information exchange or the importance of silence and waiting in Aboriginal communication strategies. Nor do many other participatory techniques (summarised in chapter 2) facilitate joint learning processes, but rather, frequently appear to serve to extract information required by an outside agent.

**Analysis**

Indigenous cultural management practices for land and sea include controlling access to specific sites and areas, flora and fauna management, fire regimes, spiritual maintenance of country, site protection, ceremonial practices, endangered species management, and public education such as disseminating information to younger generations and educating non-indigenous people. These practices were carried out by community members during the surveys at both localities. People usually
attended and conducted cultural practices in family or peer groups. Bennett (1996:6) suggests that foraging and hunting are more than obtaining food — they express knowledge, reinforce beliefs and are an important education medium whereby both spiritual and ecological knowledge is handed on to succeeding generations. Furthermore people are exercising their native title rights and interests in carrying out these activities. Land management encompasses both physical and spiritual dimensions to caring for country (Muir 1998:5).

There are also many similarities between the principles used to manage resources in both western and indigenous management systems — for example, fisheries management relies on licensing, limited entries and other ways of regulating access to resources. Similarities are most easily fused across cultures through western-based approaches such as adaptive management, rather than the prevailing positivist-reductionist approaches (Berkes 1999). Cultural (rather than traditional) adaptation to resource management has existed in resource management for a long time. Governments could strengthen, reinforce and legally protect rather than undermine these customary property rights and stewardship measures. Research programs and funding agencies in turn could regard western-style data collection as part of adaptive management approaches.

Claridge and Claridge (1997:35) recommend using locally appropriate resource management rules; however, these recommendations are usually advocated or adopted by outside agents because local rules are primarily thought to assist with environmental sustainability. In other words, the complexity and spatial variability inherent in broad area ecosystem management can be counteracted by managing resources at a local scale, which in turn results in decreased costs to administrative agencies.

In this thesis I suggest that bureaucrats need to do more than apply local rules for local area management for the motives of ecosystem sustainability. In addition to protecting endangered species and habitats, long advocated by environmental managers, endangered cultures, languages and practices need to be protected and sustained. This need is rarely expressed as a priority by environmental managers. A change in priority requires relinquishing control by researchers and recognition that
there are other values and approaches in ecosystem management, and a desire to
sustain rather than suppress alternative worldviews. Researchers can encourage and
record information from alternative knowledge systems and contribute to true
intergenerational equity, a component of ecosystem sustainability. Some of the
inertia observed may be attributed to the lack of political directives toward this end,
probably related to the potential for voter backlash, and to the lack of recognition by
bureaucracies of the need to relinquish control (Claridge & Claridge 1997:38).

There are exceptions; for example, some institutions (see CBIK 2000) see an urgent
need to draw international attention to the relevant contribution that local cultures
make to the continuity of a sustainable and equitable life. They point out the
alarming threat that globalisation poses to the survival of the problem-solving
potential that each local knowledge system represents.

Reid and Stephen (1999:7) suggest that we see ecosystem management from the
point of view of the community, and respect that stance, supporting the view
expressed above. This may require researchers to incorporate multiple knowledges
and multiple values in natural resources research, not necessarily just those based on
economic return and western priorities. Values of priority to community resource
management will probably include continuing cultural obligations to country,
teaching knowledge to young people, and maintaining aesthetics and lifestyle.

The qualities that ensure success in networking with Aboriginal communities are
open communication, respect, a willingness to change or abandon previously held
views and an ability to engage in two-way interactions (Walsh 1995:88). Respect
for cultural considerations, recognising differences, and flexibility in technique and
schedule will be paramount.

The contractual trepang research was not a high priority for community members
because so many other events were occurring in the community or out on the
country visited. In many ways a research schedule will be imposed upon the
researcher, who will frequently be working with an overburdened community and
will be told when and where events important within the community, or pertaining
to particular country, are occurring. Local people will frequently have a variety of
roles within the community some of which will be just as important, or even more pressing, than that of being involved in the research. Out on country people will also arrange research in its place among other cultural priorities.

**Key points**: Resource management varies with culture and in participatory research it must be recognised that different types of research and resource management need to be carried out. If not, the research does not promote equitable participation. Some practices will use existing cultural transmission structures, such as working in family and clan groups, which appear to be desirable to collaborators. Institutional support for encouraging indigenous research and resource management alongside western research and resource management is desirable in participatory research. As interpreted above, participant observation techniques are highly desirable so that effective participation and learning occur in a manner that facilitates equitable participation.

**Principle 3: engage local people in data gathering**

*Similarities and differences*

People were engaged in aspects of the contractual trepang survey at both localities, often assuming technical roles such as driving the boat or vehicle, or repairing equipment. As mentioned in the previous section they conducted their own culturally defined activities but watched my activities and were aware of the day’s findings. When trepang were not found at a locality where it had been expected, collaborators provided interpretations for its absence based on the physical conditions of the day, e.g. the wind or sea condition. At Maningrida people frequently offered interpretations about the results of the findings while out on country conducting a survey. At Cobourg this occurred to a lesser extent, perhaps because the people on the team were younger or because we were using the same people for the survey over the entire peninsula rather than taking the traditional owner of a particular area with us.

Planning and arranging a survey with local people also occurred at both localities. That was necessary because I could not plan specific participants, schedules or other resources without knowledge of the manner in which the community operated. A
survey was usually organised in advance with the traditional owner with whom I planned to work; and sometimes I sought help from a key liaison person in the community. At Cobourg the day’s work was always planned with the project coordinator, who also took charge of planning to secure equipment and resources needed for the day’s survey.

When engaging people in the training aspect of the survey, collaborators at both localities seemed most interested in watching the video of the day’s work; sometimes people not formally involved in training also watched the video. However, other aspects of the training component were different between study areas. At Maningrida the nominated collaborators were engaged in a number of training activities because of their formal enrolment in the NTU course. I demonstrated computer data entry and field techniques, and helped with report writing. At Cobourg there was no formal training component as this component was cancelled by government officers. Instead all training was informal, based on carrying out the work each day.

Participation, roles, structures and mechanisms

The objective of trepang survey detailed in the contractual research was one of the few formally articulated mechanisms in the arrangement that assisted participation. While not consciously designed to enable participation, the very nature of the objective, that is, conducting a survey on people’s country, appeared to be of interest to local people.

I envisaged that people would be involved in designated western research techniques such as counting trepang within transects. During intertidal walks (see Appendix B) people were interested in locating trepang so that I could count them. Sometimes they would approach me and enquire whether I had found any trepang. Sometimes people helped with the western scientific procedures, but this was usually while on the boat — they took on the roles of driving the boat, lifting the camera in and out of the boat, and watching the onboard video monitor. However, if I forgot something people reminded me. People mostly carried out their own culturally defined activities as their role on the research (see above), but were aware of my techniques and sometimes joined in what I was doing at their discretion, often to help me with
heavy equipment. Since they did not direct me, but rather, we each took our own roles on the survey, this phase of the process was collaborative in nature.

Community or individually owned resources (boats, cars) and some equipment used in the western-based approach (e.g. the video camera) were useful mechanisms with which people were engaged in the western-based aspects of work. Conducting practices pertaining to their cultural duty of care was also of prime importance.

**Analysis**

Walsh (1995:91) advocates sharing control in a collaborative process by using skills analysed and discussed by social scientists, such as the analysis of power relations. Equalising power relations necessitates equity in the working relationship, through mechanisms such as employment of local participants and establishing research objectives that assist people’s obligations to manage country on their terms.

However, Foster (1997:41–42) mentions the inappropriateness of the existing employment mechanisms for Aboriginal rangers employed by PWCNT at Cobourg, since they are based on western promotion standards. Aboriginal rangers are not considered suitable for promotion without experience elsewhere, although arrangements such as sufficient experience within the park and short courses elsewhere could be negotiated. He suggests that other mechanisms, such as part-time employment and job sharing, be used to counteract family responsibilities or problems with undertaking duties on others’ clan area. He also maintains that Aboriginal knowledge and skills should be part of the work arrangements. This means that collaborative work arrangements need to be defined from within Aboriginal culture, possibly by elders or other people with an appropriate community role.

A danger lies in employing local people to carry out work that has not been formulated from within their own tradition, but which re-imposes continuing notions of what constitutes ‘employment’ based on western standards and thus contributes to strengthening institutions rather than reordering their priorities. In fact, Suchet (1999:277) suggests that institutions may need to be overthrown rather than strengthened. Engaging local people in participatory research requires that people’s
work practices not be judged according to western standards, but rather that their employment be expressed from within the definitions of their cultural traditions.

Engaging local people in such a way results in a two-way information flow. For example, Anangu Pitjantjatjara Land Management in Central Australia advocates applied demonstration and work by outside researchers that convey scientific skills, while the researcher simultaneously benefits by visiting an area with relevant traditional owners with time for them to demonstrate concepts and practices. Employment therefore requires that people be employed to conduct their locally specific role in the process, and not take on ‘research assistant’ positions that serve the interests of the western-based approach. At both Maningrida and Cobourg local people took on technical roles for the western-based research, suggesting that people are prepared to participate in alternative western-based research activities, even though they could also be employed in their own right for their expertise and skills in Aboriginal resource management.

Part of the work appeared to consist of interpretations of the research findings offered by collaborators while on their country. Coinciding phases of survey and results interpretation reflects an action research style where the research process is iterative and cyclical rather than isolated separate stages in a linear progression. This is an important consideration when choosing an appropriate research style for interfacing western and traditional science, a point repeatedly emphasised by Berkes (1999).

All collaborators also planned resources and the day’s activities, as part of the everyday work. This was important because concepts and information not otherwise available to or understood by the outside researcher were relayed. At both Maningrida and Cobourg a substantial proportion of time was spent collaboratively planning day-to-day activities, or re-planning components of the research. This implies that planning occurs throughout the research rather than as an isolated phase of the process. Rather than simply preceding the data gathering stage, planning requires a flexible approach, similar to the one advocated by action research.
A formal western-based training course was conducted in only one of the study areas as part of the work. However, people from both areas expressed an interest in attaining western-based qualifications. It was clear that on site delivery of the training course was the preferred context at both localities. This may reflect community members’ desire to learn new approaches in resource management that can provide economic and/or social benefits as globalisation of market economies has an impact on local communities. Since young people will eventually manage resources particular attention to training them provides future direction as well as the means of retaining traditional knowledge (Johannes 1989:9).

However, more importantly, an ability to learn from the dominant research techniques trains people in the values, concepts and jargon of that culture and paradigm. In this way Aboriginal people learn what is necessary to produce information in a way that they can use to bargain with potential partner agencies and argue against imposed practices that may seriously disturb or damage their environment, such as inappropriate mining or fishing. The importance of working within mainstream research needs to be recognised for its benefits in Aboriginal terms.

However, just as indigenous community members desire to learn the concepts and approaches of western-based science, an equitable process must also leave open the mechanisms for western-based researchers to learn from indigenous people. In South Africa the failure of certain western-based techniques has led to a need for educating and training professionals in relevant cultural attitudes, perceptions and customs of local people (Suchet 1999:89). Thus training becomes a two-way process, as discussed earlier.

Dale (1996:115–116) stresses the importance of using appropriate technology, because that can determine project success or failure. The visual medium of video technology appeared to be a useful and desirable technology for the purposes of a training component in collaborative research. People of all ages and at both localities, including some who had not participated in a trepang survey, were interested in watching videos we had made during the day.
**Key point:** Engaging people in the work involves a definition by Aboriginal people of their role, not employing them to work as ‘assistants’ to western-based standards. Day-to-day planning, offering interpretations, and two-way training with appropriate techniques are all part of the work that different collaborators are involved with, however brief their involvement.

**Principle 4: interview appropriate people for relevant information**

**Similarities and differences**

This project attempted to produce equity in the research process and to assist with cultural sustainability by interviewing knowledge owners, and recording and analysing the TEK they provided about trepang. The project was not designed to capture detailed knowledge or to preserve endangered languages by recording information in a particular language. For that reason the information collected was used mainly to direct the research to appropriate areas for trepang survey. Because this activity constituted only one component of the research, and because of the need to fulfill other funding agency objectives to imposed standards, limited time was devoted to the traditional knowledge component of the research.

A larger number of people were interviewed about their TEK at Maningrida than at Cobourg. Ten people were interviewed at Maningrida: eight old men and two old women, one from Yirrkala who had been recommended by a collaborator. At Cobourg I spoke with three old men and the project coordinator spoke with a fourth; three of those people were nominated at the Board meeting. I was unable to interview other people nominated at the Board meeting because they were away or because we did not visit their country.

Although seeking information through unstructured interviews with open-ended questions elicited some useful information, the most useful context for obtaining information about trepang at both localities was being out on country with traditional owners, or talking to them in town about the day’s findings. At Maningrida, traditional owners showed me where they had seen trepang on previous occasions, and, at times, after arriving back in town, people suggested other areas that should be surveyed or reasons for trepang absence. At Cobourg the trepang
team were not accompanied by traditional owners; however, on a few occasions the traditional owner at whose home I was residing conveyed additional information after a day’s survey. At both localities the information obtained was related to trepang localities or to other useful information associated with trepang such as the fact that older people sometimes ate trepang when there was insufficient food, or that past cyclonic events had altered previous trepang habitat.

Other types of knowledge or information were sought at both localities, and were related to logistical matters such as determining the appropriate traditional owner for a survey, or identifying appropriate personnel. At Maningrida this always occurred with a key liaison person at the BAC office. Seeking information about other types of knowledge or information did not occur quite so often at Cobourg, probably again because the project coordinator was able to provide information and arrange many matters.

*Participation, roles, structures and mechanisms*

Although I had set questions to which community members responded they often added additional information about which I had not asked. One of the interpreters also asked her own questions. Volunteering extra information indicates a greater degree of participation than a simple consultative approach, probably approaching a collaborative level of interaction. Sitting with people at their homes during interviews appeared to be a useful context for this component of the work.

Traditional owners offered knowledge when accompanying me on a survey. In that context the knowledge provided was occasionally in answer to a question from me, but more often it was simply an explanation of the current situation we were observing — usually trepang absence at a place where we had expected to find it. That represented a collaborative level of participation because people were responsible for their respective roles and expertise in the research. Knowledge held and sought about other matters was similarly collaborative.

Unstructured and semi-structured interviews were probably most useful as a means of meeting people and introducing myself and the research project. That was because these interviews were not specifically designed to elicit and analyse TEK, or
because did I have appropriate linguistic background to elicit further TEK from collaborators.

One of the renegotiated objectives in the contractual trepang research specified that the research process be documented and traditional ecological information about trepang recorded. This objective explicitly gave scope to involve people in a participatory way as part of the contracted research. The renegotiated objective was consciously intended by me as an objective worthy of research, but also as a mechanism with which I could validate the participation of local people in the work as a matter of principle.

In this project the most useful means for obtaining TEK was recording it from traditional owners while out on country. That was probably related to an ability to convey information about a greater number of factors such as wind, sea conditions etc. that I must not have clearly asked about during the interview or failed to ask at all. Even if they were not able to physically accompany me it was useful to discuss the survey findings with traditional owners at the end of the day and obtain further knowledge.

Analysis

TEK interviews were useful for locating areas of trepang abundance and for introducing myself and the project; however, the most useful TEK was obtained on country. This suggests that participation with a range of traditional owners and elders may be more useful than employing a fixed set of people for the duration of a research project.

Knowledge provided by Aboriginal people has been used in past ecological research projects for various tasks, often to fulfil agendas of outside researchers. Their knowledge of Australian ecology has been used for collecting and identifying biological specimens; providing information about extinct or declining species; understanding fire regimes; analysing the similarities between traditional and western scientific knowledge; evaluating traditional resource management practices and concepts; and analysing impacts of subsistence strategies. Such initiatives have often been based on incorporating local people’s knowledge for utilitarian, rather
than ethical reasons — that is, because of the perceived benefits for western-based conservation and science.

However, because of their knowledge of the local resource base through both practical and religious affiliations, Aboriginal people have been more recently acknowledged as invaluable knowledge holders in ecological survey work in their own right (Reid et al. 1992a:251, 1992b). Their affiliations and obligations have also been recognised as a means by which people manage their own resources.

Insufficient time was devoted to this phase of the research at both Maningrida and Cobourg. Johannes (1989:8) suggests that the difficulties of investigating and evaluating TEK should not be underestimated, because like any complicated laboratory time-intensive task, collecting the knowledge and talking to people must be valued for the amount of labour invested when recording and analysing the information. This project confirms that suggestion, because a far greater effort than was expected was necessary to gain trust and to understand the context of much of the information given, and because sometimes people simply offer information over time. By allowing greater time, the listener has time to absorb information and becomes ready to hear more.

Research projects that record and rigorously test TEK are very limited throughout the world (Johannes 1989:9), and often governments do not recognise the value of funding this type of research. The value of traditional knowledge is becoming an increasingly central issue in discourse about resource management, but there is danger that dichotomies may be used in characterising it and its application — e.g. that TEK is intuitive, oral, holistic, subjective, cyclical and inclusive and western science is analytical, literate, objective, linear etc. Traditional knowledge does not mean static knowledge, but knowledge that is made traditional because of its firm roots in indigenous culture and local ecology. Continuity of information is important, but so are flexibility and the dynamics of communication. Such knowledge comes from observation and experience.

Traditional knowledge tends to be unwritten, based on what has been learnt from elders and what each generation can add. Obviously school-based education
contributes to change, but new knowledge tends to be incorporated into existing frameworks. Training people in non-indigenous resource management practices can build on the prior learning that people already hold. The visual medium of the video was useful in this project for recording data about trepang (see previous section) and many other appropriate mechanisms exist such as story, song and dance. By the same token there will be mechanisms to train non-indigenous researchers. Both traditional owners and elders and non-indigenous researchers can contribute equally from the strengths of each culturally-based approach to resource management and training. Currently research, training and education projects are based on the dominant positivist paradigm, so the subordinance of traditional approaches needs to be redressed and appropriate two-way information transfer mechanisms developed.

Claridge and Claridge (1997:32) build on this position by noting the arguments used by governments that local resource managers do not have the skills and knowledge necessary to play a role in resource management. Those researchers counteract such statements by arguing that there is little requirement for bureaucrats and industry personnel to display a similar level of expertise to play a role in collaborative resource management. I suggest that this lack of skill and expertise also applies to many non-indigenous researchers as well as to those involved in management. I would add that western personnel do not have adequate skills and knowledge to participate in, or understand, Aboriginal resource management in addition to understanding collaboration. For this reason indigenous people need to be helped to carry out education campaigns for non-indigenous researchers. This could be accomplished by conducting field trips on country for prospective researchers and other personnel. Nor do western researchers usually display an understanding of the values of contributions from alternative knowledge systems and community-based practices, because this requires downplaying their own techniques and approaches.

Many organisations typically enter into collaborative arrangements with no attempt to understand the requirements of a paradigm shift in resource management and even less support for staff to adapt and learn necessary skills in cross-cultural awareness, facilitation and group processes. Even when courses are conducted they tend to be short, full of rhetoric and often not supported by the majority of members in the institutional culture, and so are kept to an insufficient and token level within
government departments. It is rare that bureaucrats and researchers take the paradigm shift further so that the western-based bureaucrat or researcher is placed at the bottom of the learning curve, open to new knowledge and potential learning opportunities available in another cultural context. This begs the question of whether western-based scientific enquiry is really concerned with acquiring new knowledge, or only selectively acquiring knowledge that suits its pre-existing paradigm.

Traditional knowledge is in danger of being lost as young people leave communities, a fact that makes it urgent to collect TEK and further expand participatory research that concentrates on this knowledge, rather than simply leaving it as only one component of a research project. In such an approach, western scientific methods complement and contribute to research directed by the members of a local community, and the result is then truly collegiate research. The primary aim of the research becomes facilitation of intergenerational and intercultural equity and the maintenance of locally based natural resource management. When the local knowledge holders so direct, the western-based collaborators assist by bringing their expertise to bear.

This principle should govern the entire research process.

*Key point:* Aboriginal knowledge needs to be given equity in the process, often facilitated by being on a traditional owner’s country. Because different areas may be visited, there may also be different key collaborators involved over time.

**Principle 5: delegate responsibilities**

*Similarities and differences*

At both localities there were many opportunities to delegate responsibilities to local people, and likewise for them to delegate responsibilities to me. Most were related to the trepang survey. I encouraged community members to drive vehicles and boats and become involved in trepang survey. Collaborators arranged additional participants, organised food for survey trips, organised or assisted with arranging access to clan estates, and took on an interpreting and interviewing role.
At Maningrida, delegation responsibilities were shared because of the varied positions of collaborators working on the project. For example, when preparing a report or undertaking obligations and responsibilities important to their culture, I simply watched and tried to learn about their practices in a similar manner to their interactions with me, although they sometimes delegated activities to me. Community members sometimes assumed responsibility for matters of which I only later became aware.

The major difference between the two study areas is that at Cobourg one community member, the project coordinator, took on a large proportion of the responsibilities for delegating tasks in most cases, as required by his role specified on the employment grant.

*Participation, roles, structures and mechanisms*

Since this principle mostly refers to two-way interaction, the level of participation is considered to be collaborative by definition. Delegation is a two-way responsibility where different stakeholders have knowledge or skills that can be used and taught to other collaborators on the project, including those from a different cultural background. Frequently this may involve cross-cultural information and two-way skills exchange, often simply via observing one another. Also important to the community is that some participants acquire skills and knowledge so that they may teach them to other members of the community. (For example, younger men and women expressed interest in learning to drive the boat.) This process may occur through a process in which elders and rangers teach younger people their knowledge and skills; at times it may be the responsibility of a single collaborator.

Delegation usually occurred through informal interaction in which collaborators informed others about something or took on a task at their discretion. It was usually a matter of simple two-way oral communication and additionally involved the outsider researcher taking a back seat. Such informal delegation often provides opportunities for learning.
Analysis

Based on the past experiences that a community may have had with research projects, or indeed, to ensure continued interest by the community in a new research proposal, responsibility for some aspects of research should clearly be delegated equally among collaborators. As mentioned in discussing principle 3, equity in power relations is of paramount importance in the research process. Capacity building is a concept that has been formulated within western institutions and is designed to help local people conduct Eurocentric development through education and training. Tasks are delegated and local people trained to continue the research or work in other projects.

All too often the notions of capacity building are advocated in participatory research programs in such a way that local organisations and individuals build their ability to take on research and resource management activities formulated by outside agencies. As Suchet (1999:286, 288) points out, indigenous people are also the sources of capacities and in indigenous contexts it is the developmentalists and conservationists who require capacity building.

It is recognised that local people may need training to understand the thought processes and mechanics of mainstream society so that they recognise how Eurocentric knowledge and practices emerge and take shape and can translate them. In this way the common ground between fundamentally divergent epistemologies can be sought and effective information transfer mechanisms developed. Capacity building already occurs in communities through traditional means, but existing structures and mechanisms are often overlooked or undermined by outside capacity builders accountable to their donor agency, non-government organisation, or home government policies (Derman 1995 in Suchet 1999:288). Again, bureaucrats and outside researchers need to value alternative intellectual traditions and be prepared for tasks to be delegated to them by community members.

Key point: Delegation must be two-way for true participatory research. This means that individuals need to take on tasks from both knowledge systems as part of the work; and institutions need to recognise that their capacity to work with another culture may also require building.
Principle 6: communicate with key persons

I frequently needed to communicate with someone for direction and advice about the research.

Similarities and differences
Most of my communication with key contact people in Maningrida was with community rangers, although other, non-Aboriginal community members also provided useful advice from the perspective of a non-Aboriginal person working in the community. Nominated assistants and other Aboriginal people also gave helpful advice. I did not seek independent advice (e.g. from NLC officers) because I had confidence in the advice given by community members. On one occasion incorrect information was given to me by a non-Aboriginal person, who had become a senior ranger’s assistant; but I was later able to obtain correct information from another non-Aboriginal member of the community. The latter person had lived in the community much longer than the former and appeared to be well liked and respected as well as holding a senior position within BAC. The former person was later asked to leave the community because of what were locally regarded as political problems.

At Cobourg, key contacts were government officers, mostly PWCNT staff, during the planning stages of the research. Information provided by external stakeholders was not always useful and at times was conflicting, both within the organisation and with community members. The project coordinator was the key liaison contact during the data gathering stage after formulation of the trepang team, and input from other Aboriginal people was limited. Officers of the NLC, the statutory body representing traditional owners whose role is defined in the Cobourg Peninsula Aboriginal Land, Sanctuary and Marine Park Act, were essential mediators during this project because knowledge and general issues, particularly those related to appropriate traditional owner representation, were clarified with various officers.

Participation, roles, structures and mechanisms
These were clearly collegiate interactions because I actively sought the advice of key people in both communities, who directed me as appropriate.
Community members were key contact people — rangers, traditional owners, and non-Aboriginal people working in a community-based organisation. The project coordinator was very important to on-ground success.

An external stakeholder, PWCNT, provided a mechanism for liaison; however, its own agenda sometimes inhibited the research. In this case the NLC personnel were important in that the officers provided important support to represent traditional owner viewpoints.

**Analysis**

It is always possible that an outside researcher will encounter unforeseen circumstances during the life of a research project. Relationships established early in the collaborative process identify key people with whom information and behaviours can be checked along the way. It is useful at every stage or with changing circumstances to ask these key persons for advice and direction and to sound out a response or action if appropriate. In that way there is less danger of culturally inappropriate actions, and community members remain in control of the process. Continued liaison with key persons reinforces trust between the interacting parties.

While it may take extra time and effort to seek out appropriate people, it is usually worth the effort. It is useful in assisting adaptive management effort, which is an iterative process where outcomes are never fully known in advance, although such risky situations are frequently avoided by bureaucrats and politicians (Claridge & Claridge 1997:31).

**Key point:** It is important to have key community-based people to act as partner supervisors of the project.
STAGE 3: INTERPRETING RESULTS

Principle 1: ask for community members’ interpretations

Similarities and differences
At Maningrida I undertook a visit to the community with the specific intention of canvassing interpretations about the research findings from community members. I requested a meeting with rangers and also visited individual traditional owners with whom I had collaborated. I summarised the report and explained the major findings from the survey, as well as the work I had conducted independently on the NTU campus (see Appendix B). For example, I conducted satellite image processing and fisheries logbook data modelling using computer software packages, and also conducted soil sediment analyses in a soils laboratory. Rangers attending the meeting listened but did not convey any further information, nor did anyone present add any additional interpretations. I inferred that people had given the interpretations they wished to provide while on surveys.

At Cobourg I felt unable to undertake a similar visit to formally present results and canvass interpretations because government officers had made me unwelcome at the last Board meeting I attended, had asked me to leave the park once, and had made me unwelcome at PWCNT headquarters on two occasions. I did not feel it would be wise to ask for a formal meeting to present results, so am unable to comment on the appropriateness of this principle as it applied to research at Cobourg.

At both localities people frequently volunteered their interpretations about the day’s findings — that is, during the data gathering stage rather than in a separate stage of research. These interpretations were provided while out on country, or sometimes after we had spent the day in the field and reported the findings to an interested enquirer. At both localities the interpretations were related to trepang survey results; however, people also offered interpretations about personnel, technical matters and the research process in general. People also usually responded to any questions or interpretations I raised by offering their own interpretations.
Participation, roles, structures and mechanisms

At the meeting to formally present results and canvass interpretations at Maningrida I appeared to be operating at a contractual or consultative level because I informed people of my findings and they listened to me, but did not offer their interpretations. It appeared to be limited to an opportunity for community members to listen to my interpretations (see next principle). People mentioned their interest in aquaculture, which is considered a recommendation rather than an interpretation of results.

At Cobourg I simply handed in a report, clearly a manifestation of a contractual research process.

The formal visit to present results may have been necessary for me but was not useful for gathering further interpretations of the results. The best mechanism for gathering community members’ interpretations was the trepang survey, out on country. Useful tools are the skills of listening, remembering and accurately recording interpretations in the field, which can be incorporated into a report at a later stage. Sometimes I provided my interpretations to which people responded with their own interpretations, or repeated an interpretation I had expressed previously, a reflection of the communication strategies used in Aboriginal culture where information exchange is two-way (Eades 1992).

When I needed clarification about an issue such as personnel or technical difficulties I prompted people with a specific question, or again offered an interpretation in an effort to have it confirmed or rejected. For example, I said that I thought commercial fishers may have taken away trepang and someone indicated agreement by adding that fishers had been at that locality the previous year. Generating discussion in this manner also appeared to be a useful technique for gaining interpretations from collaborators.

Analysis

More complete and effective information is generated by gathering information from all sources, and for this reason it is important to obtain community members’ interpretations of the research findings. However, the ability to listen, discuss and incorporate results while gathering data, rather than during a separate research stage
or using formal meetings or structures, is advocated. It is important to react to community members’ interpretations in the field. Additional interpretations from community members may come to light when interpretations of the results are shared with appropriate people. Formal meetings, however, are usually held for the purpose of formalising an approach or agreed position and are not useful for gathering information or to reach agreement (ATSIC 1998:32). Volunteering information first is also a useful strategy in initiating communication.

**Key point:** Collaborators’ interpretations appear to be integrated during the stages of the research and not as some separate component, and again are probably facilitated by an appropriate context such as being out on the country where the resources are located, and by understanding Aboriginal communication strategies. Formal meetings are best to formalise the process.

**Principle 2: explain your own interpretations**

**Similarities and differences**
I used the meeting described above to explain my interpretations of the research results at Maningrida, but did not do so at Cobourg (see above).

**Participation, roles, structures and mechanisms**
During the meeting at Maningrida the level of participation was contractual or consultative (see above). However, the meeting was important because there was additional work I had undertaken that had not involved community members. It was therefore a useful context in which I could present the results of other objectives I had achieved while working independently on the contractual research.

When on country the work appeared to be collaborative in that I offered interim interpretations (subject to further analysis) and community members offered their interpretations (see above).

**Analysis**
The formal meeting was most effective in giving community members results generated from the work I had undertaken independently as part of the contractual
research. It was important to me to use this meeting for the sake of the principle of feedback of results, and also because in this way I learned that the community had changed its aspiration from commercial harvest of wild trepang to investigating aquaculture of trepang. Such a mechanism is therefore mostly important for consultative or contractual research where activities are undertaken in isolation from the community. These types of participation are considered to be among the lower levels of participation, being passive in their nature and not promoting active community involvement and control (Claridge & Claridge 1997:3).

Key point: Offering preliminary interpretations, again in the field, is probably useful to work undertaken collaboratively. Any extra conclusions generated in contractual components of the work need to be presented in a formal context such as a meeting.

Principle 3: synthesise results sensitively

Similarities and differences
At neither place was there a formal synthesis of results; however, as mentioned above, I synthesised information from collaborators during the survey. It is also possible that community members incorporated my results within their own knowledge systems. At Maningrida aspirations had advanced toward trepang aquaculture, which suggests that people had already synthesised results from the contractual research, indicating that wild stocks of trepang would not be harvested in the same way as they had been in the past, and that aquaculture could be a future activity.

Participation, roles, structures and mechanisms
Since both parties appeared to synthesise results of the contractual research, a collaborative level of interaction occurred. Facilitating mechanisms for collaboratively synthesising results were again the surveys conducted on people’s country.

Writing the report was a different task from that of synthesising results, and constituted my role and obligation in the collaborative arrangement for synthesising results.
Analysis

I had envisaged that results would be synthesised collaboratively after I canvassed local interpretations and provided my own interpretations. That would have involved comparing similarities in interpretation and contrasting differences. However, synthesis had occurred earlier in the research process and did not constitute an isolated stage of the research.

The interpretations expressed generally did not differ from mine, although the language in which they were expressed may have differed. Since most of the interpretations occurred collaboratively in the field, the similarities expressed by both parties were confirmations of the other’s stated position.

If there had been differences in interpretation, a further useful step would have been to go back to key persons and discuss them, preferably in the context of a field trip, so that both parties could re-think results and provide a more complete interpretation.

Key point: When both parties offer interpretations in the field these can be readily presented in a report and other communication formats. However, if work undertaken independently alters interpretations it may be necessary to undertake further field trips to collaborators’ country and discuss these new interpretations in the field again so that a complete synthesis occurs.

STAGE 4: MAKING RECOMMENDATIONS

Principle 1: incorporate ideas from all sources

Similarities and differences

The process of obtaining ideas from community members about recommendations based on the research results varied in the two study areas. At Maningrida a number of questions were used in unstructured interviews to elicit TEK about trepang. Some answers provided during this survey were useful ideas for trepang management. Eliciting that information was facilitated by a collaborator. That
person helped to facilitate the flow of conversation and was also able to translate when I could not understand the language used by traditional owners.

As well as during unstructured interviews, useful management ideas were generated at the end of the entire research process, at the meeting with community rangers. The ranger coordinator stated the community’s interest in trepang aquaculture as an activity. That was a constructive recommendation given the findings of the contractual research, which suggested that harvesting the existing trepang resource was not economically viable. When I later visited traditional owners to present results they also mentioned their interest in aquaculture, which appeared to be a community confirmation or consensus of the recommendations about trepang given at the meeting.

At Cobourg I did not obtain useful ideas about trepang management through unstructured interview techniques, as I had limited opportunity to interview people. Nor did I have an opportunity to formally present research results, so I am unsure of the community members’ final recommendations for activities based around trepang. However, sometimes during informal discussion at the end of a survey the project coordinator mentioned constructive ideas for trepang management. These ideas were volunteered by him, rather than being responses to questions I asked.

*Participation, roles, structures and mechanisms*

Initially at Maningrida I used set questions as prompts during interviews to which people responded, indicating a consultative or collaborative interaction. When the person undertaking the role of interpreter conducted the interview, the level of interaction progressed toward either collaborative to collegiate participation because that person took the initiative and designed her own questions. The proposal from community members to attempt aquaculture also suggests that participation at the end of the process was collegiate, because the research topic was formulated from within the community.

The project coordinator at Cobourg mentioned both research and management ideas on his own initiative and suggested methods and approaches whereby community members could conduct the research without an external researcher. This may be
regarded as indicating that a collegiate level of participation would be desired in future research at that locality.

Unstructured interviews and discussions were techniques used in an attempt to canvass people’s recommendations. These tools were useful at Maningrida, where collaborators facilitated community responses. Informal mechanisms — discussions held at the end of the day — were most useful at Cobourg.

The most important and frequently used mechanisms for obtaining recommendations occurred during the data gathering stages.

The final meeting held at Maningrida indicated the community’s future direction for trepang management.

*Analysis*

Open-ended questions designed to elicit information about trepang were useful prompts for obtaining recommendations about trepang management. Discussion after a survey was another useful strategy.

At Maningrida the formal meeting was useful for learning of the community’s consensus decision on aquaculture. This is in accordance with the ATSIC (1998:32) protocols for working with Aboriginal people, which suggest that formal meetings are usually a mechanism to confirm agreement or to share information and are not useful to extract information or make decisions. Usually decisions are reached outside meetings.

A community-based person acting in the role of either ranger, interpreter, or project coordinator was imperative for generating discussion about recommendations for the trepang resource, and also for instigating a high level of participation.

Recommendations are not confined in the western sense to a research stage such as data gathering or making recommendations, but rather, occur as an ongoing process.
Key point: A local supervisor, or interpreter, is useful in generating discussions with people about management recommendations. Again, these discussions are useful when they occur in context, either in the field or when talking about the day’s work. The recommendations are then formalised in a final meeting.

**Principle 2: ensure community approval of material for publication**

**Similarities and differences**
At Maningrida manuscript drafts were always sent to a non-Aboriginal BAC representative for approval to publish, and approval was always granted.

At Cobourg I sent a manuscript draft to the project coordinator via the PWCNT rangers but did not receive any response, and later discovered that he did not receive it. However, during the planning stages I had published a newsletter article and told an NLC officer that it would be desirable to have the project coordinator read the article and comment. That end was achieved when the project coordinator visited the NLC officer on another matter, indicating that community members were interested in the co-authorship role.

**Participation, roles, structures and mechanisms**
I did most of the writing for publication, and always initiated publication of research materials. Such publication is usually warranted from a western perspective as a component of research, but is unlikely to be — at least to date — an objective of community members. This principle was thus contractual in that I simply desired comment from community members and they provided it at my request.

I obtained community members’ comments on written reports through oral communication with rangers and through the community-based organisation.

On one occasion comment and approval were coordinated by an officer of an Aboriginal regional organisation. In that case it was useful to have a key person, either from an Aboriginal community or a regional organisation, act in a coordinating role. Government agents were not useful in this role.
Analysis

The community’s involvement in the process as data collectors and as providers of information and interpreters of the results is paramount, as is their right to be co-authors of any publication. As with any scientific publication, co-authors check and verify written material for accuracy before it is published. Likewise, communities may wish to formalise agreements about the checking of manuscripts prior to publication. By having community input into the manuscript, the written work itself is a product of the participatory process. Sometimes agreements concerning intellectual property rights may prevent publication of sensitive or confidential material.

Aboriginal community-based and regional representative bodies were both useful in coordinating information for manuscripts to be submitted for publication, as well as approval of the final versions. External government stakeholders were not useful in linking stakeholders for this part of the process.

However, publications often fulfil only the objectives of western-based research. Finn (1994:35) warns that communication can be a tool of domination. If Aboriginal knowledge is to be disseminated, more appropriate ways of communicating the knowledge need to be encouraged, e.g. the use of information in the forms of songs and dance, and visual media such as photos needs to be explored for presentation at conferences, as research results, and as an instrument of higher education.

*Key point:* Community-based and regional organisations supported publication of the work; however, other ways of communicating results need to be explored so that this part of the process is also participatory.

**Principle 3: ensure ongoing monitoring**

*Similarities and differences*

The process for ensuring ongoing trepang monitoring varied at the two study areas. At Maningrida, community members indicated that monitoring would continue through the ranger program and ranger activities. They also mentioned their links to
institutions that were assisting the community with other western-based management tools such as establishing a GIS. They indicated their desire to monitor trepang and incorporate data they found into such western-based management tools. There did not appear to be a need to put additional monitoring procedures in place. The position of ranger coordinator was clearly an instrumental role for helping to encourage such activities.

At Cobourg there appeared to be no structures or mechanisms for helping community representatives continue to monitor trepang or to monitor other resources unless they were employed in a technical position with PWCNT. Although the draft Plan of Management implies that traditional owners implement their rights to manage the use of the park, there did not appear to be a practical mechanism for achieving this. However, the necessary desire, skills and commitment appeared to be present within members of the trepang team as they discussed future research ideas and demonstrated competent research, technical and field skills, as well as the desire to conduct their own research; a desire not expressed at Maningrida.

**Participation, roles, structures and mechanisms**

At Maningrida, community members indicated their intention to continue monitoring in a manner they designed, probably an example of a collegiate level of interaction.

Monitoring at Cobourg is probably contractual in that PWCNT officers are responsible for monitoring resources. However, with appropriate participant resourcing (government funding and advice) there is potential for the community to move beyond the current level of participation in resource monitoring.

Existing structures and mechanisms at Cobourg such as the coordinated ranger program and related activities were a useful way to ensure ongoing monitoring. Although not directly geared to trepang monitoring, the mechanisms provide the means for rangers to check on country and report changes to resource stocks, as well as implement their own management strategies. These structures provide a means by which traditional owners, elders and other community members can pass on
information to rangers, whose organisation can act as a central coordinating body for information about resources.

**Analysis**

Monitoring is particularly important in resource management so that predictions can incorporate unforeseen problems and minimise adverse impacts. It is important that the community continue to monitor the resource after project completion, and evidence of community intention to do so suggests project success, at least in this component of the project. Claridge and Claridge (1997:34) assert that monitoring that is designed, implemented and interpreted by the community is the desired arrangement but is rare in collaborative management in Australia.

Some mechanisms and structures to continue resource monitoring were established by one community. The role of ranger coordinator and a ranger program facilitated ongoing monitoring. There was probably an advantage in having people involved during the contractual research continue to monitor the resource because of their recent experience, although monitoring could be done by any member of the community who noticed trends in resource condition and stocks.

As well as monitoring the resource, collaborative research about natural resources requires that the research process and performance also be monitored and evaluated (White *et al.* 1994b:94, Claridge & Claridge 1997:34–35). Process monitoring reveals the success of procuring inputs and outputs; performance monitoring reveals trends toward or away from project objectives.

Socioeconomic indicators are sometimes advocated as measures of project success — for example, changes in socioeconomic status. However, there is a danger in using these values for evaluating a project because they are grounded in western-based value systems which suggest money, employment, or similar indicators of ‘success’. In farm forestry, for example, the discipline itself depends on the desires of the farm forestry community and is not limited to the options sanctioned by ‘experts’ (Reid & Stephen 1999:7). A satisfying outcome in that initiative is the increasing leadership role taken by farmers; it indicates that lateral thought and
creative opportunities for monitoring resources at the biological, process and performance levels have occurred.

Buhat (1994:47) suggests that a project can be evaluated through community meetings where adjustments to the process are implemented if necessary. However, meetings are probably not the optimal method for obtaining community indicators for resource, process and performance monitoring with Aboriginal people. Evaluating and monitoring the project can be achieved by periodic visits with key persons who have requisite expertise and experience. That depends on knowing and identifying appropriate people, a skill often facilitated if the outside researcher has lived for some time in the community.

Livelihood patterns, and improved legal and institutional mechanisms for collaboration and self-management, are also important indicators of the impact of a project. The levels of community participation in planning, implementing and monitoring effort, the degree of community awareness and empowerment, the sophistication of community organisations, and the smoothness of collaboration with government and outside organisations are also potential indicators of effectiveness. During the research at Maningrida people indicated that they were happy with the research, saying, for example, they were sad that I was returning to Darwin for a temporary break from the work, expressing concerns that I was not coming back from Darwin, or simply stating their interest in accompanying me during the work even when I could no longer pay collaborators. I could not explore the basis of such statements but I inferred that they were related to the importance to community members of getting out on country, employing their own management tactics, and passing on this knowledge to their children. These were their indicators of the success of the research.

Key points: Resource monitoring can be facilitated through existing community structures and channels. Community members need to establish their indicators of success, which may be vastly different from those of western values. The research is then periodically monitored, and possibly altered in an adaptive manner, to ensure that the research process meets these criteria.
**Principle 4: ensure ongoing management**

*Similarities and differences*

At Maningrida, members of BAC had initiated or talked about plans to initiate trepang and other resource management strategies. Even though some of these plans were only at a scoping stage, community motivation and forward planning were clearly evident.

I had no access to Cobourg traditional owners at this stage and am unsure of trepang and other resource management initiatives the community were hoping or planning to implement.

*Participation, roles, structures and mechanisms*

Ensuring ongoing management at Maningrida is probably an example of collegiate interaction. There were community-initiated management strategies, and contact was made with another researcher about investigating aquaculture. Local people also continued to contact me for advice about trepang issues well after I made my final visit to the community.

For Cobourg the degree of participation during this stage cannot be assessed in the absence of further information. My contact with people was not welcomed by government officers, which made obtaining such information difficult. Although the structure of the Cobourg Board is maintained and a draft Plan of Management is in public circulation (PWCNT 1998), mechanisms for traditional owner planning and management at levels of participation beyond consultation are not specified in the plan, nor are there any mechanisms for conflict resolution and participant resourcing in the research.

Generally a community ranger program or employment strategy, and project or ranger coordinator positions were useful structures for ongoing management strategies.
Analysis
Aboriginal management of natural resources differs from western systems in that it is embodied in complex social and cultural norms and religious beliefs as a way of ensuring long-term sustainability (Ross et al. 1994:3). Aboriginal people are linked for the entirety of their lives to specific areas by custodial responsibilities to Dreaming places and totems and by their personal life history.

Such management may or may not have been consciously planned or intended as a management regime (White et al. 1994a:11). However, as in any other society, actions are intertwined with customs and beliefs. Actions may include attempts to ensure long-term sustainability, for example through declaration of sacred sites, food taboos or prohibitions against hunting on a dead person’s country, all of which are examples of cultural restrictions on resources in a region. (Conversely however, some information may not be passed on as a species vanishes.)

For this reason, it is logical to canvass ideas from both the Aboriginal and western collaborators because a combination of approaches leads to better management of the resource than would otherwise be available (Pinkerton 1989:5). It is recognised by western science that both traditional and western styles of resource management must be linked to other contexts, while respecting traditional perceptions and control of the resources as well as modern development issues.

Culturally based differences in perceptions can cause conflict between the management strategies imposed by governments and those used by Aboriginal people (Nugent 1988:2). Local management often takes place where alternative livelihoods exist, for example those based on ecotourism and sustainable subsistence fisheries. Customary marine tenure is the basis of a form of adaptive and locally appropriate fishery management that has the potential to monitor stocks, provide surveillance, regulation of effort, community education and resolution of conflict (e.g. commercial fishing), enforced by community rangers or local authorities (White et al. 1994b:93, Hviding 1996:4). The government role in these programs (in the context of a developing nation) is usually limited to local government support with some recognition at the national level. Official recognition of traditional
management responsibilities is necessary so that Aboriginal people can use and benefit from a resource according to their laws and achieve self-determination.

However, canvassing ideas is not optimal in a formal sense; rather, it should be done through local coordinators. At one community, management initiatives linked to the resource were evident, probably facilitated by the ranger program and ranger coordinator. Since community-based management is not about leaving community members to ‘go it alone’ but about working together with mutual experience, tools, and support networks (Reid & Stephen 1999:6), community-based management is well advanced at that locality. Mechanisms for participant resourcing incorporated into the formal management arrangements at the other locality would probably be useful.

Reid and Stephen (1999:6) assert that the best measure of success in participatory resource management is the degree to which the traditional owners accept responsibility for their management decisions. This implies ownership of those decisions in full knowledge of the inherent risks and uncertainty. In this research, the community referred to in the preceding paragraph accepted information from the contractual research that did not complement their aspirations, then reformulated and adapted aspirations for managing the resource.

*Key point:* Institutional support for traditional resource management strategies is necessary for effective participation in resource management to occur. Institutions may need to invest time understanding and supporting these activities. A local supervisor is a useful mechanism through which to implement traditional resource management strategies alongside western resource management.

**KEY FINDINGS**

Below are key findings from analysing the research process at the two study areas.

- To understand the scope of participatory research with Aboriginal Australians it is imperative to gain an understanding of protocols for working collaboratively
with Aboriginal people. This is the responsibility of the outside researcher and external institutions. Bureaucrats and potential partner agencies need to incorporate mechanisms into research programs so that their staffs gain this understanding. Time spent living in the community or frequent visits by extension officers well known to the community are mechanisms that can increase understanding of local values, knowledge and practices. In this way joint learning processes are facilitated, which are more effective than simply adhering to the protocols of working within another culture. Reduction in the biophysically based expectations and objectives of a research program is necessary to accomplish this understanding.

- When approaching potential partners about collaborative research, field workers known to community members are probably important. Although formal mechanisms are useful for an initial approach it is important to use approach strategies that understand and build on local authority structures, and cultural transmission and maintenance systems that are already in place, rather than constructing new structures and mechanisms to advance the research program. Field workers known to community members probably play an important role in linking community members, researchers and other stakeholders during approaches to negotiate participatory research. Field workers bring an added dimension to the process because they have knowledge of the community structures and systems in place as well as background, contextual and other relevant information prior to setting up a project. Advantages of field workers to western research institutions are the savings in the time needed to establish and negotiate a project, and a greater likelihood that research will be successful, relevant and equitable.

- The aspirations of the community may be best understood if outside researchers have a role, or at least extensive contact, with the community. In that way they further their understanding of the community and acquire background information that helps them interpret events. Such a role also probably facilitates an understanding of community members’ concepts of collaboration. Joint learning appears to be an aspiration of Aboriginal people because they repeatedly express the desire that outsider researchers learn from them, while at the same time they acknowledge the need to take a place in the global market
economy. However, it is important in that achieving the latter objective the former is neither devalued nor negated. Since values often appear to be ignored, it is necessary to place emphasis on them, similar to the cultural and transmission processes discussed above, until they acquire a status in the research process equal to the values of outside researchers.

- Participant observation techniques are useful for data collection because they do not use direct questioning. It is important that the research be flexible, which implies that positivist-reductionist philosophies and approaches are probably not optimal. Action research and adaptive management are research methods most closely aligned with indigenous knowledge systems.

- Negotiating the project early probably minimises later renegotiating difficulties. Flexibility on the part of all stakeholders is imperative. Conflict resolution mechanisms are useful, particularly where external stakeholders have an agenda they wish to implement. Research agreements probably also facilitate conciliation as well as providing a means by which to value indigenous input. Formal structures such as co-management arrangements may hinder research. The negotiation process needs to recognise the terms of reference of Aboriginal people in the research so that they do not need to give ground to a dominant paradigm. Negotiating changes on a day-to-day basis, as well as project direction, is also important during the research process; however, in the research described in this thesis these were relatively easy issues, as changes to plans could usually be arranged by community members. The implications of flexibility for the project and for the day-to-day planning are that adequate time needs to be given to the process to allow for delays.

- Formal meetings coordinated by a collaborator are useful to establish good working relationships with people during the initial stages of the process if they are not living in the community. When engaging in dialogue with Aboriginal people, it is important that two-way communication occur; this may require the outside researcher to volunteer personal information. Information volunteered by collaborators is important because it is not elicited, nor is it given in response to a direct question that may be misunderstood by both parties. Again such approaches require time for information to be volunteered because trust needs to be built.
• Obtaining trust and building good relations may be values of non-western-based research. Once key people are known, relationship-building activities can be facilitated by field trips on country in family and clan groups. Another useful practice for outside researchers is to learn aspects of the language of a collaborating partner, which requires time, preparation and practice if it is to be valued as part of the process. Establishing relationships with a broad range of community members probably enhances participation because such relationships make possible wider contact within the community. Potential partner agencies need to recognise the importance of relationship-building activities in the process.

• Aboriginal people conduct their cultural resource management and obligations as their role in the research. There is need to encourage this as part of the process because endangered cultures, languages and practices need to be maintained. Not only does this ensure cultural sustainability but it also ensures enhanced resource management based on multiple practices and local scales. This involves valuing and respecting alternative approaches.

• In this research, local people took on a subsidiary technical role for the contractual research objectives, which probably provided opportunities for Aboriginal people to learn about western resource management techniques. That was their role in the joint learning process. However, as mentioned above, their major role in the research was to provide their expertise in Aboriginal resource management. Other input to activities occurred, for example, to help plan the day, particularly through key contact people such as a project coordinator. Just as they have a role in the research and opportunities for joint learning, so too do outside researchers have a role to provide their own expertise and to engage in joint learning processes. Joint learning on the part of outside researchers about Aboriginal resource management is the factor least evident in this collaborative research and should be given greater prominence in future research.

• Input of TEK and other expertise occurs throughout the research process. This is paramount to collaboration and its input needs to be equitable; therefore, the same investment of time and energy for this dimension to the research should be given as for western-formulated research strategies. Objectives that took people out on country were important mechanisms for increasing participation.
• Western-accredited training was important, and useful mechanisms are applied
demonstration, on site delivery and visual media. These mechanisms may also
be useful for encouraging information transfer and joint learning — which are
required to fulfil equity in the process — rather than one-way approaches.

• Interpreting results and making recommendations are minor stages in the
research and are in reality incorporated iteratively throughout the research
process. Conversely data gathering, and especially planning, constituted the
majority of the work and required the greatest investment of time in this
research. In reality, collaborators’ interpretations and recommendations are
often articulated out on country. Formal meetings are probably useful for
presenting work done independently by an outside researcher; the result
emulates a consultative form of participation and is therefore desirable only as a
last resort when greater participation is not possible.

• While it is desirable to participate with a broad range of people, key contacts or
persons employed as partner investigators will facilitate the research process and
can help promote equity.

• Dissemination of knowledge from the research also needs to be equitable; thus
novel approaches that promote equity in the knowledge transfer are required.
Information presented in formats that complement written reports with
quantitative data are suggested, and should be explored for their linkages
between the intellectual traditions.

The key characteristics of flexibility and adequate time were present throughout the
research process. A participatory project is frequently difficult to achieve
effectively within the timeframe of funding agencies and additionally requires long-
term commitment. Finn (1994:36) suggests that researchers should not be hampered
by deadlines, otherwise the project is neither comprehensive nor useful.
Furthermore, as shown in the current research the integrity of the data collected in a
hurried manner is questionable. Interactive client relationships that evolve through
time are required over and above simple information transfer (Ashby & Sperling
1995:754) and a good working relationship is frequently a forerunner to further
applied research, improved feedback, and necessary modification of research
schedules. Institutions that cannot make an open-ended commitment to effective
participation should not undertake such an activity because of the time necessary for the process to mature.

Flexibility is the other key principle running through the research process. Participatory research begins with flexibility. If government agencies and funding bodies place pressures on researchers to achieve objectives, keeping the objectives modest is important because objectives can be reworked for the particular situation and the research program can presumably continue.

Expectations of change at the community level are often unrealistic. However, when it is the donor agencies, dominant research institutions and individuals holding research power — through perpetuating research from within their own paradigm — who are required to adjust, the necessary change is also hard to envisage.
CHAPTER 7: A MODEL FOR COMMUNITY-BASED RESEARCH

This chapter opens with key findings arising from the comparison of the research process at Maningrida and Cobourg. The objectives of the contractual trepang project are summarised, and the levels of participation that can be attributed to objectives as they were implemented in that research are posed. On the whole, participation throughout the process is described as inequitable, and unable to sustain community-based research and management. Some examples of major difficulties and anomalies that occurred while seeking to achieve the objectives of the contractual research are presented, and used to argue that a model research process, proposed later in this chapter, may be beneficial to future community-based research. Reasons for lack of success in the contractual research are suggested.

The findings summarised from chapter 6 are used to propose an ideal research process that would better suit the principle of community-based research with Aboriginal Australians. The approach outlined is termed an equitable research partnership. This partnership is used as a platform from which to investigate some of the differences between the study areas that were described in chapter 6. Reasons for varying types of participation are hypothesised.

KEY FINDINGS FROM COMMUNITY-BASED RESEARCH PROCESS AT THE TWO STUDY AREAS

In the previous chapter, the research process at the two study areas was compared and related to contemporary research. The key findings are summarised below and used to design an alternative research process that could be adopted in future collaborative environmental research with indigenous Australians. They are:

- Outside researchers need to understand the protocols that exist for working with Aboriginal people and transfer this understanding to their learning process.
- Research programs should build on local cultural and social structures and systems.
• Field workers should reside in the community; outside researchers need to have extensive contact with people in the community in order to build relationships, links and partnerships.
• Participant observation techniques are useful to understand and learn about cultural differences in research and resource management, and in other important behaviours such as communication strategies. These techniques avoid the eliciting of answers to predetermined questions asked by an outside researcher, thus generating more holistic research.
• Action research and adaptive management are more useful techniques than linear approaches.
• When negotiating the research partnership useful mechanisms and structures for implementing the research need to be articulated; they should allow the terms of reference of the local Aboriginal participants to be made explicit and for them to be equal in the partnership.
• Components of the research conducted in the community should be coordinated and supervised by a local partner chief investigator.
• Relationship-building activities require considerable time and are part of the joint learning process integral to an equitable research partnership.
• Aboriginal resource management is an equal component of the research process and can be facilitated by family groups making trips onto country.
• Learning about resource management in other cultures is an outcome of the research for all parties.
• Aboriginal knowledge needs to be given equity in the research process and contributed throughout the process, not as some isolated activity.
• Western-based training programs can make use of applied demonstration, on site delivery and visual mediums. Western-based programs can be complemented by Aboriginal training programs using Aboriginal educators, language and other contributions designed to teach outside researchers and to encourage joint learning and information transfer, in preference to one-way training.
• Planning may require a greater investment of time than any other stage of a research partnership, since plans need to be constantly revisited.
• Knowledge can be disseminated through novel formats such as stories, songs or pictures that may complement written reports containing data in conventional quantitative or statistical formats.

To respond to most of these issues within an appropriate research process requires that consideration be given to issues of equity and not simply those of equality. This means that since most funded natural resource management research is primarily Eurocentric, more attention needs to be given to research from the alternative cultural viewpoint to redress existing imbalances in the research process.

**RELEVANCE OF THE CONTRACTUAL RESEARCH PROJECT TO THE FINDINGS**

The aim of the contractual research involving NTU, EA and PWCNT was to determine a sustainable use strategy for trepang harvesting. As mentioned in chapter 3 the analyses and results of the trepang project are presented in Appendix B.

The objectives of the contractual research (see chapter 3) are re-presented below with reference to the participation scheme proposed by Biggs (1989 in Okali *et al.* 1994:20–21) in chapter 2, where four levels of participation are described (contractual, consultative, collaborative and collegiate). Any one of the schemes described in chapter 2 could be used to evaluate the type of participation, but this particular scheme is chosen because it simplifies the elements of participation, while avoiding redundancy. Furthermore, it is widely used, probably the best-known example of characterising the mode of participation in a program or activity (Okali *et al.* 1994:20, 49).

As described, Objective 1 involved conducting a trepang survey in differing coastal environments. Part of that objective included developing an underwater camera system, and using this equipment in a trepang survey in waters deeper than 2 metres. Boat transects were applied to survey clear water less than 2 metres in depth, and transect walks were used to survey the intertidal area at low tide. Trepang surveys almost always occurred in the presence of Aboriginal community members at both
study areas and the degree of participation is considered to be collaborative. Even so, the survey was developed in isolation from community activities, knowledge and practices. Therefore, despite the attempts for the project to be as equitable as possible, the work was not successfully integrated with existing worldviews and practices, so the opportunity to create a more active partnership was lost.

Objective 2 involved applying computer-based algorithms to satellite images in an attempt to delineate trepang habitat in the study areas. The necessary software and resources, and the difficulty of teaching this technique to collaborating partners, made it difficult to do other than process this imagery at the NTU computer laboratory. I had planned to take the maps produced as end products of the technique to appropriate members of the community so that they could check and verify the trepang habitat. However, the technique was found to be unsuccessful for the turbid waters of the study areas and I explained this during a meeting. Since no input from Aboriginal people occurred at all in this objective it is considered to be consultative.

Objective 3 involved recording and documenting the collaborative research process and collating TEK about trepang, both of which are collaborative to some extent.

Objectives 4 and 5 involved accessing and modelling fishers’ log book data since the fishery began in 1992. These data are confidential and were not shown to any other person. I modelled the data using computer software and advice from a fisheries scientist at NTDPIF. On the final field trip to Maningrida I reported the results of the modelling, explaining that the dynamics of the fishery was very uncertain. I said that, based on a precautionary approach, and given that the current fishers may increase their effort in the Top End, it was unlikely that NTDPIF would issue any further licences. I also reported on some of the other recommendations that had emanated from the modelling exercise and literature reviews of trepang fisheries in other parts of the world. At Maningrida, people had their own recommendations (about aquaculture and obtaining a sea lease); however I felt it was unwise to incorporate their aspirations into the recommendations that would be sent to government agencies. For this reason, work towards objectives 4 and 5 is largely
considered to be consultative. At Cobourg there was no reporting at all of objectives 4 and 5, so these objectives are considered to be contractual at that locality.

Clearly most of the participation in the contracted work related to the trepang survey and TEK acquisition. Quite clearly, there was not equal participation between stakeholders during the research process as a whole, despite attempts to involve local people in all phases of the research including planning, data gathering, interpreting results and making recommendations. The objectives of the contractual project as written provided little opportunity for equity, let alone approaching collegiate or active community-based research, other than during conduct of the trepang survey and the interactions related to documenting the research process.

The western-based techniques used generated information that in reality was of very little use to either local or outside resource managers. There were too many unknowns during the research, that prevented the generation of useful results from the western techniques, while a large proportion of the budget was invested in non-participatory technologies and methods, and in activities that brought no benefit to local people.

For example, one of the most interesting points raised was that until the behaviour of trepang was better understood a survey was of very little use (see Appendix B). In other words, the reasons why trepang are sometimes present and sometimes absent from the same area need to be better understood before a survey can determine where and how much trepang is available. The possibility that trepang were present but burrowed beneath the substrate was a problem in the research and casts doubt on the survey results.

During the research process I was informed that a fisher had collected very large quantities of trepang from one of the areas where no trepang had been documented during the field survey. Although local people took me to that area during the survey and said that was a good spot for trepang, in the limited time I had available I recorded none. It now appears evident that trepang were probably nearby or buried beneath the surface during the trepang survey, illustrating spatial difficulties in the research. This is a prime example of where Aboriginal knowledge would have
generated far better results than those questions formulated by western-based resource managers.

There were also cases where people told me that when I was absent they had seen large quantities of trepang in areas we had visited previously without success. Clearly, trepang were present on top of the substrate, at times that had not coincided with my field sampling schedule — an illustration of temporal difficulties in the research. Having a person on the ground noting data would have been more useful in this research project.

The logbook data modelling also suggested that there was too much uncertainty in the fishery to make any recommendations about trepang. However, Aboriginal people assured me there was “lots” of trepang and it now appears evident that this is correct. It would probably have been more useful to simply start up a commercial harvesting operation with Aboriginal people, based on adaptive management techniques.

It should be noted that one of the community-based organisations (BAC) applied for a research and development licence to start commercial harvesting and help the research during the project. The appropriate government agency indicated its informal support for the organisation to obtain a research and development licence for some time; this possibility encouraged community members to participate in the project. However, towards the end of the research, the BAC member again formally asked about the possibility of such a licence, the government agency declined to support the request, saying that a licence would have to be purchased on the commercial market.

Although Aboriginal people’s aspirations for the resource had advanced toward aquaculture of trepang rather than wild harvesting, this was clearly only necessary because non-Aboriginal people had been issued with licences to harvest the resource some years earlier. It is unclear why non-Aboriginal people were given preference over and above Aboriginal people when licences were issued. Trepang harvesting had occurred for centuries prior to European occupation, after which it was stopped by the European government, so trepang harvesting could easily have been
considered a traditional activity and its resumption encouraged with appropriate protections placed on the activity.

At the outset of initiating a participatory approach I had envisaged that local people and myself would sit down together and talk about knowledge held by differing people, and collaborate in all activities. This did not eventuate to a satisfactory extent, probably because when local people suggested trepang as the research topic I implemented an existing research proposal, primarily because of the secured funding. Part of the reason for inequity in the process then related to a need to carry out objectives of the donor agency to its standards and timeframes. This indicates that starting the project with preconceived western-based ideas of how to research the resource was probably a prime reason for lack of equity in the research process.

Research is frequently a tool for reporting findings of what is there. Rarely is research designed to investigate what is not there because of the myriad factors that could come into play. Yet what is missing, not what is found, is often crucial in advancing knowledge. While the contractual research adequately reported the results of carefully designed trepang research, and could easily congratulate itself on its involvement of local people during the process, it is only in the research presented here that the questions of what did not eventuate and what was missing are really explored.

The inappropriateness of the research was probably because the project was designed to provide answers to questions formulated from within a single intellectual tradition. It did not complement existing knowledge and practices held by local resource managers, despite attempts to conduct an equitable participation program. It further assumed that participation in a western-based research program would be relevant and desirable to community members.

It is clear that many details related to equitable participation in the research could have been improved in this research. They range from concepts of resource management to on-ground practices. For this reason, a new approach to participatory research processes needs to be proposed.
CONDUCTING AN ‘EQUITABLE RESEARCH PARTNERSHIP’

From the results of this research, and those of related international and Australian research projects, a model for a community-based research process is proposed below. In the literature the ideal mode of participation to which natural resource management programs aspire is synonymous with collegiate research (see chapter 2). Collegiate research can be paraphrased as Aboriginal self-management of resources where outside input, such as additional advice and funding, occurs at the direction and control of the community (see chapter 2). There is an inherent risk in research programs and providing resources for local people to undertake ‘participatory research’, even at a collegiate level, because community members may carry out research that is formulated on the basis of a Eurocentric epistemology. Such a situation contributes to cultural destruction, not cultural sustainability, and is not in keeping with the principles of environmental management espoused by the international community.

Researchers are now striving to understand the challenges that participatory approaches have presented (see chapter 2) so that they can be improved in future applications. However, a legacy of past practices has left some researchers and Aboriginal people with connotations about ‘participatory research’ — that is, projects based on the techniques summarised in Table 1. These techniques are often abused so that through them Eurocentric research, environmental management styles and predetermined agendas are imposed. Research aims and objectives, such as projects in land use planning, GIS, fisheries, forestry etc., are formulated from outside the community, despite declarations to the contrary, because of the difficulty outside researchers have in working equitably with alternative approaches. Techniques of participation are frequently abused to expedite information gathering, at the expense of investing time to collect data of higher integrity and engage in mutual learning. Equity in the research is thought to occur because outside practitioners hand over pens, speaking time, and other tools of domination to community members, and believe these acts ‘empower’ community members to undertake the work. All the while the notion that traditional owners already have power over outsider researchers from the outset is not acknowledged or respected; instead the power is ‘given’ by the outside researchers.
Outside researchers ‘assess’ the capacity of the community to engage in research by reverting to participatory classification schemes (see chapter 2) and justify the contractual, consultative or collaborative nature of the research because the community is ‘not ready’ to move to more active participation. This ignores the community’s actual capacity to engage in its own forms of research.

For example, one of the most profound illustrations of the impacts of participatory techniques I was privileged to witness was given by an old man at Maningrida. Personnel from an outside agency came to the community to hold a workshop in participatory techniques. The facilitators organised community members to map biophysical features of their country such as rivers, weed infestations and so forth, using a power cord and some bush materials to mark the features on the ground. After some time watching this procedure, a senior community member arose and angrily informed the outsiders that “you’re breaking my law”. They apologised and responded that they did not wish to break his law. The old man then proceeded to make a map on the ground with the power cord and bush material and showed all present an outline of the entire northern Australian coastline. He then facilitated a discussion with the audience about non-Aboriginal place names at several localities (Darwin, Shark Bay etc.). He marked those localities on the map and demonstrated how Aboriginal moieties were dispersed throughout the area. He said that was his map (and no-one argued). Later the report produced by the outside agency showed the original resources that had been mapped and described the successes of the workshop. It included no mention of the concerns of the old man at the workshop.

My interpretation is that the old man was telling all Aboriginal and non-Aboriginal people present at the workshop that people need an understanding of his law first and foremost. In an indirect way I also believe he was also saying that the techniques were not appropriate. Later I waited with a non-Aboriginal younger man whom the old man had adopted into his family so that he and I could speak with him. The younger man told the old man that he was glad he had spoken out aloud at the workshop. Then the old man pointed at him and said “you no more balanda”; he then pointed at me and repeated “you no more balanda”. While I could have interpreted that the old man was telling us not to behave like a balanda in future, he
appeared to be happy with us and angry at the outsiders, so that I hoped he was
telling us that we didn’t behave like balanda anymore — that he was happy with the
way we behaved, which was under his direction and control.

In other examples of international participatory research very little attention is given
to a detailed explanation of the process, techniques and results, so that the reader is
left with the impression that participatory techniques are carried out simply as an
introduction to the ‘real’ research, that is, biophysical data collection.

Until the project is completely directed, formulated and carried out by community
members the more active forms of participation may never be achieved. Even if
collegete participation is achieved, cultural sustainability is threatened, and thus
environmental management.

Because of these risks in participatory research, a different approach is now
proposed — a research process under the aegis of an ‘equitable research partnership’
to avoid the connotations that accompany the term ‘participatory research’. The
model is presented hypothetically and an example, that of an alternative trepang
research project, is suggested to illustrate the theoretical case and to provide content
to the proposed model.

At any point in the process presented below, stakeholders may choose to terminate
their participation in the research, an option explicitly stated in several of the
protocols that are currently available to guide research with Aboriginal people.
Withdrawal may be due to a breakdown in the process, but may also be the result of
other factors. The important point is that equitable research partnerships be begun,
documented, explored and analysed so that breakdowns lead to a learning outcome,
eventually linking the cultural and ecological components more equitably, and are
thus a step towards success in environmental management.

The process may require extended time or many visits over a period so as to spread
the impact of the research among other cultural and community priorities.
This equitable research partnership process is presented from my point of view and
does not purport to be based on an exhaustive understanding of research
partnerships, nor to present Aboriginal people’s concept of appropriate participation
in research. There will be many variants on the process, and a few illustrations of
potential variations are also presented here.

The process refers to partnerships between researchers from both Aboriginal and
western-based intellectual traditions, not to research conducted solely by community
members according to their own traditions. Neither does it refer to work in which an
outside researcher is simply contracted to undertake work without community
participation, such as undertaking a survey and passing on results. In other words,
the process presented below is applicable to situations where community members
require additional information and seek the expertise of outsiders who have skills to
complement their own in the partnership.

In this process, the term co-researcher is used to refer to researchers from within the
Aboriginal community only. Partner chief investigator refers to a particular co-
researcher nominated as a local supervisor. The term outside researcher is used to
refer to someone from an outside institution supporting western-based science
research and resource management. The term all partners refers to co-researchers
and outside researchers.
Understand the research

*Community-based research is formulated by community members*

During the course of managing their estates Aboriginal people interact with local resources. Knowledge is accumulated via feedback learning from interactions with that resource. Community members therefore conduct community-based research activity as part of their lifestyle, particularly when fulfilling cultural obligations and practices.

The ideal first step in community-based research is that the research topic originate from local knowledge about resources and an expressed need or desire from community members to gather more information pertaining to the resource. Community members articulate the desired information as a research topic.

As a variant on this process an outside researcher may have worked with members of a particular community in the past and express a belief that research about a particular topic may be useful. Experience with the community may have put the researcher in a favourable position to understand community needs and aspirations and how research on that topic may be of benefit. The researcher’s ideas may be well received and supported by community members, who take on the research responsibility.

*Example:* Members of a community express a desire to recommence trepang harvesting in their waters. They are unsure whether they have enough information to warrant purchasing a licence and articulate their need to find out information about existing trepang stocks. Alternatively, an outside researcher working with a community notices substantial quantities of trepang and wonders whether people should recommence harvesting. He or she mentions the idea to community members, who are of the same opinion and debate whether there are sufficient stocks to do so. Community members articulate a need to gather this information as a research topic.
Initiation of an equitable research partnership

Community members discuss aspects of the research topic, e.g. discussions take place between traditional owners and community rangers. Discussions cover methods to gather the necessary information about the resource and ways to initiate components of the work, through existing structures such as the community ranger program. A person (or persons) within the community is nominated as the partner chief investigator for the research.

At some point during discussions co-researchers articulate their desire to have western scientific input as a component of their research project. The partner chief investigator or a delegate contacts a research institution seeking an outside researcher with experience or skills in the area. A researcher is identified, and the research topic discussed with that person.

(Alternatively, the interest in participation may come from an outside researcher wishing to collaborate with an Aboriginal community. The outside researcher approaches a representative of the community seeking community interest in a research partnership. The outside researcher expresses the correct protocols for working in a partnership and presents his or her skills for consideration by the community.)

Example: Rangers from the community begin trepang research. They discuss aspects of trepang ecology, harvesting, past practices, knowledge, preferred localities, observation techniques, harvesting techniques etc. with elders and traditional owners during field trips. School children and teachers attend the excursions and learn from elders. After initial research on trepang, community members remain unsure whether there are sufficient quantities to warrant purchase of a licence for commercial operations. The Aboriginal partner chief investigator contacts the local government agency or university and explains that the community are conducting research about trepang and wish to collaborate with an outside researcher who can assist in their project. The community would like input from the outside researcher about whether there are sufficient trepang quantities for a commercial operation. A person from the agency or university identifies me, a
recently enrolled university postgraduate student interested in marine ecology research.

(In the example of an outsider-initiated project I write to the community stating my interest in participating in community-based research and expressing my understanding of appropriate protocols. I present my skills and experience in fisheries harvesting experiments. I explain that I am aware of the community’s trepang research and enquire whether there is scope for me to be involved. In this example my application to the community is considered useful and the partner chief investigator offers me a place in their research program. In yet another example I canvass potential for a research partnership with the community and simply send a general application to them for their consideration, similar to seeking employment in an institution.)

**Individual learning**

Whether seeking a research partnership or being invited to the partnership, it is paramount that prior to visiting community members the outside researcher understands and adheres to protocols for working with Aboriginal people. Where the researcher is inexperienced at working with Aboriginal researchers it is vital that time be devoted to understanding these protocols at this stage in the process.

The outside researcher also undertakes background reading specifically aimed to enhance his or her role on the project. The outside researcher begins learning language, and reads more extensively about Aboriginal knowledge systems and concepts of landscape, and about contemporary issues in Aboriginal resource management, including political, social and economic issues. This preparation is in addition to reading the researcher would normally undertake for a specific research role in the partnership.

**Example:** I read and comprehend protocols for working with Aboriginal communities. I invest time studying one of the dominant languages of the area documented in a language dictionary. I review some background research about Aboriginal marine issues, and literature describing marine cultural landscapes research previously conducted in partnership by the community and an
anthropologist. I read and review western ecological research about trepang and stock estimation methods for my contribution to the partnership.

The place of differing cultural values is acknowledged

Contemporary environmental management has been derived from both western and indigenous knowledge systems, and yet both systems at times have also produced erroneous information. (Chapter 2 reviews literature about contemporary resource management that suggests that many crises have not been resolved by, or have been exacerbated by, the dominant western paradigm.) There is no ‘superior’ approach to knowledge acquisition; rather, combining both approaches is probably optimal (Baker & Mutitjulu 1992:187). Combining differing paradigms, and therefore different methodologies and methods, will expand the approaches to resource management that are currently available. To do this successfully the dominant western paradigm needs to be downplayed and other cultural approaches to resource management promoted. Outside researchers need to inherently value alternative approaches from the outset.

It may be necessary that the outside researcher spend time at this point living in the community, and attend appropriate cross-cultural courses. Often this will require that outside researchers deconstruct their own Eurocentric epistemologies, assumptions, values, and unrealised prejudices and comprehend the extent to which outsider-driven concepts, language and practices, including their scientific techniques, dominate a research process and are imposed on local people (Suchet 1999). Cross-cultural courses could be taught by Aboriginal lecturers, on their country, rather than being run in an institution removed from contextual cues about cultural values.

Example: Although I acknowledge and respect the principle that Aboriginal tradition prevail in the research, it is difficult to imagine the mechanics of everyday Aboriginal community lifestyle unless I experience it first-hand. I know that my role in the research is only a component of community research, and that information about broader community and cultural values is useful to me. I suggest to community members that I need to understand more about Aboriginal knowledge and culture so that the research will be a true partnership. The partner chief
investigator organises a cross-cultural awareness-raising activity for me whereby I spend time learning about Aboriginal culture during a field trip. He suggests that I accompany elders, school children and teachers on an upcoming school camp. I participate in this activity and also spend time living in the community participating in everyday activities where appropriate. These activities include being asked to accompany CDEP (Community Development Employment Program) workers to distribute food to outstation people by boat during the wet season, and to help women collect shellfish for an artefact display they wish to exhibit in their planned ecotourism museum.

_The research issue is explored in context_

The separate worldviews regarding the resource have implications for all aspects of the project design — from the specific research questions to the methods and the logistics of carrying out the methods. Western researchers need to understand and acknowledge that indigenous people generate a method for researching a topic based on their own paradigm and technique for gathering information. The Aboriginal approach may be as unfamiliar to the western researcher as is the western approach to Aboriginal people. Because of the tendency for western approaches to dominate research, emphasis needs to be placed in the process on Aboriginal concepts and practices redress this inequity. Outside researchers supplement existing knowledge transmission processes and the resource management innovations of local people.

Once the importance of working with existing values, structures and practices has been recognised, a means with which to explore the research topic in context needs to be identified. Mechanisms such as open forums, field trips on country and applied demonstrations are ways for all co-researchers to communicate the research and explore details for carrying out aspects of the project. The partner chief investigator or a delegate coordinates a field trip with appropriate co-researchers to negotiate the nature and scope of the research project and to discuss relevant issues. Co-researchers accompany the outside researcher to relevant country and explore the resource in the context of its importance to community members. Aboriginal-directed learning experiences about the resource help the outside researcher to understand local people’s objectives, needs and aspirations.
The field trip is used as a workshop to explore and detail strategies for research. Project design is one of the most complex and time-consuming phases of the entire research. The workshop is not to be used as a ‘consultation’ to expedite the research project; rather, it is an important part of the process that may need to be repeated many times. Viewpoints and conceptual understandings arising from it may challenge the currently held notions of the outside researcher; so it is important to attempt to shape the concepts through lengthy exploration of the topic.

Because the research agenda is set by the community the outside researcher designs techniques to suit existing knowledge and practices or add further information where necessary. It is important to remember that some objectives, needs and aspirations may change as new information is found over time, and thus research styles that incorporate iterative questions and answers, such as ethnography and action research, may help to guide the outside researcher. During field trips the outside researcher builds on information presented. Community members in turn become confident that the outside researcher has understood resource issues from the perspective of Aboriginal people. They can gauge what the outside researcher will be like to work with and begin relationship-building activities.

*Example:* The partner chief investigator arranges appropriate traditional owners and clan groups to accompany me to trepang localities. This requires a number of trips straddling different days because I work with diverse clan groups in their respective estates. Traditional owners and rangers from respective clan groups explain to me concepts and issues about trepang. They tell me how they harvested in the past, they convey relevant knowledge such as trepang preference for calm water, and tell me of a failed attempt by the community to harvest trepang around ten years ago. I record their knowledge, understand recent harvesting practices, and construct a historical profile of the community’s involvement with the resource. I suggest that people resume harvesting in the same way as in the past, but take only a small amount of trepang at the start. Rather than buying a licence they eventually supply an existing licensee with the product they collect. I suggest that I count the number of trepang they take from each locality and we weigh a sample. That way we can check whether trepang are becoming scarce or becoming too small over time. Traditional owners think this might be useful. During the trip traditional owners convey other
knowledge they consider important for my role in the research. They teach me some bush survival techniques, convey an important story and explain intricacies of some other ecological components of the trepang habitat. Together these build up a total picture for the trepang research because of the interwoven nature of knowledge. I ask if I can record that information for a more comprehensive trepang project. I am given permission to write down the information and to take photographs, but am asked to keep the information I have recorded stored at the school in the short term, rather than taking it away from the community.

Scoping study
It is not often that an outside researcher has funds to visit a community to explore a research topic in context. A research proposal may thus need to be written and approved prior to a field visit; in this event the research topic is discussed when initiating the partnership, and broad aims and objectives are indicated. The proposal indicates that there will be an initial scoping phase of the research. The remainder of the submission is kept open and flexible, stating that further phases will build on the scoping study and will be negotiated later.

In other words, the general research area is known and in line with the mandate of the funding agency and the skills of researchers. Aims and objectives are open-ended rather than closed. Objectives are refined following in-depth understanding about the research concepts and practices, and the potential roles of collaborating partners. When funds are secured, the above step in the partnership model (exploring the issue in context) can then be carried out.

Example: A research proposal is submitted to a funding agency. Collaborators specify the need to investigate the feasibility of trepang harvesting. The research strategy expresses phase 1 as a scoping study to explore trepang issues, ecology and current traditional knowledge. Phases 2 and 3 are submitted as data gathering and evaluation phases but specify that details will be negotiated at a later stage after further exploration of the exact nature of the research and methods. The proposal indicates that open-ended objectives, and research styles that suit emerging hypotheses — such as ethnography and action research — will be followed. Further
funds are to be negotiated following a better understanding of the research requirements.

**Meeting to formalise research partnership**

Next, the partner chief investigator (or delegate) facilitates discussions in the community. These occur initially through existing communication channels and strategies. A meeting to formalise the research partnership is then organised by the partner chief investigator (or delegate), nominating the forum and setting. Part of this meeting may be simply to introduce stakeholders who have not met, because some community members may not have been available to attend the field trips. Agenda items are detailed below in items (a) to (d):

*Example:* The partner chief investigator organises a meeting with appropriate people. He or she introduces me and explains what I have been shown over recent days. He says he thinks it would be useful to continue the research partnership and people suggest we “give it a go”. Other traditional owners suggest that I visit their country because I did not go there during the field trips.

*(a) Formalise the research*

One of the agenda items at the community meeting is to discuss and formalise aspirations for the resource and ways to ensure cultural sustainability. The local facilitator recapitulates on the field trip for those who could not attend, and on aspects of the project design, which were probably articulated by the various partners during the field trip (or scoping study). Traditional owners who have not previously had input express any additional desires for the research. Some aspects of the partnership may need to be refined. Community practices for gathering information about the resource are detailed.

Unless otherwise directed, the outside researcher listens and notes the issues as articulated. At some point the researcher is asked by the local facilitator to indicate what concepts and practices he or she can bring to complement the research schedule articulated by the community members. The outsider researcher explains which elements arising from his or her training are likely to be relevant to the particular area of the researcher allocated to her or him. Western-based research
practices that ideally complement the research are probably those based on adaptive management styles, so that the research follows the process of feedback learning (defined in chapter 6). These practices are probably most effective if guided by an action research framework, with techniques such as quantitative and qualitative sampling or participant observation nested within the process as appropriate.

*Example:* Generic outcomes such as the need to manage country during the research are articulated, as well as issues specific to the resource in question such as not wanting to waste trepang during harvesting. The partner chief investigator states that community rangers will take the boat and collect trepang, return and gut the trepang and prepare it according to past practices. After this it will be stored in a building. He then asks me to express the monitoring program I have devised. I suggest that I make up a sheet of paper with the coastline and pictures of weighing scales with measuring needles. I explain that each day we take a new sheet and record the name of the bay on the section of coastline where trepang was collected. I propose that after community members gut the trepang it is weighed and a mark drawn on a picture of a scale to best show individual trepang weights. I explain that we can see if trepang become smaller as we continue harvesting. At the meeting co-researchers formalise a partnership agreement with me.

*(b) Negotiate roles*

Both parties negotiate and shape the roles and responsibilities of partners and individual researchers. Elders are acknowledged as having a role in knowledge transmission, and community support structures are used where possible. Knowledge custodians are identified, recognising their particular expertise.

The capacity and the skills of community members are recognised and expanded. This includes employment for the partner chief investigator to speak with appropriate knowledge owners, to check on-ground support for the project, and to suggest changes where necessary. Co-researchers with appropriate skills or in a position to obtain the necessary knowledge are identified.

Support roles played by other community structures such as local schools and personnel may be part of community in-kind contribution to the research so that
children and elders, for example, work together. In addition to conducting their own research, local people may also wish to be employed as interpreters, or in technical roles on the component of the research initiated by the outside researcher.

The discussions under this agenda item refer to field trips but also to any work the researcher may undertake outside the community — such work should also be detailed.

**Example:** Traditional owners identify particular elders as important people for outside researchers to speak with. People to drive the boat, harvest trepang, weight trepang and record information on the sheets are identified. One young ranger explains that he learnt to take GPS readings in the army and volunteers to record this information during the research. A young woman learning computing is identified by community members and a traditional owner asks if I can help her enter the GPS information into a computer. She and the GPS recorder participate in the other trepang activities to understand how their data entry role complements. They desire that family members or peers attend during their work. A local council representative present at the meeting suggests that some of the building crew could cut local timber and erect a structure for drying the trepang. A school representative suggests that a school project complement the research and that traditional owners agree to teach children as well as rangers about trepang during the work. The school representative suggests that we take photos for a school project that can be expanded to include bilingual reading and writing and school biology lessons. A community coordinator suggests that a government or fishing representative view the research as soon as it starts so they can help obtain a licence if necessary at a later stage.

(c) *Produce a research agreement*

In the past, Aboriginal intellectual property rights, cultural property rights and resource ownership have been of little importance in the western research process. However, the concepts of native title are now being tested for their potential to encompass issues such as Aboriginal ownership of knowledge and resources (Bennett 1996). A research agreement or a memorandum of understanding dealing with such matters has become a preferred way to formalise negotiation.
To draft a research agreement, all partners start with a blank sheet, entering the research topic, aims, objectives, responsibilities, roles and practices discussed during the negotiations. Other aspirations, concerns, or envisaged tangible outcomes are identified, but it is acknowledged that these may occur at a later stage. Specific community indicators to evaluate the process and modify it where necessary are identified. The commitment to use community support services is made explicit. Principal investigators from each party are named on the agreement. A commitment to produce periodic progress reports may also be useful.

The agreement formalises how information generated by various activities is used. Information access and control mechanisms, such as certain community members’ consent to disseminate knowledge, require particular attention. Publication of research results in either a written manuscript or oral presentation format in line with western research conventions should be subject to the written agreement of all parties and to joint authorship where possible. Reference to foreground and background intellectual property will be useful. Background intellectual property is considered to be what one party owns prior to the research and brings to it, and should remain the property of the owners of that information, with its use controlled by them. Foreground intellectual property is the results created by the joint project, it should be jointly owned, and its use subject to the written agreement of all parties; all such material and its copyright are then jointly owned.

The disclosure of any information of a potentially commercial nature needs to be controlled by one or more community representatives and written consent required for its dissemination. Sacred information needs to be respected by each individual, and its dissemination subject to written agreement.

Depending on each partner’s capacity to negotiate, mechanisms to assist the negotiation process may be necessary. A local person or a trusted outsider, familiar with some of the technical jargon used by the outside researcher, may help to negotiate the community position.

Field work should not begin until the research agreement has been finalised.
Example: The partner chief investigator (or delegate) notes on a blank sheet or whiteboard that the research topic is to survey trepang and the objectives are to start trepang harvesting, record the harvest, and refine the harvest during the research. Methods to carry out these objectives are noted, including trepang collection methods, and the recording techniques (including school photographs) suggested. The roles of people are formalised, including my consent to train two young people in data entry. We agree that knowledge dissemination of any kind requires agreement of all knowledge custodians. A representative of the NLC is nominated as a mediator in the event of any conflicts.

(d) Organise funding

Assuming that financial resources are required, a collaborative role in organising funding (or negotiating funding to follow a scoping study) is necessary. Community organisations may have financial resources from existing sources (e.g. existing grants, money from royalties) or pipelines to funding agencies. Other resources available to them that could be contributed to the research (vehicles, boat, radios etc.) are specified in the submission.

As mentioned above, the proposal should specify open objectives and adaptive mechanisms so that objectives can be reworked, emulating action research styles. The funding proposal is written by a person(s) identified for the task, and feedback obtained from all stakeholders, facilitated by a locally organised workshop to finalise the proposal. When both parties agree to the research plan and techniques the funding proposal is submitted.

Budget requests require attention to equity for all partners, so that budget items are available to community members and not the outside researcher only.

Example: The community specifies contributions of staff and resources that can be provided in kind. Further funding for community employment positions and resources is justified, as it would be with additional employment positions that are created in outside institutions. Requests to purchase equipment also require attention to equity. I indicate that I need to purchase camping equipment from the
budget because we will be camping at remote localities during the trepang research. Co-researchers also identify a need to be provided with camping equipment.

Liaison with funding agency and other outside stakeholders

Funding agencies should be able to consider holistic research and understand that cultural values, knowledge, practices, training, etc. are as important for natural resource management as knowledge about the resource itself because of the interwoven nature of all factors. Applying appropriate resource management stems from appropriate research projects. This requires that funding agencies relinquish their focus on quantitative natural resources data, because other elements are equally important. Dale and Bellamy (1998:86) stressed that a recent initiative (CYPLUS) failed because of its focus on the biophysical component of natural resource management at the expense of public participation (both insufficient time and financial resources were provided for public participation in the project). Funding agencies may also need to coordinate approaches so that a research proposal receives some money from a resource management agency and another from a training institution. Recent developments in north Queensland suggest that all stakeholders should come to a negotiating table to discuss appropriate delivery for community-based natural resources. This means that all outsider interests and roles are identified at the outset, after the community have explored the research in context.

Funding agencies are partners. In this way they are involved in negotiating the objectives and funding the research according to the agreed details. Their role is to keep the project flexible until the detail has been negotiated.

Horizontal links to other institutions are identified to maximise coordinated information gathering. These links are identified as early in the possible in the process to avoid using multiple researchers. Information obtained across government departments will reduce the burden that visiting researchers place on communities and also avoid replication of the work by outside organisations with similar data collection interests.
Example: After securing a research grant the first phase, that of the scoping study, is conducted. The partner chief investigator (or delegate) organises a meeting with all co-researchers to present to the funding agency representative the detail of the next phases in the research agreement. The agency agrees to the strategy detailed in the research agreement, and suggests that it link to this work another project that it wishes to fund on mudcrab research. It wonders if people may also collect mudcrab while harvesting the trepang, and later weigh the mudcrab collected. Traditional owners agree to this suggestion, and request funding for an additional mudcrab harvesting position. A fisheries management officer is also present to advise on matters relevant to the agency. He suggests that the partner chief investigator undertake a trepang processing course that the agency has developed for commercial fishers to ensure best quality trepang is exported. The funding agency covers the cost of attendance at the course. A representative of a training institution attends the meeting and suggests that the data entry skills that co-researchers acquire be accredited as a module in a computer course it is delivering in the community; this reduces the institution’s need to visit the community as frequently as in the past, and cuts its costs.

Collect information

Field activity is conducted

The collection of information begins according to the manner negotiated. The partner chief investigator supervises components of the work conducted in the community. The partner chief investigator may be placed in a difficult position because internal pressures may have an impact on his position; therefore some support for his role may be necessary.

In the past the outside researcher has often acted as a facilitator, but employing a local supervisor, instead for this function changes the participatory emphasis. The consequences of such a change are that the risk of data misinterpretation is reduced, and the process is facilitated in an appropriate way, rather than as perceived by the outside researcher. The latter conducts his or her role in the research. Components that the outside researcher undertakes in isolation should be viewed by co-researchers during a work exchange tour.
Example: The partner chief investigator arranges a co-researcher to record knowledge from knowledge custodians. The partner chief investigator contacts the traditional owner prior to harvesting and organises co-researchers and the necessary resources such as vehicles, boats, other equipment and food. Traditional owners oversee the processing of trepang. I help with the monitoring and recording information I have suggested, and with data entry.

Ensure that appropriate protocols are followed
At all times, appropriate protocols are followed. The partner chief investigator acts as an advisor; alternatively a committee of appropriate people may be identified by the community to guide the outside researcher, to any one of whom the outsider researcher may direct queries about the research. This committee is not a formally structured committee in the western sense, rather people nominated as advisors and who are useful when the partner chief investigator is not available.

Example: I ask the partner chief investigator whether we could increase female participation in the project. He or she suggests that I speak with some of the traditional owners who were present at the meeting to formalise the research. I visit these people and they suggest some young women to help on the project.

Time establishing credibility and rapport is invested
To redress past perceptions of western scientists as usurpers of traditional knowledge and imposers of inappropriate practices, it is important to reestablish trust and credibility with community members. This will involve spending time with people in activities not related to the resource in question; and may be facilitated by the partner chief investigator. During these non-resource-related activities community members will provide learning opportunities by directing the outsider researcher’s activities and behaviours.

Example: I spend time in the school environment, where ecology is taught to children. They learn about ecology from both intellectual traditions, write in both languages, use the computer etc.
Methods are explored

It is important to critically review all techniques used, including participatory approaches and techniques. Some will have potential in the research project and others may present challenges. Participant observation is rarely mentioned in participatory research techniques summarised in Table 1 (chapter 2). As mentioned by Berkes (1999:xiv), volunteered information can be very different from that extracted with prompts and with researcher-initiated questions. Participant observation techniques provide an ideal means for learning in ways other than by questioning people. When observing, listening or engaging in practices the outside researcher may raise some questions about the behaviours occurring. As these questions arise in the context of the behaviours a more complete understanding will be gained than if a verbal response were to be given to an imagined or hypothetical situation that would differ under various scenarios.

Appropriate people identified by the community show the outside researcher ‘their way’ of researching the resource in question. The outside researcher also demonstrates the methods proposed for his or her role in the research. Some of the proposed technological or western-based research styles may be shown to be inappropriate after demonstration, and the methods employed may require refinement. Such activities provide opportunities for thought: creating and integrating Aboriginal practices with western-based research practices, through both technical and non-technical techniques. In this way, valuable learning experiences evolve to foster the creativity of all researchers.

Example: I learn that frequently during the wet season there are periods when people have no food. We discuss the potential for keeping some of the harvested trepang for community consumption. This means that we design another aspect to the project: someone investigates methods of cooking trepang to make it palatable to local people. We also design an arrangement so that after harvesting in a particular estate is no longer feasible, a portion of the product that does not prevent a marketable quantity being processed, is allocated for consumption by the clan concerned.
Ways to record and disseminate information are explored
Aboriginal ways of recording and disseminating information are explored. Information transfer may be via song, story, dance or art. Other useful technological tools that could be used include video, photographs, CD-Rom and visual media tools.

The information recorded is linked with other western-based recording techniques used in the research. The interface between the recording techniques used by both parties becomes an important component of the knowledge generated. This interface for information transfer is an area where further research can be conducted.

Example: Photos, stories and the monitoring records are entered onto an Internet web page created in a projected at the school. Children add local language and create a video linked to the web page to accompany the work.

Continuously interpret results of the data collected
Data collection and interpretation are a continuous activity rather than a linear progression of the process. Reflection on the research results occurs simultaneously with the data collection and the program is adapted where necessary.

Example: Co-researchers notice that after three weeks, trepang numbers and weights in an area are diminishing. We terminate the research for that area and move to another locality to resume the research, and plan to wait until the same time during the following year to harvest the first area again.

Training
Aboriginal people frequently express a desire to receive training in western resource management. Training in research and assessment techniques can be provided by the outside researcher. However, it is important that the training be appropriate: simply providing western-based accreditation programs may not be appropriate. Aboriginal people also express a desire to teach outsiders. For this reason effective mechanisms for information transfer between the two cultures are important for an equitable partnership. Such mechanisms can be acknowledged in western institutions.
This does not devalue outside researchers who have western qualifications and experience, but recognises that some of their concepts, tools or information can be imparted that Aboriginal people may choose to take on board in the future. In a similar vein, Aboriginal intellectual tradition has been acquired over a long time, and some of its concepts, tools or information can be passed on to the outside researcher.

*Example:* Co-researchers invite a western-accredited trainer to view their trepang numbers and weight monitoring activity using on site demonstration. The trainer acknowledges their understanding of western research techniques in the context of the resource harvesting and recognises that a component of a western-accredited program has been completed.

We promote the Internet web page developed, and the cultural transmission processes used during the research, with the university at which I am enrolled. The project is used as a case study in resource management. A lecturer from that institution asks that one or more Aboriginal people act as guest lecturers for a group of western students; they visit the community on an excursion to view the research program. Over time, the community develops an entire curriculum on Aboriginal resource management programs and their interface with western research, which is used in outside teaching institutions.

*Conduct periodic evaluations and a final workshop to share information*

Co-researchers produce progress reports for the ranger program and school curricula using the ways of disseminating information they have explored (see above). The chief partner investigator or the informal advisory committee discusses and evaluates the project when crises arise or perhaps periodically, such as after progress reports are produced. Any difficulties or new ideas are redesigned in the research.

The results about the resource have been constantly interpreted during field work but are formalised at a final meeting to share results. The term ‘share information’ is selected because ‘feedback results’ suggests that a consultative approach has been adopted and that the results of the research have been created by one partner to
inform another. While this may be so for some components of the research, it is important that information and insights collected by all partners be shared with each other and with the wider community. Much of this information may have been discussed while in the field, but it is important to formalise the results and relate the findings to the original objectives expressed.

Example: Co-researchers and school children make posters periodically, explaining changes to the research. They add extra information to the web page. A workshop to share the information is conducted for the wider community — for example in the school. The workshop is informal in nature and information is shared. Mechanisms such as the passing on to children of research findings by elders and traditional owners are used. School personnel may help with workshop organisation and show attendees the school’s web page. I explain that the monitoring work I have been helping to initiate using the western techniques has shown that we should be able to continue harvesting the trepang at this rate, which means it would be economically viable to purchase a licence. If that is done, it would be important to continue the monitoring program.

Think about the future

A final meeting to evaluate the partnership is conducted
It is important to evaluate components of the partnership. There may turn out to be many disappointments in the research, such as not obtaining the data envisaged about the resource, or simply not obtaining the desired level of participation. In this case it is important to think positively about what has been learnt and present this as a success. Some of the issues may have been raised at earlier stages in the process, but it is important to consider them in a more formalised way toward the closure of the process. In this way future strategies for research partnerships can reflect any findings and recommendations.

It is important to determine what the results mean to different collaborators. Partners could identify what has been learnt during the research. Outside researchers need to identify what has been learnt from Aboriginal people, not simply their improved knowledge about the resource. While it is important to use
knowledge for resource management, outside researchers also need to articulate to the wider community important aspects of the process and cross-cultural concepts. In this way the dialectic learning process is carried out and institutional learning occurs to effect political, administrative and policy directions. Aboriginal people identify what they have learnt from western science.

Measuring success is difficult because the concept of success means different things to different individuals, communities and organisations (Suchet 1999:226). Members of funding agencies and potential partner institutions need to remember that success in community-based research needs to be articulated by community members. Outcomes may be characterised not necessarily as success or failure, rather as characteristics of similarities and differences of the particular community and the social dynamics, participants or specific resource issues that govern the context of the research. The ideal approach is that partners be aware of differences and recognise that specific indicators of success vary.

The final meeting, coordinated and facilitated by the partner chief investigator (or delegate), formalises these issues with traditional owners and rangers:

(a) Determine whether the information and knowledge gained were adequate/successful for the research

Discussions are held about the resource studied and the ability of the partnership to deliver knowledge about it. The degree to which outcomes for community members, in relation to their interactions with the resource, were productive may be indicators of success. Questions to explore these issues might be:

- Did the research provide appropriate and useful information?
- Were the objectives met? If not, what were the obstacles?
- How did the research help with broader objectives related to the resource?

Local people’s concepts of participation and equitable partnerships are in themselves an area requiring an intensive research project. However, a guide to success can be determined from questions related to the research partnership process, such as:
- Was participation equitable?
- Did the project meet community members’ desire for a research partnership?
- What were the problems that emerged between different conceptual understandings of the resource and related issues?
- What components of the process, and what structures, mechanisms and practices, were appropriate and inappropriate? How can these be improved next time?

Example: Attendees discuss and confirm that the research showed there was enough trepang to warrant commercial harvesting. They conclude that the broad aim was met. However, objectives could have been met more efficiently if they had had another boat and operators working in another locality. Thus inadequate resources might be an obstacle in future research programs. At one point during the discussion someone mentions the possibility of farming trepang, and an interest in trepang aquaculture as a future aspiration for the trepang resource. Community members confirm that some training was recognised by western institutions, and that recognition of Aboriginal knowledge has also been achieved at tertiary institutions, thus achieving one of their broader community aspirations. In relation to the process, community members articulate the difficulty they had with describing their concepts of resource management to the funding agency because the representative had not spent time in the community. We identify as an important future consideration in future partnerships, an important need for mechanisms to teach outsiders who spend minor amounts of time with Aboriginal communities about alternative worldview. We identify a potential partner institution — the education faculty of the university at which I am enrolled — to help teach these worldviews in a future partnership. Community members suggest that success occurred in some respects because all clans’ estates were represented, elders had greater opportunity to pass on knowledge in context, rangers had opportunities to undertake cultural management practices and to learn new approaches, and the community had control of the research. In my view success may be related to the numbers and range of people participating, including the representation by age, sex, occupation or community role, and by clan estate representation. It may be evaluated by
community member’s level of interest in the research, by socioeconomic indicators such as increased employment or wealth creation, or simply by enhanced ecosystem management. Both quantitative and qualitative indicators may be necessary if an in-depth evaluation is required.

(b) *Action plan is devised*

Because co-dependency can sometimes develop it is important to devise strategies for continued resource management and research, based on the results of the partnership. It is important to understand the relationship of the partnership outcomes to on-ground implementation and management and to devise an action plan (see Table 1) to continue successes and tackle the obstacles articulated during the final meeting.

Ideas articulated during the meeting and during the entire process are included in the action plan; it specifies mechanisms for future initiatives, and thus ideas are formulated that will initiate new research partnerships. The plan may require links to other researchers, institutions or funding agencies. Potential negative impacts on the community from harvesting the resource may also need to be considered and researched.

*Example:* Co-researchers identify community members to continue the trepang harvest and monitoring. They decide to channel a portion of the funds from trepang harvesting toward another boat to continue research partnerships and expedite future initiatives. Co-researchers express in the action plan their desire to try trepang aquaculture. A partner chief investigator is nominated to supervise a new research partnership about aquaculture. That person is to identify a new suite of potential outside researchers with aquaculture experience to invite to the partnership.

*Knowledge is disseminated*

Funding agencies, policy makers, outside researchers and sometimes people within the community will need to disseminate knowledge about the research, with respect to both the resource in question and the partnership process. Co-researchers prepare sections of the report pertaining to their role and skills. Sections including, for example, what has been learnt (as identified in the previous section) are part of this
The knowledge generated can be disseminated in standard western formats such as a report but also in other ways. Conferences and other forums for knowledge exchange about indigenous knowledge, culture and biodiversity can explore alternative formats for knowledge presentation.

Example: A written report and CD-Rom, complete with hypertext links to an Internet web page, is provided to the funding agency. I suggest that I write a paper for an Australian journal so that other scientists can read about our work; and traditional owners agree to this and approve the final manuscript. Co-researchers present the results at an international conference using a poster they have developed that complements some text I have written, all of which explains the research partnership.

Conclusions about an equitable research partnership

Aboriginal people use resources, have highly developed knowledge systems and management practices about those resources, and change and adapt their interpretations in relation to changing knowledge. In ecosystem management it is important that both cultural survival and ecosystem health are supported. Community-based environmental management programs can be a forum to sustain both components of ecosystem management. Mutual respect and encouragement are required, which necessitates a comprehensive consideration of the issue of equity between cultures in participatory research. Unless this is done existing imbalances will never be redressed and cultural sustainability will be lost, an irreversible consequence of current ecosystem management with Aboriginal Australians.

The ability of outside researchers to understand that two very different worldviews are operating is paramount, as is the creation of ways to reflect both these worldviews within the research. Innovation, flexibility and long-term commitment, as well as specific issues such as equity in budgeting arrangements, need to be upheld in the partnership. Partners conduct their research according to their expertise and assigned roles.

Project design is probably the most important phase. This is where the roles and the equity of participation are established, and the scene is set for the project.
Indigenous people need to design the project and then help outside researchers to complement their design. Although this is the objective of truly collegiate participation, such a process is in fact rarely followed, despite attempts to be participatory, and the dominant western styles of research are perpetuated.

The research partnership proposed centres on a methodology of action research and ethnography for the process, and on adaptive management as a way of understanding information about the resource. Components of the research process are thinking, acting, observing and reflecting. As with the many methodologies not based on the positivist-reductionist approach to information gathering, specific hypotheses may need to emerge and be revised, as well as the specific aims and objectives, as component parts of the process. In this way a truer representation of the appropriate questions and hypotheses emerges rather than being predetermined and preconceived in advance of the research. Furthermore the questions are formulated from the viewpoints of two worldviews rather than just the worldview of the outsider researcher. Western-based adaptive management styles for the resource are also probably useful because these techniques are based on feedback learning.

Sufficient time for all those involved to work at their pace is necessary. This is particularly important in communities where there are multiple and sometimes simultaneous demands on people’s time occur, frequently that of non-paid or partially-paid workers. Imposing rushed agendas to meet bureaucratic exigencies compromises the integrity of the process, the data collected, and the aims and objectives of the research project itself. It is far easier and more appropriate for the funding agency to recognise that greater time is needed and simply build this into its reporting requirements or funding time frame. Better still, it is important to recognise the need to learn from, and about, partnerships in resource management, rather than to simply learn about the resource from within a single knowledge system.
RELEVANCE OF THE PROPOSED MODEL TO RESEARCH AT THE TWO STUDY AREAS

The model of an equitable research partnership described in this chapter is used as a platform for analysing the important similarities and differences in the process described in chapter 6.

Understanding the research at the study areas
At Maningrida, an equitable approach was envisaged from the outset, although an ideal process in reality did not occur. At Cobourg no such approach was envisaged from the outset, although a similar process to that followed at Maningrida was implemented much later into the process. Because the work was planned together at Maningrida there was probably a greater tendency for the research to take account of some components of equity there than at Cobourg.

At Maningrida community members formulated the topic, while at Cobourg they agreed to the topic.

I engaged in the same amount of individual learning for both localities, conducting the same preparatory reading about protocols. As far as possible, I acted in the same manner subsequently. (Differences may have occurred where directed by a local person.) Because of this I was prepared to be flexible and ensure local direction of the process, and to be guided to discover new learning experiences that constitute the outcome of this research. However, although I acknowledged the importance of differing epistemologies, paradigms and techniques from the outset, the aims and objectives of the funding agency made it difficult to incorporate multiple knowledges.

I was offered “a job” at Maningrida by community members after introducing myself via letter and telephone. Community members at Cobourg had no input to my selection for the program; I was simply approved by the Board and not introduced. This may be because local authority structures were better encouraged
by the community-based organisation at Maningrida rather than by the formal joint
council-and-chair model of authority at Cobourg.

This conclusion is further illustrated by the presence of external stakeholders during
negotiations. Although both communities eventually indicated in-principle support
for participatory research, the added government presence during negotiations about
the logistics and practices of participatory research (described in chapter 6) made the
incorporation of alternative intellectual traditions, and an approach beyond that of
consultation, a difficult feat. Such findings strongly support suggestions that the
capacities of some Australian institutions to work cross-culturally with indigenous
Australians in resource management require attention.

I participated in formal meetings to discuss the research topic at both localities, but
did not discuss the concepts and views of the resource management from the point
of view of Aboriginal people. This is probably because I lacked true understanding
of alternative values and because I did not have the experience or skills to
understand Aboriginal communication strategies from the outset. Therefore, at
neither locality did I conduct a field trip to explore the issue in context. That might
have given me a better understanding of the importance of the alternatives available
in the research from the outset. However, given the agendas of donor and
implementing agencies, it was difficult at the time for me to see how the project
could have been altered within the time frame allocated. Thus future research in this
area must recognise that it is imperative for outside institutions to value alternative
intellectual traditions.

The role of ranger or marine biologist that I was given at Maningrida probably
indicates an informal negotiation of roles. While it was not specifically related to
the contractual research, community members expressed expectations that I learn
aspects of their culture and lifestyle, indicating the importance in the process of joint
learning. The lack of community role at Cobourg was probably related to the more
contractual nature of the project implementation.

At Maningrida, research topics were frequently submitted to funding agencies
through community structures based on ideas from traditional owners, although
usually written by a member of BAC or an outside researcher with experience within the community. At Cobourg the research emanated from the PWCNT stakeholders or other outside agencies and researchers such as myself, rather than through the Board or personnel from a community structure interested in community management. However, at Cobourg it was quite clear that at least one key individual expressed ideas that could be easily presented as a research proposal in a western scientific style, or with both western and traditional components. That person was the project coordinator, whose commitment to the trepang survey makes him, in my view, an ideal partner chief investigator in future research at that locality.

I enquired about arranging a written research agreement at Maningrida but was told by a non-Aboriginal BAC member that it was not necessary and that verbal arrangements would suffice because Aboriginal people appeared to trust me, based on my conduct to date of the project. He and the senior community ranger said that Aboriginal people were happy with my attempts to seek local direction of the contractual research. At Cobourg a research agreement with community members may have been useful because data suggest that the external stakeholder’s indication of in-principle support for participatory research was not matched with on-ground commitment to the realities of implementing the work. Individuals within the funding agency also differed in their commitment to participatory research, and some or all of them may have been unaware of the principles and realities of such a process. Again the need for institutional capacity building is evident.

Relationship-building activities and joint learning processes were encouraged at Maningrida by all stakeholders, including non-Aboriginal members of community-based organisations, and by all participants at Cobourg.

Community-based organisations appeared to be useful for facilitating research, but external agencies appeared to complicate the research unnecessarily so that outside agendas could be advanced rather than those of community members.

**Collecting information at the study areas**

Collecting information at the two study areas did not differ substantially because at both localities Aboriginal resource management and visits to country were of
paramount importance in the process. In some cases people helped me with the western-based techniques, usually when they were unable to conduct their own resource management roles. My use of participant observation techniques at both localities was also helpful to my role in the joint learning process. It was important to invest time establishing rapport.

The reasons why more people were interviewed at Maningrida than at Cobourg were probably twofold. I had access to older people because they were resident at the time in the community. It was a relatively easy matter to visit them at their home to conduct an unstructured interview, even if I had to wait until one of my visits coincided with their presence in town. Secondly, in Maningrida I was always accompanied by a person from the community who acted as an interpreter, explained the research and probably helped engender a sense of trust between community-based actors and myself. At Cobourg I was not resident at a central place and so could secure access to traditional owners only when both they and the team were simultaneously at the same place. On the occasions when I tried to spontaneously speak with a couple of older men I found it difficult to communicate satisfactorily and was not sure I had understood their information, or had made my questions clear. Again the need for a partner chief investigator with responsibility for equitable input is evidenced by these findings.

At Maningrida the senior community ranger acted as the local supervisor, but in reality he delegated much of the coordinating work to me or suggested I talk with other people. This might in part have been due to the fact that he originally offered me “a job” and to my conceptualisation of him as a supervisor. My role in the community further fostered these impressions of our respective roles. The project coordinator at Cobourg took greatest responsibility for organising the logistics of the project at that locality. He appeared committed to making the project work and expressed desires to conduct further research of that nature.

At Maningrida a non-Aboriginal member of BAC suggested a workshop at the school so that the rangers could disseminate information about their work. While this did not eventuate during my time there it is likely that photographs, video material and oral information would have been useful workshopping formats.
Institutional obstacles to using these ways of presenting information probably prevent their widespread acceptance in the western scientific community.

At both localities the cyclical nature of the research was evident, in terms of both interpreting results and revisiting the planning stages. Thus the linear approach to research was not appropriate.

**Thinking about the future at the two study areas**

Most of the issues relating to future research, discussed in the model research partnership described in this chapter were not covered by my role in this research. Other than my presentation of the results to the community, the contractual research project did not aim to evaluate the equity of participation, local indicators of success, joint learning outcomes or future strategies, or to prepare joint reports.

The difference between the two study areas on future research was the observation that community members at Maningrida intended to continue to explore options for the trepang resource through other channels, namely aquaculture. These aspirations were facilitated in part by the role of the ranger coordinator, which started at the concluding stages of the contractual research. The research described here may have been part of a necessary progression toward implementing programs with a greater community-based component at that locality, and thus part of an evolution of community-based research there. If so, the involvement of people from the outset, and other findings from this research (such as the need to engage in joint learning processes rather than implementing contractual research), have probably been of use to community members because they may alter future research based on these experiences.

As mentioned earlier, I cannot provide comment on the progress of research aspirations at Cobourg, but understand that no further developments in relation to the trepang resource have been initiated.
AFTERWORD

The preceding chapters theorised participatory research to support natural resource management, presented research at different study areas, analysed differences, and provided new directions for participatory ecological research based on these findings. This chapter links the findings to the questions presented in the introductory chapter, and to current thought in the area, and generates implications for future collaborative ecological research with indigenous Australians. The conclusion is that the same cultural shifts as Aboriginal Australians have experienced in the past are required by western researchers who engage in participatory ecological research programs with indigenous Australians, so that participatory programs generate equity in the process.

INEQUITY IN PARTICIPATORY NATURAL RESOURCE MANAGEMENT

There is a wealth of literature describing participatory approaches to resource management, e.g. the works reviewed by White et al. (1994b:96–106). There have been many failures and internationally only modest successes (Wiggins 1996:434). Data to answer important questions that might advance thought in participatory resource management, such as how to translate participatory principles into equitable practices, are not collected by agencies and are difficulty and costly to gather. The best that outside researchers have come up with to date is perhaps to have stopped completely top-down approaches and encouraged some two-way interaction during the process (Wiggins 1996:434). Current Australian literature on collaboration also describes only the arrangements, and there is a shortage of, and need for, literature that analyses and evaluates reasons for the success or failure of these arrangements (Claridge & Claridge 1999:6).

The research presented here expands and analyses participatory resource management processes in more detail, and is novel in its application to collaborative work with indigenous Australians. The key factors determining success in involving indigenous people were the ability to allow flexibility and sufficient time, factors that are often interwoven. The process involved testing initiative in unexpected
circumstances, refining procedures where necessary, and sometimes gathering information in an informal or opportunistic manner, characteristic of the need for flexibility. White et al. (1994c:110) suggest that data collection alone may take only a few months whereas true integration and project presence in the community may take much longer, reiterating the need to allow sufficient time during the process. The case studies in this research also suggest that planning and understanding the work need to be significant components of research.

The major lesson from this thesis was that participatory research and resource management need to move beyond existing techniques to approaches that make the research equitable for all researchers, rather than those that make all researchers equal in the process. (For example, all researchers could simply undertake equal roles in western style research programs). I conducted the work as suggested by research protocols and attempted to ensure that the work was participatory at all stages. My role was to incorporate the western procedures as appropriate. Community members wished to direct and control the work on their terms and did not follow the western-based research except as a means to help me in my role, which was only a small component of conducting the work on their terms.

Alternative culturally based research needs to be given greater attention than western-based research in participatory resource management to redress the current imbalances. Such an approach needs to be recognised from the initial stages of a research partnership, that is, when understanding the nature of the research. It is paramount that this aspect of the partnership be embraced by all stakeholders. Once an understanding and valuing of equity in the process occur the remainder of the process can occur more smoothly.

The problems with past approaches in participatory resource management are related to a lack of equity in the process. Despite the simultaneous environmental crises evident throughout the world — which have not been solved by western resource management — inequity in resource management is perpetuated through the importance placed on western science, and the lack of recognition by western scientists of their need to learn and adjust to other ways of resource management.
Current approaches favour western science
By failing to move beyond the confines of their epistemological tradition, many western scientists risk limiting their research to an understanding of only some components of the ecosystem. This in turn exacerbates ecosystem crises that are manifest all over the world. It also fails to recognise or silences alternative approaches to ecosystem management emanating from indigenous cultures, so that western scientists continue with approaches that are as irrelevant as they are undesirable (Pinheiro et al. 1998, Berkes 1999, Suchet 1999). Such approaches regress cultural and social factors in ecosystem management. If resource management is to incorporate the concerns and aspirations of indigenous people it will require a shift in western research thinking so that research programs are designed to this end, that is, to equitable processes that link cultural and environmental sustainability.

There are many instances where the objectivist epistemological foundation to research is relevant and desirable, but it is not a panacea for natural resource management. The global market economy also brings new challenges for indigenous people where western research plays a role in providing specialist input or assistance. Also, human invaders frequently introduce new species, concepts and socioeconomic institutions when they colonise a landscape, imposing differing knowledge systems, practices, beliefs, and worldviews (Berkes 1999). The invaded group frequently does not have answers to the new ecosystem created, introducing a myriad problems that cannot be solved by traditional knowledge and traditional management practices, because of the insufficient time to evolve and adapt to the dynamic. In some cases, the invader group may be called on for management advice and resourcing, although often its approaches are also inadequate because they are imposed onto a new landscape. Thus research about these issues is important and desirable because local people identify the issues that require research and drive the process toward improving their management of natural resources.

However, western assistance and resourcing become a part of a collegiate resource management process to which practitioners aspire. Sinnamon and Epworth (1999:59) stress that western science and technology, regional organisations, and planning are only part of a process and are not the solution to natural resources
research and management with indigenous Australians. In Aboriginal land management the worldviews, values, concepts, culture and practices related to land management are a broad picture in which western scientific research and advice constitute only a small component because of the complex relationships, which cannot be framed within the western approach alone.

Unfortunately western researchers often assume that they have a monopoly on knowledge generation that will answer environmental management issues of the day. Furthermore, they may believe that the scientific method they employ, as detailed by their particular paradigm, is the only method of integrity capable of producing research. The role of indigenous science as an equitable component of research, particularly in ‘participatory’ research, is rarely acknowledged adequately.

Sometimes researchers working in another cultural setting may benevolently collect TEK or consult with community members in a tokenist gesture of acknowledging that there is another culture in which they are working. They may begrudgingly input ‘anecdotal’ information to the research, rather than understanding and valuing that knowledge. Such actions do not devolve power, facilitate community-based research, or remove the underlying assumption of the predominance and accurateness of western-based research. Nor do they show understanding of the values and priorities of traditional management of country; rather, they simply document information because of its relevance to their own research needs.

For equitable participatory projects to occur there needs to be an acceptance within the mainstream scientific community of the value of alternative ways of conducting research. When western scientists acknowledge that TEK, cultural, intellectual and spiritual property, and belief systems of other cultures are equal to those of mainstream sciences there will be true equity and participation.

Joint management and other forms of co-management that occur in Australia imply equitable systems with shared benefits and responsibilities. These systems suggest a desire to redress disadvantaged stakeholders such as remote Aboriginal communities. However, they have been criticised because in practice the more powerful institutions only painfully and with immense reluctance and resistance can
be persuaded to share power (Ashby & Sperling 1995:766, Cordell 1995:13). Thus equitable partnerships need to be promoted.

**Current approaches do not encourage indigenous peoples’ instruction of western researchers**

Equitable participatory research presents an opportunity for western researchers to learn about alternative approaches to resource management, rather than simply to develop local people’s capacity for western-based research. Participant observation techniques kept me open to such a richer learning, which would not have eventuated without it. I am also more confident that the research findings represent a more accurate account of the research than had I not used those techniques.

Often there are barriers to information flow between cultures during a research process, and conflict tends to follow (CERPI 1999). Instead of recognising these barriers, western-based research, through its predominance in education and in mainstream society generally, has ignored and silenced the resulting conflicts in favour of perpetuating western approaches. Researchers continue to produce reports and other outputs to satisfy their needs and those of outside agencies. This means that instead of equity in participation, a single worldview that attempts to subsume cultural diversity under its banner is imposed on all partners.

Instead of taking opportunities as important ‘learning processes’, retrogressive steps toward consultation rather than collegiate participation are used to disguise the fact that true participation is difficult, both in principle and in practice. Yet it is these ‘learning experiences’ that are needed, substantiated by evidence about the effects and impacts of participatory research, so that true progress in this area can occur. In an emerging field where sceptics abound, a critical evaluation of participatory resource management is necessary if the predominance of failures is not to prevent further work in this field.

Although some recognition of alternative viewpoints has occurred in other disciplines, a corresponding effort from western-based bureaucrats and researchers in the discipline of natural resource management, which is based on positivist-reductionist approaches, has not occurred. A legacy of inappropriate approaches and
unsuccessful research outcomes for Aboriginal Australians has resulted. Not only is there a large amount of information that has not appropriately been communicated to Aboriginal land and sea managers, there have been no initiatives focusing on learning by institutional personnel from local resource managers so that effective two-way dialogue — and thus equitable participation occurs.

The devaluing of cross-cultural resource management occurs at the level of donor and implementing agencies, as well as that of individuals. Ananda and Razaak (1998) argue that often under the cloud of rhetoric top-down planning approaches continue, and that processes need to be institutionalised to help improve outdated approaches. These and other researchers (e.g. Schramm & Hubert 1996:10, 11, MWLR 1999, Claridge & Claridge 1997:3, 30–33) suggest that some of the main issues and challenges for institutionalising a process are related to capacity building within institutions, or institutional strengthening, rather than capacity building at the community level.

Characteristics of institutional strengthening may include: institutional accountability (such as for the impact of actions in the project) to community members; flexibility; long-term commitment; encouraging adaptive management techniques in ecological research; mechanisms to encourage joint learning and training in research and natural resource management; and a concentration on process rather than content and results. Personnel in the institutions concerned must recognise and respect diversity and include the needs, values, opportunities, arrangements and capabilities of the participating community, and personnel adjustments to new roles/functions and orientations may be necessary. Underlying these changes is the need for mechanisms to alter the political bias of institutions through public and ministerial education or through political pressure.

Institution building will take time, and requires attitudinal change, exposure to experiences, training in appropriate skills, and individual personnel empowerment to devolve authority and not feel a loss of professionalism. Western professionals with experience in cross-cultural research require recognition from within their own workplace, because their experience constitutes a highly valued and desirable quality in a professional person. Experience shows that research assistants and young
researchers with no experience are often employed to work with Aboriginal people, as if there were no need to value experiences gained by long-standing workers in this field. The employment of western scientists with little or no experience in understanding the cultural and social dimensions of the work devalues the importance, expertise and skills gained by those westerners who do have extensive experience in the area. The ability needs to be recognised as a profession in itself, and the appropriate learning time and skills necessary for such a position acknowledged by western scientists.

Even implementing new approaches may result in a desire to instigate community-based participation for success in resource sustainability, rather than a search to achieve meaningful ways of accelerating efforts to concurrently check poverty, promote human rights and sustain ecosystem components, recognising their interconnectedness. Changing paradigms to put people first and to use equitable rather than one-sided approaches is not easy to put into practice, and may simply take the form of rhetoric, so it is important that on-ground implementation should be monitored, as well as institutional reorientation at the policy and program level.

Future activities need to go beyond simply jumping on the bandwagon of participatory research and critically evaluate what is being imposed by some well-intentioned techniques. Until outsiders cease to impose research, and to presume that local people have limited capacity to produce knowledge, the research will be regressive in terms of environmental management. For example, mapping needs to be directed by Aboriginal people, starting from their concepts of resource management. The modes of participation need to be defined according to the terms of reference of all partners. In other words, outside researchers need to understand what an Aboriginal person’s model of collaboration is. For example, the model in this research describes a participatory process from my point of view. Until representatives of partner communities also articulate their concepts and practices of participation there is much work to be done in analysing participatory research.

All too often Australian scientists and professionals are engaged with capacity-building programs in overseas nations or in Australia, yet neglect the need to build the capacity of their organisation to work with indigenous cultures. This may reflect
a perception on the part of bureaucrats that there is no need for such combined approaches and that western researchers need to teach their resource management approaches to the rest of the world. Again, there is a danger that we are disseminating the dominant western paradigm. To redress equity issues in community environmental research, emphasis now needs to be placed on mechanisms for outsiders involved in these programs to understand their own learning needs and opportunities for working within another cultural resource management system.

Government programs that strengthen rather than displace or subordinate indigenous self-management and self-governance institutions are required, but workable mechanisms and methods to facilitate involvement of and control by local people of local resources have yet to be satisfactorily identified. The devaluing of alternative approaches, and the institutional blocks to implementing genuine participation, are the areas that require attention in future participatory research with Aboriginal Australians.

**Inequity in the process perpetuates assimilation and racism**

World-wide interest in Australian Aboriginal culture and their knowledge of the ecosystem is recognised. However, as in many other parts of the world, Aboriginal land and sea managers have been subject to repeated attempts by personnel from government institutions to impose research, education and training programs from the perspective of Eurocentric epistemologies. A growing body of international and national academics is recognising the need for such programs to be informed by two intellectual traditions (e.g. Berkes 1999, Suchet 1999).

Environmental management and planning in Australia are dominated almost totally by non-indigenous agencies and individuals where the pretext is that environmental problems require mainly technical or western scientific solutions. Government agendas in natural resource management usually prioritise conservation and ecologically sustainable development over social and cultural equity concerns. Research programs that concentrate on TEK are rarely funded, nor have equitable research partnerships been encouraged.
Suchet (1999) explains how western-based researchers often seek verification of their work within their own term of reference and are thus judging their work from their value system and standards, proclaiming superiority over other knowledge systems and legitimising their behaviour from within. She suggests that many programs encompassed by participatory approaches, including those advanced under the banner of community-based natural resource management and co-management, are embedded within western epistemologies and their paradigmatic limitations. These foundations constrain a researcher’s beliefs, questions, and approaches, while limiting and controlling local people by ignoring, devaluing or silencing their approaches, a point often echoed by Berkes (1999). Both those researchers suggest that because western-based approaches are embedded in mainstream power structures, most participatory research attempts to assimilate indigenous people so that they cannot act according to their own terms. Most current approaches do not as yet provide a new direction for resource management because the research proponents mistake their western epistemologically held constructs, values and assumptions for universally held principles and beliefs. Thus they fail to link the cultural and ecological components of environmental management.

This research supports the above views because the principle of equity across cultures was not manifest during the research, despite a carefully constructed process and framework to guide a participatory approach for community-based research with Aboriginal Australians. By assuming western-based approaches to trepang research it failed to encompass Aboriginal resource management and joint learning processes. Intercultural dialogue was insufficient, so it did not properly bridge the cultural gaps between the western scientific community and Aboriginal people, and thus did not live up to the rhetoric nor the principles of appropriate participatory research. This research has proposed a more workable solution to future participatory research with Aboriginal Australians in natural resources research.

The solutions require that personnel from outside agencies desist from perpetuating outsider-controlled approaches, and will require vision and long-term thinking. The fundamental differences between bureaucracies and community structures are embedded in philosophical foundations, shaped by culture and society, from which
resource management actions are driven. Rarely is attention paid to the differing value systems evident in cross-cultural research and on the impacts they have on all components of research, from the language used and the concepts and practices employed, through to the results disseminated to the wider public. While there is increasing awareness and respect for indigenous or local knowledge, there are limited and token attempts to use it. Where indigenous expertise is acknowledged, the agenda seems to focus on the added benefits to western society rather than an intrinsic valuing of cultural differences.

The role of outside researcher is a privileged position because as facilitator of research the outsider has a position of power, which can be an external threat to lifestyle and cultural maintenance. In such a privileged position the outside researcher has a responsibility to implement appropriate approaches and not to simply inflict western research on indigenous communities. Until the outside researcher has the skills and expertise to understand cross-cultural research, or is prepared to make the effort to gain these skills, they should not take on the challenge of working with indigenous communities.

Current western biophysical science research is primarily a service delivery to indigenous recipients, where indigenous resource managers are encouraged to adopt western ways. The service delivery of science is at best patronising and assimilationist, and at worst racist, where racism is defined as a system of advantages based on race. It continues to try to impose western values and practices on an indigenous society, and attempts to assimilate participants under the banner of science, education, training, capacity building or a swag of other outreach activities, all the while not tolerating the contributions of indigenous science. Yet no-one bothers to think about the consequences of his or her actions when they are presented under the banner of science or education. Why these systems are perpetuated is another question, probably best dealt with, at least in part, by proponents of political ecology and related disciplines.
EQUITABLE RESEARCH PARTNERSHIPS ARE NEEDED TO LINK CULTURAL AND ENVIRONMENTAL SUSTAINABILITY

To adequately respect differing cultural traditions and values many western scientists need to move beyond interdisciplinary research, because such approaches merely meld a combination of the dominant western research approaches, whether they study biophysical, social or cultural data. The concept of interdisciplinary research is not novel, and in fact is increasingly advocated in research programs, but interdisciplinary studies still may not adequately span the intercultural divide in worldviews about landscapes and ecosystems.

An equitable research partnership employs the concept of ‘intercultural research’, rather than that of interdisciplinary research. An intercultural research project design, rather than an interdisciplinary project, is advocated here. Equitable participatory research requires the sort of intercultural approach to research where the differences in the cultural foundations to research are embraced and elaborated within the research process. Such research is intercultural in its conceptualisation, and in the tools and techniques employed. Responsibilities in such partnerships are two-way because western researchers acknowledge their need to learn from indigenous experts: effective instructions need to be issued by indigenous resource managers to outside researchers who are prepared to encourage equity in the process. Intercultural research has not been advanced previously and there is an urgent need to develop ways to make possible approaches that acknowledge and value alternative cultural approaches; otherwise cultural diversity will be lost, as well as the links to, and potential for greater understanding of, ecosystem components.

It is well accepted that less than ideal participatory processes occur in many research projects. While bureaucrats continue to demonstrate a lack of interest in, and recognition of, the importance of understanding how to work with people of fundamentally divergent worldviews about resource management, less than ideal processes will continue. Equitable research partnerships require full equity in the research process. Future research partnerships need to stimulate discussion and
make recommendations about how to enhance the ideology of the approach. Then when aboriginal people speak of their knowledge system they may command the same respect from western researchers, and true participation based on respect will be attained.

In Australia we are a long way from achieving participation, even within mainstream Australian communities:

“It is considered that much that passes for collaborative management of marine and coastal resources in Australia is either not collaborative management or is at the lower end of the spectrum (minimal community involvement and control). Where collaborative arrangements with significant roles for non-government stakeholders are being put in place, they are in general project-oriented, short-term and probably not sustainable, especially in the absence of government funding.” (Claridge & Claridge 1997:3).

Unless there is a means by which research can involve dialectal learning it will not only probably fail or continue in mediocrity, but worse, will perpetuate inappropriate research paradigms. Such an outcome is unacceptable both in principle and in practice, and in generating research of integrity. If Australian researchers fail to recognise international developments in the recognition and conservation of cultural diversity and its associated knowledge and practices, the final opportunity we have will be lost as elders of Aboriginal clans and language groups pass away, and thus the links between cultural and ecological sustainability are forever destroyed. If as professionals we are unable to deal with and withstand a revision of our values and philosophies and their binding structures and practices, then the rhetoric will continue without the reality.

To advance international thought in participatory research with Aboriginal Australians requires that western scientists downplay their usual research role and be prepared to take on joint learning processes directed by Aboriginal community members that will help redress current imbalances in current work programs. Many Aboriginal leaders are encouraging Aboriginal people to undertake western-based
education and training so that they can use these tools to the benefit of their culture and people, and western researchers have the opportunity to initiate partnerships that match those desires. Western researchers also have the opportunity to engage in partnerships that benefit cultural diversity and its links to environmental management. Alternatively they can wait until a generation or more of Aboriginal youngsters, educated within western paradigms, are able to voice their concerns within mainstream sciences and either initiate new responses, or simply practice the dominant western research without recognition of their culturally-based environmental expertise. However, should we wait until indigenous Australians also speak the language of western science, the intervening destruction of cultural wealth, its link to ecological components of the ecosystem, and the perpetuation of racism associated with current approaches are unconscionable for teachers and practitioners of tertiary education and research. An equitable future requires that personnel in western institutions take on the same cultural shift as Aboriginal people have been forced to undertake over recent generations.
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ATSIC (Aboriginal & Torres Strait Islander Commission) (1998) Protocols for consultation and negotiation with Aboriginal people. Department of Aboriginal and Torres Strait Islander Policy and Development, Brisbane.


Centre for Aboriginal and Torres Strait Islander Participation, Research and Development (1995) Guidelines on research ethics regarding Aboriginal and Torres Strait Islander cultural, social, intellectual and spiritual property. James Cook University, Townsville.


NARU (North Australia Research Unit) (undated) Advice on field work in north Australia and on research with aboriginal & Torres Strait Islander people. Adapted from AIATSIS booklet Research Grant: information and conditions for applicants 1990, Australian National University, Canberra.


APPENDIX A: RESULTS OF APPLYING THE GUIDING FRAMEWORK AT THE TWO STUDY LOCALITIES

<table>
<thead>
<tr>
<th>STAGE 1: PLANNING THE RESEARCH</th>
</tr>
</thead>
</table>

**PRINCIPLE 1. CRITICALLY EXAMINE COLLABORATIVE RESEARCH RECOMMENDATIONS**

Principles important for **planning** collaborative research derived from a total of 13 sources (4 institutional guidelines, 6 literature sources and 3 interviews):

- advance community aspirations 8
- conduct negotiations 11
- establish personal relationships 1
- allow flexibility and sufficient time for a collaborative style 13

Principles important for collaboration in **gathering data** derived from a total of 13 sources (4 institutional guidelines, 6 literature sources and 3 interviews):

- establish personal relationships 1
- follow culturally appropriate procedures 7
- engage local people in the work 13
- interview appropriate people for relevant information 4
- delegate responsibilities 5
- communicate with key persons 1
- allow flexibility and sufficient time for a collaborative style 13

Principles important in **interpreting data** of collaborative research derived from a total of 13 sources (4 institutional guidelines, 6 literature sources and 3 interviews):

- ask for community members’ interpretations 3
- explain your own interpretations 5
- synthesise results sensitively 7
- allow flexibility and sufficient time for a collaborative style 8
Principles important for making recommendations from results of collaborative research derived from a total of 13 sources (4 institutional guidelines, 6 literature sources and 3 interviews):

- incorporate ideas from all sources 4
- ensure community approval of material for publication 5
- ensure ongoing monitoring 2
- ensure ongoing management 4
- allow flexibility and sufficient time for a collaborative style 8

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**PRINCIPLE 2. APPROACH POTENTIAL COMMUNITIES**

Maningrida

Initial telephone approach to communities via representative member of community organisation 6

Letter sent to communities to formalise approach 4
- sought interest in collaboration
- ensured I would follow community priorities for research

Receipt of response from communities
- job offer 1
- interest in concept 2
- already overburdened 1

Participation in meetings to discuss potential research opportunity
- present ideas after request from community representative 2
- listen to representative’s ideas 2
- meet other community members/or visit community 2

Research agreed
- availability of resources/infrastructure 1

Cobourg

Existing research proposal/funding
- meeting with government agencies 1

Research agreed
- availability of resources/infrastructure 1
PRINCIPLE 3. ADVANCE COMMUNITY ASPIRATIONS

Community aspirations noted informally:

- trepang licence/fishing initiatives 4 1
- use GIS 3 0
- female involvement 2 3
- local involvement/employment 2 2
- formalised training in the community 2 1
- collaborative work 1 1
- resource surveys 1 0
- desire to do research independently 0 3
- access to better housing and infrastructure 0 1

Participation in meetings to discuss community aspirations

- ranger/research/marine role 7 0
- personnel 4 7
- other 3 0

Participation in other activities related to community aspirations:

- ranger/scientist role 11 0
- organise and implement employment grant 0 18

PRINCIPLE 4. CONDUCT NEGOTIATIONS

Regarding research direction and logistics

- formal meetings 2 2
- informal directions 1 3

Changes in research direction

- personnel 8 14
- field schedule 3 7
- financial 2 2
- research objectives/plan 1 14
- resources 0 17
- accommodation 0 2
- training 0 5
## PRINCIPLE 5. ESTABLISH PERSONAL RELATIONSHIPS

<table>
<thead>
<tr>
<th>Formal meetings related to research</th>
<th>Maningrida</th>
<th>Cobourg</th>
</tr>
</thead>
<tbody>
<tr>
<td>during the planning stage</td>
<td>3</td>
<td>6</td>
</tr>
</tbody>
</table>


### PRINCIPLE 1. ESTABLISH PERSONAL RELATIONSHIPS (CONTINUES)

**Formal meetings unrelated to research**
- Maningrida: 11
- Cobourg: 0
- held outside the community: 11
- in the community: 2

**During unplanned encounters and informal Conversations**
- Maningrida: 14
- Cobourg: 1
- at the office: 14
- in passing: 17
- at home, while seeking another person: 7
- through meals/drinks: 0

**During involvement in everyday activities**
- Maningrida: 9
- Cobourg: 3
- while acting as marine ranger: 9
- transporting people: 7
- conversation about favours: 4
- learning about/watching something: 0
- offering hospitality: 0

**During trepang data gathering**
- Maningrida: 23
- Cobourg: 3
- visits: 23
- discussing language: 6
- eating: 5
- interviewing traditional onwers: 2
- providing information about country: 3
- watching the video of trepang survey: 1
- while staying in a traditional onwer’s house: 0
- building encouragement/trust: 0
- research: 0

### PRINCIPLE 2. FOLLOW CULTURALLY APPROPRIATE PROCEDURES

**Facilitated collaborative research**
- Maningrida: 25
- Cobourg: 6
- sought access permission: 25
- family/peer groups: 16
- hunting, fishing, gathering food: 13
- dreaming site: 3
- smoking ceremony: 2
- take guide: 2
<table>
<thead>
<tr>
<th>Constrained collaborative research</th>
<th>Maningrida</th>
<th>Cobourg</th>
</tr>
</thead>
<tbody>
<tr>
<td>health and family</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>non-availability of physical resources</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td>meetings</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>people liked to watch</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>human resources</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>general maintenance work</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>public relations</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PRINCIPLE 3. ENGAGE LOCAL PEOPLE IN DATA GATHERING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>During trepang survey</strong></td>
</tr>
<tr>
<td>used/fixed resources</td>
</tr>
<tr>
<td>showed or interpreted trepang presence</td>
</tr>
<tr>
<td><strong>Planning survey and trepang matters</strong></td>
</tr>
<tr>
<td>planned the day before (boat, TEK, training)</td>
</tr>
<tr>
<td>confirmed that day</td>
</tr>
<tr>
<td>asked for help to find new collaborator</td>
</tr>
<tr>
<td>spontaneous trip</td>
</tr>
<tr>
<td>meeting for rangers input to book chapter</td>
</tr>
<tr>
<td>equipment and resources</td>
</tr>
<tr>
<td>clearance</td>
</tr>
<tr>
<td>worked alone</td>
</tr>
<tr>
<td>other request for access</td>
</tr>
<tr>
<td><strong>Formal training component</strong></td>
</tr>
<tr>
<td>watched video</td>
</tr>
<tr>
<td>data entry</td>
</tr>
<tr>
<td>demonstrated/explained techniques</td>
</tr>
<tr>
<td>report writing</td>
</tr>
<tr>
<td>formal training cancelled</td>
</tr>
</tbody>
</table>
**PRINCIPLE 4. INTERVIEW APPROPRIATE PEOPLE FOR RELEVANT INFORMATION**

<table>
<thead>
<tr>
<th>Information</th>
<th>Maningrida</th>
<th>Cobourg</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEK</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Knowledge about trepang given at other times</td>
<td>23</td>
<td>10</td>
</tr>
<tr>
<td>Other types of information</td>
<td>18</td>
<td>4</td>
</tr>
</tbody>
</table>

**PRINCIPLE 5. DELEGATE RESPONSIBILITIES**

<table>
<thead>
<tr>
<th>Responsibility</th>
<th>Maningrida</th>
<th>Cobourg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related to trepang survey</td>
<td>50</td>
<td>large #</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>

**PRINCIPLE 6: COMMUNICATE WITH KEY PERSONS**

<table>
<thead>
<tr>
<th>Key Person</th>
<th>Maningrida</th>
<th>Cobourg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community ranger</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>Ranger/project co-ordinator</td>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td>Non-Aboriginal BAC/PWCNT staff</td>
<td>10</td>
<td>41</td>
</tr>
<tr>
<td>Other Aboriginal persons</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>
### STAGE 3: INTERPRETING RESULTS

#### PRINCIPLE 1. ASK FOR COMMUNITY MEMBERS’ INTERPRETATIONS

<table>
<thead>
<tr>
<th>Topic</th>
<th>Maningrida</th>
<th>Cobourg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trepang presence/absence</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Other matters</td>
<td>11</td>
<td>4</td>
</tr>
</tbody>
</table>

#### PRINCIPLE 2. EXPLAIN YOUR OWN INTERPRETATIONS

<table>
<thead>
<tr>
<th>Topic</th>
<th>Maningrida</th>
<th>Cobourg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trepang report</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>During trepang survey</td>
<td>0</td>
<td>4</td>
</tr>
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SUSTAINABLE HARVESTS OF TREPANG BY TRADITIONAL OWNERS OF GURIG NATIONAL PARK AND THE MANINGRIDA AREA OF NORTHERN ARNHEM LAND

Report to Environment Australia
(Sub-Contracting Agency: Parks & Wildlife Commission of the Northern Territory)

THIS REPORT CONTAINS INFORMATION OF A COMMERCIALLY AND CULTURALLY SENSITIVE NATURE.

J. L. Carter
Faculty of Science
Northern Territory University
DARWIN NT 0909
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DISCLAIMER

The views expressed in this report are those of the author and do not necessarily reflect those of any party.
SUMMARY

The potential for sustainably harvesting trepang by Aboriginal communities at Maningrida and the Cobourg Peninsula was collaboratively researched.

Trepang abundance was determined by counts from an underwater camera, boat, trawl net and intertidal walks. Densities were determined and varied by up to an order of magnitude, similar to international research results. Generally, average densities are lower than found elsewhere.

Sandfish occurred in an array of habitats, on substrates of varying particle size and coverage. The highly variable abundance of trepang and habitats occupied means distribution and abundance are difficult to predict on the basis of factors studied in this research.

Satellite images captured under different moon, tide and wind conditions, were acquired. Algorithms to differentiate water depth, habitat type and suspended matter in the water column were applied. However, water turbidity inhibited the effectiveness of technique for mapping trepang habitat. An alternative approach using GIS techniques was trialled and maps of verified and potential trepang habitat produced.

Traditional ecological knowledge was collected, and mainly related to trepang localities. Principles for working collaboratively with indigenous Australians were derived from literature, institutional policies and other researchers, and used as a framework to guide the research process.

Biomass dynamics modelling was applied to commercial fishers’ logbook data. Data covered a relatively short times-series and effort varied within the area of the fishery. Any number of fits to the data were possible. Modelling will be more useful as the fishery ages and generates further data.

Recommendations for further research and monitoring are given.
INTRODUCTION

Relevant holothurian ecology
Sea cucumbers are epibenthic marine detritivores with an elongated body wall (Harriott 1984, Kerr et al. 1993). Some fourteen species of sea cucumber are listed by the South Pacific Commission (1979) as suitable for use as trepang, or beche-de-mer, which is the edible product that is marketed after sea cucumbers are collected, boiled, smoked and dried to make the body wall firm (Harriott 1984). Internationally trepang is in high demand and many areas of the world have been overfished, probably due to poor management of the fishery (Preston & Lokani 1990).

All holothurians which can be used as trepang belong to the order Aspidochirotida (Phylum: Echinodermata, Class: Holothuroidea). Members of the order Aspidochirotida are found in shallow coastal waters (Fechter 1974), however, factors which influence their distribution in this zone are poorly known.

Shelley (1981) reviews literature sources which suggest factors which may influence holothurian distribution include substrate type, particle size of the substrate on which they feed, wave action, water velocity, reef morphology and seagrass distribution. Another factor thought to limit the distribution of holothurians is the decomposition products from microorganisms such as hydrogen sulphide and methane, while waves and currents are probably the ultimate limiting factor (Yamanouchi 1939). Holothurians may also display a diurnal response to light which possibly affects distribution (Shelley 1981).

Sea cucumbers ingest sand and mud from which they digest bacteria, microorganisms, detritus and other organic matter and expel the remaining substance (Bakus 1973). Frizzell et al. (1966 in Bakus 1973) suggests the main ecological role of deposit feeding holothurians is bioturbation of the substrate which results in destruction and mixing of the initial sediment stratification, and aeration and release of organic material and nutrients from interstitial water into the water column. He also suggests bioturbation may inhibit larval settlement and development of suspension-feeding and meiofaunal populations.
Sea cucumbers are capable of locomotion but are generally sedentary. However they are known to crawl up the sides of aquaria and some species burrow into the substrate (Bakus 1973, Cannon & Silver 1986).

Tropical holothurians are thought to have few predators probably because of the tough integument and toxicity (Bakus 1973), although some predators include seagulls, sharks, gastropods such as *Tonna perdix*, and fish (Uthicke 1996). Holothurians are generally dioecious (Shelley (1981).

**Holothuria scabra**

Vail (1989) surveyed three sites of the Northern Territory coastline and found four holothurian species: *Holothuria (Metriatyla) scabra* Jaeger or Sandfish; *Holothuria (Halodeima) atra* Jaeger or Lollyfish; *Holothuria (Mertensiothuria) leucospilota* Brandt; and *Bohadschia marmorata* Jaeger. Only Sandfish was considered to be of commercial value to an Australian trepang industry because of its size, abundance and market value. For this reason, and because the current Northern Territory fishery is based on Sandfish, (NTDPIF 1994) this research project will investigate Sandfish only.

Both *H. scabra* and *H. scabra var. versicolor* are two colour morphs of the same species, and will hereafter be referred to as *H. scabra* or Sandfish. The species is characterised as grey or white ventrally, and grey or black with transverse wrinkles dorsally (Cannon & Silver 1986) as shown in Fig 1. They are dorso-ventrally flattened with marked dorso-ventrally differentiation due to the presence of tube feet on the abdomen. Sandfish may reach a size of 40cm and a weight of 1.5 kg (in Uthicke 1996).

*H. scabra* generally occur on silty substrata and in seagrass beds in low energy environments, often in areas of decreased salinity (Shelley 1981, Uthicke 1996). Habitats include areas behind fringing reefs or inner reef flats, inner lagoons and bays, and areas close to mangroves. Although the species has been reported from areas of strong tidal current close to the reef margin in Belau in Japan (Yamanouchi 1939), this report was for a group of holothurians including Sandfish and the
proportion of Sandfish found in this environment was not reported. In the Northern Territory *H. scabra* was found on silty sand (Vail 1989).

Although usually in the intertidal zone and shallow water Sandfish have been reported to a depth of 12 m in New Cadelonia where a hypothesis was put that a rich supply of organic matter of terrigenous origin influences distribution (in Shelley 1981). In the Northern Territory *H. scabra* occurs from the intertidal zone to 10m, with highest densities to 4m (Vail 1989).

According to Yamanouchi (1939) *H. scabra* eats with a definite diurnal rhythm, not correlated with tidal events. He suggests Sandfish burrow in the early morning between 2 and 4 o'clock and emerge again in the afternoon between noon and 1800, although individual behavioural differences were noted (Yamanouchi 1939, 1956). At least a third of the diurnal cycle of Sandfish was spent not eating (buried) and in a state of low activity. However, Wiedemeyer (1993) reported that Sandfish feed both day and night, even when burrowed and select for fine particles. Yamanouchi (1939) suggests that burrowing occurs to seek shelter because in his study burrowing
was observed after lengthy exposure to the air before the usual burrowing time. Individuals in the intertidal zone spend part of the day burrowed but subtidal individuals appeared to be always on top of the substrate (Vail 1989, Uthicke 1996). Juveniles observed by Vail (1989) were always found in seagrass beds.

Sunter (1937), a trepang collector during the 1920’s and 1930’s, describes trepang (in the Northern Territory therefore presumably Sandfish) as lying on the bottom of bays, but qualifies this statement by mentioning that on a cold day Sandfish are frequently absent from the surface of the sea-bed. He reported that populations could be buried for a week at a time, but on a bright day the seabed in the same place could be suddenly smothered with trepang.

On the northeast coast of Australia, PNG, the Red Sea, and in New Caledonia *H. scabra* spawns at the start of the wet season from November to January (Shelley 1981, Uthicke 1996), although some localities show a second spawning peak in the cold months (Aug-Sep) (Shelley 1981, Preston *et al.* 1988). In India two spawning seasons are found and spawning is year round in the Philippines (Uthicke 1996, Ong Che & Gomez 1985). There is a theory that echinoderms closer to the equator tend to spawn year-round while further defined spawning seasons exist with distance from the equator (Pearses 1968 in Shelley 1981). Since the patterns are indistinct it is necessary to establish the spawning time at a particular locality (Uthicke 1996).

Shelley (1981) used size-frequency data of *H. scabra* to analyse the modal progression of Sandfish age classes over time, and generated average growth of age classes. He tentatively suggested Sandfish increased at 0.5 cm/month (and converted this to a wet weight of 14g/month). Although size-frequency data has been argued to be inconclusive because of unpredictable recruitment of echinoderms in the tropics, the data at least provides some estimate of growth and these methods are used elsewhere for holothurian growth analysis (e.g. Guillou & Michel 1993). James *et al.* (1994 in Uthicke 1996) state that the life span of Sandfish is 10 years and calculate a growth rate of 22.6 g/month based on wet weight.
Size at first maturity has been estimated at 16 cm, 21 cm and 22 cm (Shelley 1981, James et al. 1994 in Uthicke 1996, Conand 1989c in Uthicke 1996) although this may vary up to 100% even between populations separated by a small distance.

A reliable measure of size is difficult to find in holothurians because of their fluid nature and elastic body wall (Sewell 1990). Variability in weight results from differing food content, seasonal changes in internal organs and quantity of water in the respiratory tree. Derived measures of size such as drained or gutted weight are unsuitable for live animals and measures of dried weights are difficult, time-consuming and labour-intensive to obtain. Measurements of totally contracted animals or a bidimensional index (contracted length x contracted width x scaling factor of 0.1) as used by Cameron & Frankboner (1989) can partially overcome the problem. However, the relationship between these measures and the uncontracted state observed needs to be established (Sewell 1990).

Interest by Aboriginal people
In past centuries, certain Aboriginal communities of the Top End were involved with the harvesting of trepang to supply Macassan traders, and the fishery is considered to be Australia's first export industry (NTDPIF 1994). Some communities expressed an interest in resuming trepang harvesting from their waters for commercial purposes. Before such activity can proceed, a sustainable use strategy needed to be developed, in accordance with ecologically sustainable development principles adopted by the Commonwealth and States/Territories. The following research was conducted in collaboration with traditional owners of two study areas (described below) who wished to determine whether there was room for additional effort and licenses in the existing Northern Territory fishery or whether there was economic viability for supplying existing licensees.

Study areas selected
Two study areas were selected: the waters around Gurig National Park (on the Cobourg Peninsula) and around Maningrida, in coastal Arnhem Land (Fig 2). Billyard (1995) and Ferns (1994) derived a regional classification for north Australian coasts, based on biophysical and structural properties. The Cobourg Region is categorised as having no major drainage systems, with a mesotidal range
of 3 m. Annual median rainfall is 1200-1400 mm with a mean annual runoff of 500-1000 mm. In contrast, the Arnhem-Wessel Region (including the Maningrida area) has the Goomadeer, Liverpool, Blyth, Goyder and Buckingham Rivers as drainage systems and a mesotidal range of 3 m west of Castlereagh Bay. Annual median rainfall is 1000-1200 mm with a mean annual runoff 250-500 mm. Variability in sea surface temperature of both regions is around 6°C (Ferns 1994).

The low-gradient Northern Australian Continental Shelf (NACS), less than 200 m in depth, reaches to New Guinea coastline in the Arafura Sea region (Davis 1985, Ferns 1994). Wave energy on the northern coast is usually low except during storms and tropical cyclone activity. Energy is dissipated by the NACS because the 20 m isobath occurs more than 10 km from the shore. During heavy rains river discharge increases, causing massive debouchment of fine sediments, and altering estuarine and coastal salinity.

Sediments of the inner shelf and coastal margins are not well known around the Arafura Shelf section, however, it appears that little recent sedimentation has occurred in the vicinity of the study areas (Ferns 1994). Around river mouths where river sediments mix and coagulate with seawaste, and in areas where water turbulence and current velocities are reduced, extensive areas of fine-grained anoxic saline substrate (mud) occur (Davis 1985). This mud may be an extension of the mangrove substrate which is typically richer in organic matter, however, processes vary from river to river, depending on tidal and flood cycles.

Offshore regions have sediments comprising mainly muds and sandy muds (Billyard 1995) with tertiary alluvial surficial sediments of the Cobourg Region and quaternary sand and silt in the Arnhem-Wessel region. Saline muds beneath mangroves may extend for up to 13 km in Castlereagh Bay (east of Maningrida) at a 0.1 m low tide (Davis 1985).

Sandy beaches tend to occur in areas free from the deposition of mud (Davis 1985) although these are infrequent and narrow, typical of humid coastlines (Ferns 1994). In these areas, sands are generally well sorted into ridges and troughs, running
parallel to the shoreline and persist through tidal cycles because of the low wave energy. Dunes are typically chenier ridges.

Where the outflow from creeks combines with backflow from currents passing islands, muddy foreshores are found to the landward side of the islands while sandy beaches occur on the more exposed side. Islands further seaward are generally freer of estuarine deposition. Some reefs in the area hold *Avicenna marina*, however, seaward islands and reefs are more commonly of coral nature (Davis 1985). Occasionally cliffs with rocky foreshores feature along the northern Australian coastline.

Although the Arafura Sea is an extension of the Indian Ocean, the input of Pacific derived waters into northern Australia, suggests the region is essentially a convergence zone and should be referred to as Indo-Pacific (Ferns 1994). During the dry season (March to August) the dominance of easterly prevailing winds drive
currents predominantly from east to west, however, during the North-West Monsoon currents flow from west to east (Ferns 1994).

Australian marine waters are amongst the most nutrient-poor in the world, receiving little input from sub-Antarctic waters, being obscured from wind induced upwellings of the Equatorial Pacific and Atlantic Oceans by land masses and confined shallow seas (Ferns 1994). Coastal processes such as runoff and seasonality probably determine nutrient concentrations in the coastal zone. Nutrient concentrations can also elevate rapidly around areas of high terrestrial runoff (Ferns 1994).

**Research objectives**

Australia is currently believed to hold some of the largest stocks of *H. scabra* (Adams *et al.* 1993), although very little survey and ecological work has been conducted on the species. This fishery has a history of overexploitation elsewhere in the world, with boom and bust cycles for industry and regional economies (NTDPIF 1994). International demand for Sandfish is currently high (NTDPIF 1994).

Development and management of a trepang fishery requires knowledge of the standing stock before harvesting, how it is distributed in habitats, changes in the population as a result of harvesting and size of individuals available for harvesting, frequently determined from resource survey methods and regular censusing (Shelley 1985a, Harriott 1984). From this knowledge questions then need to consider where populations are sufficiently large to provide a sustainable harvest; and at what rate of collection should individuals be harvested. To address requirements, the objectives below were researched to gather information and assist with the development of a sustainable use strategy for the trepang resource.

- **Objective 1:** Develop, evaluate, document and apply a suitable method for determining distribution and abundance of trepang within the Maningrida/Cobourg study area and characterise favoured habitat by descriptions of environmental features.
• Objective 2: Apply remote sensing techniques to identification of suitable trepang habitat and provide maps of both verified and potentially suitable habitat for the Gurig and Maningrida study sites, and areas outside them for which relevant imagery are available.

• Objective 3: Collate information from traditional custodians of land or knowledge on trepang distribution and abundance and document the collaborative process and its implications for resource management in Gurig national park and Maningrida area.

• Objective 4: Employ available log-book data from commercial harvesters to draw inferences regarding harvest dynamics.

• Objective 5: Provide recommendations on further research and/or activities required as a basis for a management strategy for sustainable harvest of trepang.

This report presents the above objectives, as commissioned and funded by Environment Australia and sub-contracted through the Parks & Wildlife Commission of the Northern Territory.
SECTION 1: METHOD DEVELOPMENT AND APPLICATION TO TREPANG DENSITY AND HABITAT

Objective 1: Develop, evaluate, document and apply a suitable method for determining distribution and abundance of trepang within the Maningrida/Cobourg study area and characterise favoured habitat by descriptions of environmental features.

1.1 INTRODUCTION: DEVELOPMENT OF A SUITABLE METHOD

Previous methods
When surveying sedentary species such as holothurians, total collection counts are useful because they require little equipment and site preparation, and theoretically generate absolute densities. However, this method is labour intensive and not suitable for large-scale survey. Furthermore, the cryptic nature of Sandfish makes search time longer and counts less accurate than for non-cryptic species (Harriott 1984). The known densities generated from total counts can still be used as a measure against which to compare other techniques. Several researchers have evaluated various techniques for surveying trepang species (Harriott 1984, Preston et al. 1988, Vail 1989). A technique generating precision is preferred over one generating accuracy (Caughley 1978 in Harriott 1984) because although a precise estimate may not be close to the true value, its narrow confidence intervals imply a high repeatability of the method. Such results are useful for comparisons over time and between sites. On the other hand, accuracy may generate values close to the true value but may have wide confidence intervals.

During holothurian survey in Fiji, Preston et al. (1988) compared three methods and found that although quadrats (100 m$^2$ and 1600 m$^2$) were accurate they were also labour intensive; belt transects (100 - 650 x 2 m) were time consuming and subject to boundary errors on the swath edge; and manta tows (variable length x 2 m) were not useful for large cryptic species nor when the water was too shallow for towing. Those authors obtained low precision because of observer variability and suggested
a better estimate would have resulted from standardising the technique with respect to duration and tidal phase.

Harriott (1984) surveyed holothurians on the Great Barrier Reef and found manta tows were a more useful index of abundance than S.C.U.B.A. swims because there was a higher level of precision with this technique and results could be linked to accurate correction factors. However, she also suggested manta tows could underestimate stocks by a quarter to a half and were not suitable in low visibility conditions or deep water (greater than 10 m).

Vail (1989) surveyed holothurians in Northern Territory waters using a 5 m and a 2 m beam trawl with tickler chains for sampling trepang. He also sampled with snorkel, S.C.U.B.A. and reef walks and occasionally an observer on the bow of the boat, resulting in his use of a combination of survey techniques. The 5 m trawl collected around 80% of individuals and the 2 m trawl collected around 85%. He determined catching efficiency by underwater observations. Catching efficiency decreased when the bottom was uneven, contained obstacles e.g. coral or rock, or when the tickler chain was not positioned correctly. Walking was found to be the most efficient technique but only feasible at low tide which restricted data collection. Snorkel and S.C.U.B.A. were useful for spot checks but not for abundance estimates because of poor visibility, strong currents and the presence of saltwater crocodiles Crocodylus porosus. He suggested trawling as a useful technique for Sandfish survey because H. scabra is restricted to soft silty sand substrates with few obstructions (Vail 1989, Wiedmeyer 1992).

From the above literature review the beam trawl appears to be the optimum sampling method (except for low tide walks) for Sandfish survey unless the topography is rough or there are reefs and obstructions. The drawback from using this technique is damage to seagrass beds, sponges and other benthic flora and fauna, and the potential initiation or acceleration of habitat threatening processes. S.C.U.B.A., snorkel and manta tows, in addition to their imprecision, are considered dangerous in Northern Territory waters where saltwater crocodiles and other marine hazards frequent nearshore habitats.
Based on the above literature, a new technique was developed to replace the S.C.U.B.A., snorkel, trawl and manta tow techniques previously used.

**Videography**

There is increasing interest in developing new techniques to assess distribution and abundance of fishery species because of bias, imprecision or habitat destruction from conventional fisheries biology sampling methods (such as rod and reel, handlines and bottom trawls). Remotely operated videos (ROV’s) are an increasingly utilised vehicle from which underwater photographic censuses are conducted (Bergstedt & Anderson 1990, Michalopoulos et al. 1992, Ellis & DeMartini 1994). Rapid developments in ROV technology have occurred in recent years, particularly with higher resolution capabilities of camera systems, which assist species identification, habitat description and recording other ecological data. Video has advantages over still photography because it offers continuous recording, immediate playback for review or verification of data, has the potential to be used as a series of stills, and can record motion. An implicit assumption of these techniques is that the ROV or submersible must maintain a constant attitude, thereby producing video frames of equal and known size.

Where the field of view is known, quadrats, belt transects and strip transects can be used to calculate densities of organisms. Bergstedt & Anderson (1990) found that belt transect sampling on a sledge-mounted underwater video camera provided useful visual assessment for estimating the density of stationary objects on a lakebed compared with trawling techniques which have inherent biases such as assuming that all individuals are collected by the trawl. However, frequently the field of view has unknown variations due to changes in altitude, pitch and roll.

Although techniques which generate density estimates are prefereable, species-time censuses are an alternative analysis technique which replace area with time so that estimates are based on time of encounter where area coverage cannot be ascertained. Michalopoulous et al. (1992) showed that where video records with differences in altitude pitch and roll occurred, one species-time technique known as the visual fast count (VFC) method produced relative abundance estimates which were not significantly different from the strip transect method (or true values), however,
another method known as the rapid visual technique, RVT, produced significantly different results. Transect data were easily converted to VFC or RVT abundance estimates for comparison with studies which used those methods. However, these techniques compare species richness/diversity in the community and the accuracy of the methods for species density is unknown.

Sledges, too, can be custom-built to the application. Turnbull and Watson (1992) sampled the seagrass meadows of the Torres Strait, and found that corals which interspersed this habitat could easily snag conventional sledges typically designed for smooth silty substrates. They compared different sledge designs, including one based on a water-jet with 100 mm rubber flap placed beneath the net mouth to operate over rough substrates, and one with an electrode array to replace a tickler chain which previously caught on small lumps of coral. The electric sledge was ineffective because it continued to catch on coral and it was difficult to detect whether electrodes were operating effectively.

They pointed out that an optimal sledge design was difficult to effectively trial because of tidal constraints. In that environment navigation and trawling was dangerous and difficult because of strong tidal currents flowing across the reef front, large coral outcrops which threatened the motor and camera system, and some areas which were simply inaccessibly by dinghy. They pointed out that the sampling strategy was necessarily based on a trawl path free of coral outcrops in the correct habitat/location.

In Top End waters the turbidity of the water places further constraints on selecting a path because coral outcrops need to be avoided by a wide margin when they cannot be seen. In other words, charts or local knowledge can point out where the dangers lie but a wide berth must be taken to allow for error. Turbid patches of water interspersed with clearer patches are also characteristic of shallow subtidal areas. Since the originally proposed manta tows were not permissible for safety reasons, a combination of transects walked in the intertidal zone, and subtidal videography trawls, boat transects and beam trawls were believed to be the most useful techniques for sampling the various zones. While intertidal walks (transects) and
subtidal boat and beam trawl transects are relatively straightforward, the camera trawl required substantial development of an appropriate system.

1.2 DOCUMENTATION OF THE METHOD

Videography system
Initially an existing underwater videography system was used which consisted of a SONY Handycam Hi8 video camera, encased in waterproof housing and surrounded by aluminium crash-proof frame. A sledge was designed to trawl the existing camera system (see below), however, that initial camera sustained irrepairable damage and similar camera models to suit the waterproof housing were no longer on the market.

An entire new tow videography system was necessary and was custom-designed to the application. Requirements were for a tow camera system which could be hand-deployed, operated by a single researcher if possible, was transportable, and operated off low voltage (12V/24V) power. The system is depicted in Figs 3 – 6.

The requirements for hand deployment were met by using a compact but robust UVS – Pulnix TMC – 63M miniature camera. The camera generated a high resolution (450 lines) picture from a 40 mm diameter x 70 mm plus 4 mm lens. The small size of the camera reduced the size of housing required to encase the camera so that a small, lightweight anodised aluminium, cylindrical housing fitted with clear acrylic front viewing port was constructed (Fig 3). The camera and housing were attached to UVS – NC8 – 50 sub-sea cable through a ruggedised 3-pin stainless steel bulkhead connector to guard against corrosion.

The opposite end of the sub-sea cable was attached to a UVS Model 9701 topside control interface unit (via waterproof connectors) with electrical switch gear and waterproof cover (Fig 4). This unit was used to interconnect all system components and operate each component independently if required. It was selected for its IP 65 rating and robust construction. The unit was powered via a UVS – C10 power lead
Fig 3: Camera system mounted on sledge.

Fig 4: Topside control unit and TV/VCR unit.
Fig 5: Stabiliser fin.

Fig 6: System deployed using bridle and towrope and connecting subsea cable.
from a 12V battery and an optional 6V battery connected in series (=18V) for when lights were in use. Two large finned heatsinks were fitted to dissipate heat associated with the lighting power regulation circuit.

The unit was also attached to an Orion 10VRE colour TV/VCR unit (Fig 5) for real-time monitoring via UVS – CO5 BNC-RCA video lead and UVS – C11 monitor lead. A stainless steel cabinet with perspex hinged front viewing port was constructed to protect the TV/VCR unit from saltwater spray while onboard the boat. The video camera images were displayed and recorded on the TV/VCR unit via the video input jack.

The subsea cable was constructed with Y-splice to 3 underwater connectors for optional use of lights and lasers. Small efficient lights were also constructed using 2 x DPL – Micro-SeaLite lights in stainless steel housing with acrylic front viewing port and 2 x Micro-SeaLite-IF-1 light interface cables. The lights had a depth rating of 1000 m and could operate continuously in air or water, and could also be immersed in water after burning in air.

Laser projectors were thought to be useful for providing length measurements and/or a constant altitude if the sledge could be eliminated and a tow camera stabiliser used instead (see below). Two LMU – 001 laser measurement units inside stainless steel underwater housings with toughened glass port (to reduce aging caused by laser beams) with 1 x LMU – IF-1 laser interface cable were attached to the Y-spliced connectors. These were blanked when not needed.

The lens of the camera was mounted 30 cm above the substrate and aimed forward and slightly downward. Sled runners were 120 cm in length and 90 cm apart. The towrope was mounted so that the bridle just ahead of the camera was marked with coloured rope at 50 cm intervals in front of the camera lens, permitting various widths of quadrats, which would be used depending on lateral visibility conditions of the day of sampling. This technique is similar to the lanes described by Bergstedt & Anderson (1990). Rerunning the videotape allowed an improved estimate of the average transect width on each occasion, depending on daily conditions.
**Sledge design**

Initially a sledge was built to specifications designed to trawl the existing underwater videography system. That sledge was constructed from aluminium, with the base wider than the top and with struts angled in to afford stability. A rope bridle with movable D-shackle was attached between the front of the sledge and rear of the tow rope to assist with turning (Fig 6). Another bridle was attached between the front of the tow rope and back of the boat to span the motor and assist with turning. This sledge was trawled at idle speed (see below), at a distance of 30 m behind the dinghy and found to provide a good stable trawl apparatus.

However, upon trial at the study site with a boat motor of larger capacity it was found that the front of the sledge was positively buoyant tending to lift, stir sediment and reduce visibility. The buoyancy was probably a counteracting force to oppose the force of pull by the tow rope. The length of tow rope was altered to change the angle of pull but shorter lengths results in the entire system rolling. Likewise, tying the point of pull on to different parts of the sledge, including the back and the top, still resulted in sledge instability. A second sledge was constructed from steel, which appeared stable with the particular camera system used, regardless of the length of tow rope used and the pull position.

After damage to the camera occurred, the original sledge was found to be too buoyant for the new system, again lifting at the front to oppose the force of pull of the tow rope. A hydrofoil was welded onto the sledge so that water pressure would force the front of the sledge toward the substrate. The final sledge design is shown in Fig 3 and the entire deployed system in Fig 6.

**Speed of trawl**

During the trials the speed of trawl was varied. Speed of trawl was eventually set to idle as faster trawls were found to make discrimination of Sandfish versus bottom rubble/sticks etc difficult. Trawls faster than idle speed additionally generated internal camera instability and a broken picture (see below).
**Camera stability**

Certain habitat differences, in particular, areas of rubble and dead coral caused camera vibration and a broken picture, making viewing the footage difficult. The system was modified so that a rubber strip was placed between the steel sledge and aluminium crash-proof framing surrounding the camera housing. This worked adequately to cushion the bounce and footage was clear.

**Focussing and camera shot length**

The initial camera was trialled at different shot lengths and the widest angle found to generate discernable results while retaining a large transect width. The focus was trialled at 1 m, 2 m and 3 m on land. Sections were then marked off on the rope and visually displayed on the camera footage so that the 1 m, 2 m and 3 m distant marks were known on-screen. Lateral visibility occurred to 2 m and at this point transect width was 4 m.

However, the new lightweight camera system lens could not offer the same quadrat width capabilities. The widest possible angle was requested, however, at 2 m the transect width was also 2 m. Most of the time transect swaths were narrower, depending on physical conditions of the day of sampling and lateral visibility. During trials it was found that automatic gain control was necessary because manual gain control could not allow differences in lighting to be accounted for while trawling the system.

**Videography trawl length**

Bergstedt & Anderson (1990) suggest that only organisms which are readily visible on top of the substrate should be considered in videography survey. They suggested that water clarity is related to the population being estimated because low visibility results in narrow transect widths and limits the use of the method to populations with high densities. High visibility permits wider transect widths and the method is then more effective for populations with lower densities under these conditions.

Other researchers using ROV strip transects have used ten minute trawls (in Michalapoulous et al. 1992) or shorter periods of time as the sampling unit, however, since trepang show notoriously large variability in density (Harriott 1984,
Vail 1989, Kerr et al. 1993, Uthicke 1996), including very low density, it was thought that longer transects may be required.

On 17th, 21st and 23rd July 1996, the initial sled-towed camera was trawled behind a boat travelling at idle speed at three separate sites. Each site was visited on each sample day with a total of 20 trawls conducted. Trawls ranged from 5 to 10 minute shots and were estimated to cover between 160 and 320 m². The samples were all taken during daylight hours, between new and neap moon. Samples were taken at random stages of the tidal cycle and water depth was estimated to range between 2 m and 10 m (using charts as the depth sounder was defunct at this time). Wind speed and direction varied with day of sampling.

Wiegert’s Method (described in Krebs 1989) was used to determine optimal transect size. Results show that longer transects provide the optimal results in both relative variability and relative cost (Table I), despite the fact that the number of transect replicates of this size was only 5, since a greater number of replicates usually decreases variability.

Table 1: Pilot study to determine optimal transect size. Relative variance is determined from samples of trepang abundance. Fixed cost component was recorded Australian dollars, representing travel costs. Cost (in time) was recorded in Australian dollars (based on the minutes spent sampling and the charge per minute for the researcher’s time). Relative cost is estimated by summing values to represent fixed costs (time spent travelling to sampling points and locating random points) with a value to represent the cost (in time) for taking one sample quadrat of that size. The quadrat size which minimises the product of relative variability and relative cost is the optimal transect size.

<table>
<thead>
<tr>
<th>Transect size m²</th>
<th>Number (n)</th>
<th>Rel. variance (1)</th>
<th>Rel. cost (2)</th>
<th>Product (1)(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>160</td>
<td>6</td>
<td>16.00</td>
<td>1.00</td>
<td>16.00</td>
</tr>
<tr>
<td>240</td>
<td>9</td>
<td>4.69</td>
<td>1.25</td>
<td>5.86</td>
</tr>
<tr>
<td>320</td>
<td>5</td>
<td>1.00</td>
<td>1.50</td>
<td>1.50</td>
</tr>
</tbody>
</table>

Previous researchers have found high variability in estimates of trepang abundance (see next section), and suggested that larger quadrats should reduce some of this
variability and represent the ecological parameters of Sandfish density and distribution more adequately. Results of the pilot study show that larger quadrats were preferable to smaller quadrats in terms of the trade-off between cost and statistical precision and support the suggestions of previous researchers that larger transects may help reduce the high variability found in Sandfish density estimates. The pilot study showed that accuracy increased with transect size so that even larger sizes again may have increased accuracy. Because the pilot study was conducted in areas of high trepang density (not known in advance), and because international literature and subsequent surveys indicate that trepang density can be exceedingly low, it was considered wise to adopt even larger transects than indicated, where possible. The videography method limits quadrats to being rectangular in shape.

Initially a rangefinder was focussed back onto a buoy which marked the start of the transect. However, vertical movement of the boat with swell movement made it difficult to accurately focus on the buoy. The rangefinder was discarded in favour of a differential global positioning system (DGPS). Geographic coordinates were recorded for the start and end points of camera transects and input to a Geographic Information System (GIS) at a later stage to generate transect lengths (see below). Because Landsat TM remote sensing (pixel size 30 x 30 m) analysis was also to be used in this study, DGPS readings were advantageous because sub-pixel accuracy could be obtained when ground-truthing the satellite image.

**Videography image analysis**

Video tapes were replayed at the end of the day because sunglint on the TV/VCR monitor screen made viewing immediate playback difficult. For each trawl the number of Sandfish was recorded. The length (in seconds) of footage was also recorded and the number of trepang per minute video footage used as an index of catch per unit effort (CPUE) or catch rate. These estimates were necessary to compare catch rate with transect length (see below).
1.3 APPLICATION OF THE METHOD: TREPANG ABUNDANCE

Sampling strategy
In the current study a stratified random sampling design was used to sample Sandfish abundance. Shelley (1985b) suggested that charts can be used to identify appropriate depths and geographical configurations, then deduce potential areas of abundance which reduces the time needed for survey. Previous holothurian surveys (Preston & Lokani 1990, Harriott 1984) used this approach and the area in these studies was limited by the depth to which S.C.U.B.A. could be carried out and by the degree of exposure to prevailing winds. Charts were used in the current study to delimit the seaward boundary of the sampling region and other strata boundaries (refer section 2.4).

In the Northern Territory highest Sandfish densities were found to occur in water less than 4 m depth (Vail 1989). The two study areas (Maningrida and Cobourg) were each divided into four zones (Figs 7 and 8), and within each zone two strata were sampled: the intertidal zone; and the subtidal zone to 5 or 6 m depth (depending on the chart used) because of the ease of finding this depth contour on nautical charts. Eight samples were taken in areas beyond 6 m depths to verify whether trepang occurred in high densities beyond this area. Preliminary estimates from the current survey showed Sandfish did not occur seaward of this depth contour, supporting the findings of Vail (1989).

Since trepang were generally absent in habitats adjacent to exposed coastline (refer results section) bay enclosing lines were drawn between opposing headlands of bays. Where the 5 or 6 m depth contour was seaward of a bay enclosing line only the area within the bay enclosure was sampled. This further restricted trepang habitat to calm areas (enclosed by bays).

Several researchers have incorporated local knowledge about trepang occurrence into their sampling design to reduce the time needed for survey and so that suitable trepang habitat is sampled more intensely than unsuitable habitat to generate density
Fig 7: Zones sampled in the Maningrida study area.

Fig 8: Zones sampled in the Cobourg study area.
estimates (Shelley 1981, Preston et al. 1988, Vail 1989). To effectively collaborate with traditional traditional owners of the area and to maximise efficiency the first transects in each zone were placed on the basis of traditional knowledge. After this, areas were randomly surveyed where no information about trepang presence was available.

In all methods used to count trepang, an individual occurring on the boundary was estimated to occur within or outside the transect, based on where the greater portion occurred. If inside it was counted as a whole individual, if outside it was not counted. Any individual half in was counted as in.

It is not possible to compare any of the methods at the same area. A boat cannot be driven in the intertidal area at low tide, (the only time trepang are visible in the intertidal zone). Conversely walking in the subtidal strata cannot occur as this becomes a dive technique, with visitibility altered by a diving mask etc or simply by the water column. Development of new techniques (objective 1) for the subtidal strata occurred because of the presence of Saltwater Crocodiles in the sampling area.

Within the subtidal strata the boat transects cannot be conducted in areas deeper than 2 m because it is impossible to see the bottom beyond those depths. Conversely in most instances the videography could not be trawled in areas shallower than 2 m because the boat motor stirred up the water in front of the camera lens, making it impossible to see clearly, until the video was well below the depths of the motor. The trawl method was the only method that could be conducted in all subtidal depths, however, there are ethical issues involved with trawling such as habitat destruction and bycatch so that this method had to be deployed as infrequently as possible.

There is no pragmatic solution or one-off solution to sampling trepang, a remark asserted by trepang researchers all over the world many of whom have suggested multiple sampling strategies (e.g. Harriott 1984, Preston et al. 1988, Vail 1989). The Northern Territory waters are not different to other localities, and in fact, probably present far more problems.
The effectiveness of the different methods was the first and foremost consideration in this methodology. Because it was not possible to compare methods at the same area an alternative means of evaluating methods occurred to the extent that it was possible to do so. The science of ecology is fraught with the problems about how to best implement the ideals of theory into the difficulties of reality and the complexity of ecosystems. Most often, trade-offs are required for an optimal sampling strategy.

Only the videography and boat transects could be reliably compared because of the known logistical error obtained with trawl methods and because it is not theoretically nor pragmatically sound to compare intertidal and subtidal strategies. Walking and trawl were excluded as a consequence. Boat and video could be compared because these were the same subtidal strata, and because no differences in trepang density were found with depth zonation (representing the differing areas sampled by the boat and video methods) within the subtidal strata (refer Table 7).

**Subtidal sampling**

In past holothurian surveys a combination of techniques has been used for comparative purposes and to effectively sample stocks (Harriott 1984, Preston *et al.* 1988, Vail 1989). In the current study a combination of three methods was also necessary to sample subtidal stocks: videography, boat transects and beam trawls. A total of one hundred and thirty transects were conducted in the subtidal zone.

*Videography*

The camera technique outlined above was applied to subtidal stock sampling. Eighty-seven camera trawls were conducted in water depths where the bottom was not visible from the bow of the boat, usually beyond 2 m depth. Coloured rope markers were placed at 0.5 m intervals on the tow rope in front of the camera lens (see above). A tape measure was placed across the ground at the distance of each marker from the camera (0.5 m, 1 m, 1.5 m and 2 m). At each of these distances the width of the transect viewed on the TV monitor was recorded. In this way the width of the transect was predetermined for differing conditions of water quality and lateral visibility (which varied temporally) as these factors affect the transect swathe width (Preston & Lokani 1990). Data quality is influenced by several factors including lateral visibility and water clarity on the day of sampling.
An important assumption of line transect sampling is that objects directly on the line are never missed. In some instances there was a possibility of Sandfish occurring on the edges of the TV monitor but these were difficult to discriminate where only a part of the Sandfish was seen on the edge. For this reason the estimate of the quadrat width was revised, for example, if the original transect width on the TV monitor was 1 m, then the transect width was revised to 0.75 m and the outer extremities of the transect excluded from sampling. In this way the transect size eventually used showed only whole Sandfish visible.

Constant speed and direction of the boat was maintained throughout the transect. Transect lengths varied because of limited area available for sampling; because of obstructions such as snags, rocks, coral reef; or simply because the water was too turbid in some places to use the camera system. Wide area Differential Global Positioning System (DGPS) locations were recorded at the start and end points of each quadrate. This type of GPS computes positions based on local receiver raw data which is weighted against broadcast reference station data to obtain a best-estimate fix. Position fixes vary between ±5 metres (95% C.I.) with system reliability of 99.97%. Average transect size was 245 m².

Where there were patches of clear water, the proportion of clear water in comparison with the total video image length was recorded during playback later in the day. This way the proportion of the area sampled was calculated and the trepang density calculated for that area only. This is another reason why transect lengths varied.

**Boat transects**

In this report the phrase boat transect is used to refer to the transects where two observers were used to count trepang numbers in depths less that 2 m. Thirty-eight boat transects were conducted in shallow water where the bottom could be clearly seen, because it was not possible to operate the dinghy in depths less than 1 m. Boat transects were a logistically easier technique in clear water up to 2 m. The depth to which this technique could be used varied temporally with light conditions and water quality.
This technique involved an observer on either side of the boat (similar to the observer on the bow of the boat as described by Vail 1989). Data from both observers were combined and used in the areas covered by observers. Constant speed and direction of the boat was maintained. Boat quadrat widths were measured using an arm’s span from the side of the boat (in the manner described by Shelley (1981) and Harriott (1984), equivalent to just under 2 metres). DGPS locations were recorded at the start and end points of each quadrat to determine transect length, which again varied with the size of the area available for sampling and with water quality and bottom conditions. Average transect size was 640 m².

**Beam trawls**

A 2 m beam trawl as described by Vail (1989) was used to sample subtidal stocks in the mouth of one river because of high water turbidity in this area. This technique was necessary to determine whether Sandfish habitat occurs where rivers discharge into bays.

Due to seagrass damage and snagging of the trawl apparatus only 5 effective samples were taken. Swath width is known in this technique (2 m) and DGPS locations were recorded at the start and end points to determine trawl length, which was again variable. The area of the sample unit averaged 1200 m².

**Intertidal sampling**

One hundred and eighty-four transects were conducted in the intertidal zone, all of which were carried out by walking the transect within one hour either side of low tide.

**Intertidal walks**

Using the DGPS, start points were recorded from the boat (where the intertidal transect commenced) and end points occurred at a headland or recognisable feature of the coastline configuration so that a fix could be recorded from digital data in a GIS at a later stage and the transect length generated. This method was necessary because of the variable length of the intertidal zone, the problems of non-traversable areas of soft substrate in many instances and dangers of walking adjacent to resting crocodiles or in potential crocodile habitat.
Transect width was measured by a double-arm span, in the manner described by Shelley (1981) and Harriott (1984), equivalent to just under 2 m. The area of the sampling unit averaged 970 m² quadrats.

All data recorded were entered into a database for data analyses and for importing to a GIS.

**Analytical methods**

*Data transformation*

Trepang density (number/m²) estimates were generated from abundance data and the sampled area. Inspection of the values for trepang density showed that data were positively skewed. This suggests that in many instances no trepang or small numbers of trepang were found in the sampled areas, while on far fewer occasions high densities were found.

Trepang density values were transformed according to the equation

\[ X' = \log(X + 1), \]

as this transformation is useful when values are small numbers (Zar 1996). Statistical analyses were applied to all transformed data, other than density estimates.

*Adjustments between trepang density and video catch per unit effort (CPUE)*

In past research both Shelley (1981) and Conand (1989c in Uthicke 1996) calibrated catch per unit effort (mean value per diver hour or other index) with conversion factors from known holothurian densities and generated density estimates from the catch rates. In this study 21 videography transects which showed Sandfish presence were conducted prior to obtaining the length of the transect with DGPS start and stop position fixes. These videography transects only contained the number of Sandfish recorded per minute of video footage (the catch rate).
To use these initial estimates the relationship between observed trepang density and trepang/minute video footage on the remaining videography transects was calculated using a multiple regression where Sandfish density was the dependent variable and catch rate the independent variable. The regression was calculated for the relationship between trepang density and trepang/minute video footage when both were available within a transect. The equation expressing the relationship between the two variables was then used to recalculate the catch rate (number of Sandfish per minute video footage) and express this new value as Sandfish density.

_Evaluation of the method developed_
Descriptive statistics were obtained for the four methods used and used to evaluate differences between methods. A single factor analysis of variance was applied to test for differences in Sandfish density which may be related to the differing methods used.

_Tidal, lunar and diurnal effects on trepang density estimates_
Due to the uncertainty of estimates obtained under varying lunar and tidal conditions the same area was sampled at varying tidal and lunar stages during daylight conditions only and Sandfish density calculated. Only two of the methods were used to test for differences with tidal and lunar variables: walks in the intertidal zone and videography transects in the subtidal zone. A two-way (3 x 2) analysis of variance was applied to these estimates to detect any bias in trepang density estimates arising from such data collection methods. The two factors were tidal and lunar phase. Tidal stage had three levels: low tide, one hour either side of low tide and 2 hours or more either side of low tide. Lunar phase had two levels: spring moon and neap moon. Four replicates of each observation were recorded.

A multiple regression analysis was also applied to test correlation between trepang density and time of day (800 – 1900). This analysis was performed over the pooled data for both intertidal and subtidal strata (and consequently the pooled methods).
**Sandfish density estimates**

Available habitat was delineated in ArcView by digitising polygons from nautical charts (see section 2.4) to represent the mainland, intertidal zone and subtidal zone to 5 or 6 m (depending on the chart) in the bays enclosed by headlands. (Polygons were converted to shapefiles and added as themes.) Where the 5 or 6 m contour occurred seaward of the bay then the bay was enclosed by a line joining the two opposing headlands and the corresponding area occurring only within that bay enclosure was calculated.

Area estimates were generated using ArcView. The polygon shapefile was reprojected as Transverse Mercator and a program (calcaplave script) added and compiled in the GIS project. This program calculates the area (and perimeter) of polygons and was used to add polygon areas and perimeters to the shapefile attribute table. The intertidal and subtidal area within each of the four zones in each study area were then summarised from the statistics menu operating on this area field of the polygon attribute table. Trepang density estimates were extrapolated to the intertidal and subtidal area of each zone.

In aerial transect surveys where transects are of differing lengths the Ratio Method (Jolly 1969, Krebs 1989) can be used to estimate density. Density is calculated for each transect and extrapolated to the total census zone.

Average density for the area is then calculated as:

\[ R = \frac{\text{Total animals counted}}{\text{Total area searched}} = \frac{\sum y_i}{\sum z_i} \]

where \( y_i \) = Total animals counted in transect \( i \)
\( z_i \) = area of transect \( i \)
\( i = \text{sample number} \ (1, \ 2, \ 3, \ ..., \ n) \)
\( n = \text{total number of transects counted.} \)

The total population is given by:
\[ Y = RZ \]

where \( Z \) = area of total census zone
and \( R \) = average density per unit area

Because the density and area of transects vary the variance of this estimate (sampling without replacement) is given by:

\[
\frac{N (N - n)}{n (n - 1)} \left( \Sigma y^2 + R^2 \sum z^2 \right) - 2R \Sigma yz.
\]

T-tests to test for differences in densities between study areas and between strata were applied. Single factor analyses of variance were applied to test for differences between and within strata in zones in each of the study areas.

**Habitat analysis**

During the videography transects habitat information was recorded where visible on the video footage: categories were nominated as bare sand, coral/rubble/shell and seagrass based on the dominance of each coverage. Dominant habitat type was used to classify habitat. Habitats which were substantially mixed were noted by more than one descriptor.

Where muddy/sandy sediment was observed to be the dominant coverage (noted on the TV monitor in real time) a substrate sample was taken from the sledge after it was hauled onboard the dinghy at the end of each transect. Particle size analysis was then conducted in the laboratory (see below).

During the boat transects categories were recorded as bare sand, coral/rubble/shell and seagrass based on the dominance of each coverage. Habitats which were substantially mixed were noted by more than one descriptor. Where muddy/sandy sediment occurred an observer jumped into the water at the end of each transect and collected a substrate sample. Particle size analysis was conducted in the laboratory (see below).
During intertidal walks habitat data was also noted and categorised as channel (tidal channel or rock pool), coral/rubble/shell, seagrass or rocky (edge of rocky platform). Where the substrate was predominately muddy or sandy sediment a substrate sample was taken at particle size analysis conducted in the laboratory (see below).

Mechanical particle size analysis was conducted on each substrate sample according to the method outlined by Bowles (1986). An air-dried substrate sample was quartered and weighed and oven-dried for 24 hours. The subsample was again weighed (to obtain the soil-moisture correction factor) and then washed with distilled water through differing sieves and placed on a shaker for approximately 1 minute to sort the sample into fractions of different particle sizes. Each fraction was weighed and expressed as a proportion of the total subsample. Sieve sizes were chosen to produce fractions finer than 4.75 mm, 2.36 mm, 600 micro, 212 micro, 75 micro and 75. The substrate was then classified as fine gravel (if predominately 4.75 mm or greater); coarse sand (2.36 – 4.75 mm); medium sand (600 micro – 2.36 mm); medium/fine sand (212 – 600 micro); fine sand (75 – 212 micro) and fine-grained meaning fine silt or clay (<75 micro). Where no substrate samples were obtained the habitat was categorised by other habitat descriptors: channel/rock pool is an area covered by water at low tide, usually a tidal channel or rock pool; coral/rubble/shell refers to substrate where small particles of coral, rubble and shell were noticeable, seagrass is self-explanatory and rocky edge refers to bare sand but close to rocky platforms.

Thus final habitat categories were channel/rock pool, coral/rubble/shell, fine-grained, fine sand, medium/fine sand, medium sand, seagrass, and rocky edge. A one-way analysis of variance was applied to test for differences in Sandfish density resulting from habitat.

In the Maningrida area only, depth was recorded from the depth sounder onboard the dinghy. Depths were categorised as described in section 2.4 and a one way analysis of variance applied to detect any relationship with trepang abundances.
Habitat variability could not be discerned within strata (refer section 2) therefore area estimates of different habitats within strata could not be generated. The density estimates for each strata are based on the random sampling within that strata.

Habitat was recorded were possible for many of the transects and differences in trepang variability with habitat are conducted as a separate analysis. These analyses are not used for generating density estimates. Habitat features and analyses were conducted simply to assist with providing additional ecological information about trepang habitat in NT waters.

1.4 RESULTS

Initial sampling (n = 11) along exposed coastline to verify whether Sandfish occurred outside bays in this region, showed that trepang were generally absent in habitats adjacent to exposed coastline.

Comparison of density with video catch per unit effort

Fig 9 shows the relationship between the two variables (Y = Sandfish density, X = catch rate). There was a significant positive relationship between density estimates and catch rate from video footage which can be expressed as:

\[ \text{Density} = 0.1 + 2.29 \times \text{Catchrate} \ (R^2 = 0.84, \ p = 2.84 \times 10^{-9\text{**}}). \]

Fig 9: Relationship between sandfish density (number/100 m2) and catch rate (number/min).
Evaluation of the method:

Table 2 shows descriptive statistics related to Sandfish density, as obtained from the different sampling methods. Transects which appeared to be outside the spatial extent of Sandfish habitat were discarded from further analyses.

Table 2: Estimates of Sandfish density (using log transformed data) and related descriptive statistics showing accuracy of the methods and density estimates, obtained from the four different methods used in this survey.

<table>
<thead>
<tr>
<th></th>
<th>Video</th>
<th>Boat</th>
<th>Trawl</th>
<th>Walk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean density</td>
<td>0.011304</td>
<td>0.008897</td>
<td>0.005625</td>
<td>0.007535</td>
</tr>
<tr>
<td>Variance</td>
<td>0.000235</td>
<td>0.000353</td>
<td>0.000029</td>
<td>0.000387</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.155122</td>
<td>3.813794</td>
<td>2.319384</td>
<td>23.585348</td>
</tr>
<tr>
<td>Skewness</td>
<td>1.675976</td>
<td>2.251686</td>
<td>1.408283</td>
<td>4.535879</td>
</tr>
<tr>
<td>Count</td>
<td>84</td>
<td>38</td>
<td>4</td>
<td>177</td>
</tr>
<tr>
<td>CI 95%</td>
<td>0.003326</td>
<td>0.006175</td>
<td>0.008619</td>
<td>0.002920</td>
</tr>
</tbody>
</table>

Despite using the log transformed data, the walk method shows a relatively higher positive skewness and kurtosis compared with other methods. Because of the variability between the two strata (either naturally occurring or method related - see discussion section) the walk method cannot be compared with the other methods for statistical robustness. Secondly, trawl data may only be 80-85% effective in detecting trepang (Vail 1989) and in this instance is constrained by the sample size of n = 4. For this reason, only two techniques were compared: the videography transects compared with boat transects. The video method shows lower variability and confidence intervals in comparison with the boat methods.

Variances of means obtained from the boat methods and the video method were tested for statistical differences but did not differ statistically so the t-test for equal variances was applied. A value of

\[ T_{0.05 (1), 120} = 0.78, p = \text{n.s.} \]

was calculated, therefore population means estimated by differing methods do not differ statistically.
Effects of tidal, lunar and diurnal variables on trepang density

Results from the two factor analysis of variance using log transformed data are given in Table 3. From the table it can be seen that:

\[ F_{0.05, 1, 18} = 0.58 \ (p= \text{n.s.}) \ i.e. \ no \ significant \ effects \ of \ tide \ on \ density; \]
\[ F_{0.05, 2, 18} = 0.30 \ (p= \text{n.s.}) \ i.e. \ no \ significant \ effects \ of \ lunar \ stage \ on \ density \]
\[ F_{0.05} (1), 2, 18 \ = 0.30 \ (p= \text{n.s.}) \ i.e. \ no \ interaction \ of \ tidal \ and \ lunar \ variables \ on \ trepang \ density. \]

Table 3: Two way analysis of variance to test for the effects of tidal and lunar phases on Sandfish density.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tide</td>
<td>0.000189</td>
<td>1</td>
<td>0.000189</td>
<td>0.581139</td>
<td>0.45574</td>
<td>4.413863</td>
</tr>
<tr>
<td>Lunar</td>
<td>0.000194</td>
<td>2</td>
<td>9.72E-05</td>
<td>0.298323</td>
<td>0.74566</td>
<td>3.554561</td>
</tr>
<tr>
<td>Interact.</td>
<td>0.000193</td>
<td>2</td>
<td>9.64E-05</td>
<td>0.296135</td>
<td>0.747241</td>
<td>3.554561</td>
</tr>
<tr>
<td>Within cells error</td>
<td>0.005863</td>
<td>18</td>
<td>0.000326</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.006439</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig 10 shows the regression analysis between time of day and trepang density. There was no significant relationship between the variables with:

\[ R^2_{(0.05), 301} = 0.005, \ p = \text{n.s.} \]

\[ y = 0.000809 + 2.14 \ E^{-6} \times x \]

Density estimates

Density estimates for each strata and census zone are given in Table 4. Extrapolated population densities are also given.
Sandfish density (m^{-2}) ranged from 0.0042 to 0.0443, varying by an order of magnitude. Confidence intervals were large relative to the mean showing high variability of results about the mean. Intertidal densities ranged from 0.0048 to 0.0250 and subtidal densities range between 0.0042 and 0.0443. Densities at Maningrida ranged between 0.0046 and 0.0182, while densities at Cobourg ranged from 0.0042 to 0.0443.

Fig 10: Relationship between Sandfish density and time of day.

Variances in intertidal Sandfish density between the two study areas were not equal ($F_{0.05(2), 112, 66} = 2.85$) while variances in subtidal Sandfish density between the two study areas were equal ($F_{0.05(2), 41, 57} = 1.5$). The t-test for unequal variances was applied to determine whether intertidal densities varied between study areas and the t-test for equal variances was applied to determine whether subtidal densities varied between study areas.

For intertidal densities between study areas the t statistic showed:

$$T_{0.05 (1), 92} = 2.29, p = 0.02^*$$

suggesting there were differences in intertidal Sandfish densities between study areas. For subtidal densities between study areas the t statistic showed:

$$T_{0.05 (1), 96} = 2.01, p = 0.05^*$$
Table 4: Mean densities (number of trepang/m²) and population densities for strata within each census zone.

<table>
<thead>
<tr>
<th></th>
<th>Intertidal density</th>
<th>Intertidal population</th>
<th>Subtidal density</th>
<th>Subtidal population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MANINGRIDA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 1</td>
<td>N.S.</td>
<td>N.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 2</td>
<td>0.00479581 ± 0.0066273</td>
<td>42 680 ± 56 416</td>
<td>0.0043795</td>
<td>30 210</td>
</tr>
<tr>
<td>Zone 3</td>
<td>0.00802796 ± 0.0043795</td>
<td>56 408 ± 30 210</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 4</td>
<td>0.0051106 ± 0.00044211</td>
<td>7 680 ± 6 425</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Subtidal density</strong></td>
<td><strong>Subtidal population</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 1</td>
<td>N.S.</td>
<td>N.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 2</td>
<td>0.01815723 ± 0.00733475</td>
<td>263 283 ± 102 860</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 3</td>
<td>0.0046164 ± 0.00533654</td>
<td>64 982 ± 64 173</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 4</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>COBOURG</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 1</td>
<td>0.0144158 ± 0.00818787</td>
<td>904 859 ± 501 883</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 2</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 3</td>
<td>0.025 ± 0.1075664</td>
<td>89 985 ± 177 271</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 4</td>
<td>0.00713991 ± 0.0046919</td>
<td>55 242 ± 33 896</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Subtidal density</strong></td>
<td><strong>Subtidal population</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 1</td>
<td>0.00420188 ± 0.00270466</td>
<td>114 501 ± 70 498</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 2</td>
<td>0.0125 ± 0.03470564</td>
<td>638 272 ± 1 257 396</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 3</td>
<td>0.04425498 ± 0.04711091</td>
<td>903 350 ± 595 278</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 4</td>
<td>0.0056054 ± 0.0039717</td>
<td>72 594 ± 48 860</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N.S. = no sampling

suggesting there were differences in subtidal Sandfish densities between study areas. The two study areas are therefore different in Sandfish density. Densities at Cobourg are significantly greater than those at Maningrida.

To determine differences within study areas: Sandfish density variances between strata at Maningrida were not equal but at Cobourg were equal. The t-test for unequal variances was applied to test for differences between strata at Maningrida.
and the t-test for equal variances was applied to test for differences between strata at Cobourg.

At Maningrida:

\[ T_{0.05 (1), 55} = 3.20, \ p = 0.002^{**} \]

At Cobourg:

\[ T_{0.05 (1), 121} = 1.06, \ p = \text{n.s.} \]

Although there were no differences in Sandfish density with the differing strata at Cobourg there were differences in Sandfish density with the differing strata at Maningrida.

Table 5 shows the single factor analyses of variance applied to test for differences between zones in the study areas, for each of the strata.

There were significant differences in Sandfish density between intertidal strata in differing zones at Maningrida but not at Cobourg:

\[ F_{0.05, 2, 109} = 3.15 \ (p= 0.05^*) \]

\[ F_{0.05, 3, 62} = 0.99 \ (p= \text{n.s.}). \]

A Tukey test for unequal sample sizes applied to the intertidal strata densities at Maningrida failed to detect differences between any pair of means, with q = 0.21, 0.23 and 0.25 for zones 3 vs 4, 3 vs 2 and 4 vs 2 respectively.

There were no significant differences in Sandfish density between subtidal strata in differing zones at Maningrida, but there were differences at Cobourg.

\[ F_{0.05, 2, 38} = 3.14 \ (p= \text{n.s.}) \]
Table 5: Differences in Sandfish density between zones: (a) intertidal at Maningrida (b) intertidal at Cobourg (c) subtidal at Maningrida (d) subtidal at Cobourg.

(a) Intertidal densities between zones at Maningrida

<table>
<thead>
<tr>
<th>Source of SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>2</td>
<td>5.757715</td>
<td>3.152472</td>
<td>0.046669</td>
<td>3.079592</td>
</tr>
<tr>
<td>Within Groups</td>
<td>109</td>
<td>1.826413</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>111</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) Intertidal densities between zones at Cobourg

<table>
<thead>
<tr>
<th>Source of SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3</td>
<td>5.349713</td>
<td>0.988069</td>
<td>0.404341</td>
<td>2.752969</td>
</tr>
<tr>
<td>Within Groups</td>
<td>62</td>
<td>5.414311</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(c) Subtidal densities between zones at Maningrida

<table>
<thead>
<tr>
<th>Source of SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>2</td>
<td>10.73062</td>
<td>3.139038</td>
<td>0.05474</td>
<td>3.244821</td>
</tr>
<tr>
<td>Within Groups</td>
<td>38</td>
<td>3.418443</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(d) Subtidal densities between zones at Cobourg

<table>
<thead>
<tr>
<th>Source of SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3</td>
<td>19.54221</td>
<td>12.08591</td>
<td>3.66E-06</td>
<td>2.775764</td>
</tr>
<tr>
<td>Within Groups</td>
<td>54</td>
<td>1.616942</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>57</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
F_{0.05, 3, 54} = 12.09 (p<0.0001**) 

A Tukey test for unequal sample sizes applied to the subtidal strata densities at Cobourg failed to detect differences between any pair of means, with q = 0.48, 0.49, 0.60, 0.44, 0.44 and 0.26 for zones 3 vs 1, 3 vs 4, 3 vs 2, 2 vs 1, 2 vs 4 and 4 vs 1 respectively. 

**Density vs habitat**

The one way analysis of variance on the differences in trepang density with habitat is shown in Table 6. There are no statistical differences in trepang densities with habitat type:

F\text{ }_{0.05 (1) }7, 152 = 1.05, p = n.s.

<table>
<thead>
<tr>
<th>Source of SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat</td>
<td>7</td>
<td>5.22E-05</td>
<td>1.054352</td>
<td>0.395906</td>
<td>2.070308</td>
</tr>
<tr>
<td>Within Habitat</td>
<td>152</td>
<td>4.95E-05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>159</td>
<td>0.007887</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No habitat data was recorded during beam trawls but sponges, seagrass, baitfish, a sea snake and other bycatch were observed in the net.

The single factor analysis of variance on depth effects on trepang density is shown in Table 7. There are no statistical differences in trepang density with depth:

F\text{ }_{0.05, 4, 30} = 2.58, p = n.s.
Table 7: Single factor analysis of variance to test for the effect of water depth on Sandfish density.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Depths</td>
<td>0.000295</td>
<td>3</td>
<td>9.84E-05</td>
<td>2.578269</td>
<td>0.07722</td>
<td>3.008786</td>
</tr>
<tr>
<td>Within Depth</td>
<td>0.000916</td>
<td>24</td>
<td>3.82E-05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.001211</td>
<td>27</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.5 DISCUSSION

Evaluation of the method developed
The videography technique developed in this study provided additional data and complemented the other methods employed. The method developed appeared to be statistically robust and capable of delivering estimates which were more precise than the boat method (lower variability than boat method, lower confidence intervals than boat and trawl methods), although the higher variability found when using the boat method may be due to the number of transects. A larger number of transects for this method would more accurately determine robustness of each method, as larger variability normally requires a larger sample size to accurately reflect precision (Zar 1996).

Of prime practical consideration to applying the videography technique, however, is the nature of the northern Australian nearshore environment. In sheltered bays and under calm conditions videography techniques proved successful in the current study. In areas subject to heavy sediment loads from river discharge, strong tidal currents and in areas close to mangroves where the surface substrate layer was composed of finegrained particles, videography was not successful. Along exposed coastline videography was successful but only during a combination of calm tidal and wind conditions. Successful application of videography techniques was dependent on habitat and geomorphology of the area, and therefore spatially restricted for Sandfish survey.
Videography techniques were also constrained on a day-to-day basis. Sampling was not successful during an incoming tide, which tended to transport sediments landward toward the nearshore area where sampling occurred. These constraints were further restricted by the difficulties of launching boats from a land base (restricted to times between mid-tide and high tide due to water depth at the land base). For example a low tide occurring in the late afternoon required arrival back at the land base two hours prior to the low tide, and departure from the sampling area even earlier, so low tide sampling was not possible. Videography in this environment is therefore limited by the time and tide combination on a daily basis. Research from a larger vessel or mother ship would expedite field survey.

In northern Australia there are also seasons when winds are calm, usually occurring around October/November and May/June (between the change over of seasons). Calm winds are required for videography sampling and the remainder of the time videography was rarely useful for stock estimates. Although it was possible to see Sandfish on the video replay, footage was only discernable in patches of clear water which was interspersed with patches of turbid water from the sediment load. Therefore videography is logistically practical only during the seasonally optimal times and is further limited temporally in its application in the northern Australian environment.

Such limitations have implications for broad scale survey. To sample an area as vast and remote as the Top End coastline, or even the two study areas in this research, videography can only supplement other techniques. Pragmatically a combination of techniques, as found in this study and by other researchers (Harriott 1984, Preston et al. 1988, Vail 1989) remains the ideal sampling strategy. Alternatively a number of researchers each working at different localities with similar equipment during the seasonally optimal times would allow a greater number of samples to be taken at optimal times with this technique.

Bergstedt & Anderson (1990) also found that videography could be an unbiased sampling method with some measure of precision, but could not totally replace conventional sampling gear because images did not allow taxonomic discrimination nor mathematical measurements of individuals. These issues were not important in
the current case study as Sandfish were not observed to co-exist with other holothurian species and length measurements are not useful for Sandfish due to their fluid nature. However, Bergstedt & Anderson (1990) pointed out that using videography as a sampling technique presents substantial logistical difficulties and the current survey supports those suggestions, with the major difficulty in this study being water clarity.

The efficiency of standard fisheries biology sampling techniques (e.g. trawls, dredges and grab samplers) is frequently not known and samples taken with such gear only provide crude indices to abundance. Data collection using videography in the current study was severely restricted by spatial and temporal (diurnal and seasonal) factors. While trawl methods are logistically easier to conduct (very little technical difficulty arising from the combination of saltwater and electrics, independent from water clarity), there is a trade-off with potential damage to seagrass beds and the initiation or acceleration of other habitat threatening processes introduced by trawling. Sampling Sandfish by other techniques such as S.C.U.B.A. or manta tow is dangerous in the murky waters of northern Australia, and complicated by low water clarity and low precision. In reality, a combination of sampling techniques is the only feasible means to conduct broad-scale survey in this region (by a limited number of personnel). Sampling is further complicated by the different bottom strata present, where methods used in one strata cannot be used in the other.

**Effects of tidal, lunar and diurnal variables on trepang density**

Trepang densities have varied with time of day and with seasonal fluctuations (Shelley 1981, Wada 1992). Shelley (1981) suggested that differences may be a result of his sampling schedule with differing proportions of the population buried according to their burrowing-feeding cycle. The current study centred primarily around samples taken two hours either side of low tide and found no significant effects of these variables on trepang density estimates.

However, there is some factor which influences observed trepang density and requires further study. On one evening at low tide a high density of trepang was observed in a small lagoon during an intertidal walk. The densities appeared to be
uniform over the whole lagoon. The following morning, again at low tide, the exact
location was again checked by walking (having camped at the spot overnight to
ensure no commercial exploitation) and not one Sandfish was observed anywhere in
the lagoon. Why trepang are sometimes present *en masse* and sometimes absent
(presumably buried) is unclear from this study, but is a very important consideration
for trepang study and stock estimates, so that Sandfish are not reported as absent
from a location when in reality they are present (buried). Until a behavioural study
is conducted a broad-scale survey can not return results which are repeatable.

Further study is needed to ascertain what variables influence trepang to emerge from
the substrate. One possibility is that Sandfish respond to light intensity and
illumination conditions as Sunter (1937) also found that when collecting trepang
there would be no Sandfish on some days but the next bright day the bottom could
be smothered with trepang. Tidal currents may also influence Sandfish presence as
Sandfish have been noted to roll in tidal currents. However, it is likely that there is a
factor influencing Sandfish emergence other than tidal currents because it is unlikely
that in the example discussed Sandfish had all rolled away from a lagoon, largely
enclosed by rocks, in a single night. Although time of day was not found to
significantly influence Sandfish density in the current study this particular example
of Sandfish buried occurred around 0800 and was earlier than the usual sampling
time of 0930 or later.

At a seasonal level, salinity or water temperature may also influence trepang
presence/absence but there are clearly many other ecological factors such as wind
speed also worth considering.

Now that broad-scale survey has estimated areas of trepang abundance, a
behavioural analysis looking at factors affecting the burrowing-feeding cycle of
Sandfish could occur at a locality where a closure to commercial harvesting of the
species is enacted and enforced. The challenges are now to refine the broad-scale
survey with more precise stock estimates and to refine the sampling strategy to
optimise the likelihood of surveying when Sandfish are emerged from the substrate.
A behavioural study should focus on examining Sandfish behaviour temporally with
diurnal and seasonal changes in abundance determined, against which, broad-scale survey results can be calibrated at a later stage.

**Density estimates and standing stock**

The densities found in the current study are in line with those found by previous researchers surveying Sandfish in northern Australia. Vail (1989) found Sandfish densities ranged between 0.0005 m\(^{-2}\) and 0.07 m\(^{-2}\) (mean = 0.00877 m\(^{-2}\)) at Gove, and between 0.0004 m\(^{-2}\) and 0.065 m\(^{-2}\) (mean density of 0.01668 m\(^{-2}\)) at Croker Island (with densities varying by an order of magnitude between differing localities surveyed). Long *et al.* (1996) found average Sandfish abundances of 0.00241 m\(^{-2}\) in the Torres Strait.

In New Caledonia, Sandfish mean densities have been reported at 0.0683 m\(^{-2}\) (with a maximum value of 0.6000 m\(^{-2}\)) for *H. scabra* and 0.0082 m\(^{-2}\) (with a maximum value of 0.0450 m\(^{-2}\)) for *H. scabra var versicolor* (Conand 1989c in Uthicke 1996). Shelley (1981) reported high Sandfish densities in Papua New Guinea, averaging 0.29 m\(^{-2}\), although aggregations sometimes were as high as 0.37 m\(^{-2}\). The average densities appear to be a little higher in other parts of the world compared with surveys conducted in northern Australian waters.

Other researchers have also suggested that commercial holothurian densities may vary by an order of magnitude within a survey (Harriott 1984, Kerr *et al.* 1993, Uthicke 1996) and the current study confirms those findings. It appears that the northern Australian environment is similar to other parts of the world in that densities show wide variability between samples, however, average densities in other parts of the world appear to be higher than average densities in northern Australia.

Several researchers found that localised holothurian abundance is difficult to predict because habitats which appear to be suitable may or may not have trepang and each potential habitat needs to be individually inspected (Harriott 1984, Kerr *et al.* 1993, Uthicke 1996). Harriott (1984) suggested the high variance of holothurians (not Sandfish) she found on the Great Barrier Reef was probably due to the small area of the sample unit in that study relative to the patchy distribution of holothurians.
However, much larger sample units in the current survey also resulted in high variability of estimates. Several researchers have reported large aggregations of Sandfish in some places while finding only scattered individuals elsewhere, sometimes varying by an order of magnitude (Shelley 1981, Conand 1989c in Uthicke 1996, Vail 1989). This generates high variability in sample estimates and makes standing stock estimation difficult (Shelley 1981). The current study also supports those conclusions, despite the possibility that comparison between research projects is not appropriate because of the differences in methods used.

Restriction of surveys to depths of 10m was considered realistic in Harriott’s (1984) survey because many large holothurians are found in 10 m or less water depth. Knowledge of holothurian density only to those depths was also thought beneficial as it may also leave some breeding animals (when collecting) so that the rate of depletion is lower and a source of new recruits provided. Preston & Lokani (1990) also limited their standing stock estimates to those occurring landward of the 30 m isobath based on fisher’s inaccessibility to deeper stocks beyond the nearshore environment and because of the distance from the land base. However, they felt there were probably deeper stocks beyond their sampling zone. The current survey is restricted to the 5 or 6 m depth zone because of the densities reported previously by Vail (1989) and because of the difficulties of surveying beyond this zone (suspended particles appeared to increase so that videography is not successful; deeper waters occur some distance from the land base on the low gradient continental shelf). Furthermore, a study conducted in Northern Territory waters (of depths 20 – 50 m) found that in offshore prawn trawl nets <1 % of the bycatch (wet weight measured in tonnes) were holothurians (Pender et al. 1992). In other words very few holothurians were found in deeper waters during survey in deeper waters, an important finding for trepang survey. Although prawn trawl nets do not select for Sandfish, these samples were taken at night when most Sandfish are more likely to be on the substrate (Yamounchi 1939). These results suggest that high densities of Sandfish are in depths to 4m, as found by Vail (1989). Trawling with nets set to catch Sandfish would provide information on the depth limitations of this species, however, is a topically and politically contentious issue and the trade-off to obtaining additional information is potential damage to habitat.
With respect to sampling in the intertidal stratum, the higher positive skewness of walks suggests this method detected more instances where there were low abundances of Sandfish. Walking probably offers a greater opportunity to detect individuals which are burying or individuals which would have been missed by the other less intensive search methods used in the survey. Alternatively walking only occurred in the intertidal strata and Sandfish densities between strata were found to be equal at Cobourg but unequal at Maningrida. The differences between strata at Maningrida could reflect a real difference in Sandfish density between strata.

Intertidal densities were not equal between zones at Cobourg but were at Maningrida. Subtidal densities were equal between zones at Cobourg but were different at Maningrida. The Tukey test failed to detect any pairwise differences between zones at both study areas. The lack of significant pairwise differences between zones using the Tukey test for unequal sample sizes result may reflect the lower power of the Tukey test (greater likelihood of Type II errors) as discussed in Zar (1996). Again the differences in densities found in adjacent areas (similar strata) reflects the highly variable abundance of the species.

Estimates are probably underestimates because of the burrowing-feeding cycle of Sandfish. Morgan (Bribie Island Aquaculture Centre, unpublished data) tagged Sandfish successfully for around 3 months and calculated that underestimates may be as much as 60%, probably because of burrowing or migration.

**Habitat analysis**

Habitat characteristics of holothurian are difficult to conclusively determine and the influence of environmental factors such as bottom type coverage or nutrient concentrations in sediments on holothurian abundance has rarely been tested (Uthicke 1994). The results of the current study support that claim.

Kerr et al. (1993) found that holothurian species were often found in more than one microhabitat. With respect to Sandfish, Skewes et al. (1998) reported no correlation between environmental data and densities in the Torres Strait. The environmental data they collected was substrate coverage type (seagrass, live coral, soft sediment, rubble, consolidated rubble, pavement and boulders). Previous surveys in the same
region indicated that *H. scabra* was negatively correlated with live coral habitats and positively correlated with seagrass habitats (Long *et al.* 1996). However, the correlation with seagrass was low and they suggested other factors also influenced Sandfish abundance. Shelley (1981) found that *H. scabra* was distributed in shallow lagoons, landward of fringing reefs, on substrates varying from mud to sand. It occurred with beds of mixed and single species seagrass as well as areas of reef flat with little or no seagrass present. This study supports the previous research suggesting various substrate particle sizes and coverage types are suitable habitat for Sandfish. Since Long *et al.* (1996) did not survey subtidal habitats the correlation they found between Sandfish and seagrass may be a characteristic of the intertidal zone only.


Water depth is also a difficult issue. Preston & Lokani (1990) found strong stratification of holothurian density with depth (across different species), with highest densities found on leeward island shores and offshore reefs. Tidal limits found by Shelley (1981) appeared to be Low Water Neap and Extreme Low Water springs. *H. scabra* was not found deeper than 3 m and always in sheltered environments.

In the Northern Territory, Vail (1989) found highest Sandfish densities at Gove occurred in less than 4 m, with smaller individuals occurring in less than 2 m depths; and highest densities at Croker occurred in depths up to 2 m. The current study did not find abundance stratification with depth which contradicts the findings of previous authors. Since the current study was more of a broad-scale approach than most of those previously applied (except for Preston & Lokani 1990) then it may be that depth zonation occurs at individual sites but in the bigger picture the depth zonations are not as relevant. In other words, across the Top End waters highest densities were found in one depth strata at Gove and in another depth strata at
Croker, so that across the entire Top End there may be no depth effect, or at least, it was masked in the current study covering two differing study areas. This may be related to the results in the current study which showed differences between zones (within strata) occurred both at the Maningrida and Cobourg study areas. Alternatively, in other parts of the world where waters are clearer and safer, sampling beyond the depths in this study has occurred and the depths chosen in this study may not have been enough to show a difference.

Harriott (1984) found that although highest densities of commercial holothurians (not Sandfish) occurred in forereef and backreef slope habitat, holothurians were not present in all reefs which appeared to be suitable habitat. This meant that a habitat likely to contain significant numbers of holothurians could be predicted, but then needed to be verified separately to determine whether high densities were present. This was similar to the findings in this study for Sandfish and together suggests that some factor other than habitat type as categorised is necessary for holothurian density prediction.

Since none of the factors in the current study appear to influence Sandfish abundance and distribution it is possible that hydrodynamic factors are an influential factor. Localised distribution patterns of some tropical deposit feeding holothurians are thought to be generally limited by water movement (waves and currents), but this has not been determined for *H. scabra* (Uthicke 1994). Kerr *et al.* (1993) suggested that storm-generated waves may strongly influence the distribution of holothurians, particularly those which occur on exposed substrata which have less protection from the waves. Although they did not survey *H. scabra*, they found most species in their study were in relatively calm water and species richness was lowest in areas exposed to waves. Uthicke (1994) also found that distribution of holothurians could be linked to water movement. *S. chloronotus* distribution was linked to calm areas, but *H. atra* was more adapted to stronger currents, probably because *H. atra* (and *H. leucospilota*) can maintain position against surf-generated wave action and water agitation by occupying depressions and other cover such as rock or reef (Bonham & Held 1961).
Anecdotal evidence suggests Sandfish roll in tidal currents. Hydrodynamic conditions such as swell and current play a role in other holothurian distribution (Picard 1965 in Guillou & Michel) where video has shown individuals of other species rolled by swell or caught in algal drifts. Other evidence suggests active migration of *Sphaerechinus granularis*, both passive movement (with tidal currents) and active migration (probably induced by the change in feeding behaviour with age such as different textured algae). Hydrodynamic conditions may therefore influence Sandfish distribution firstly through wave action and secondly through tidal currents.

Calm areas also favour the accumulation of organic sediments. Kerr *et al.* (1993) suggested that the first limiting factor for holothurian distribution is exposure to water movement, with other factors such as food availability influencing aggregations within potential habitat. However, Uthicke (1994) found nutrient concentrations did not correlate with abundances. The influence of hydrodynamics and other factors in combination with hydrodynamic factors on Sandfish abundance and distribution requires further investigation.

### 1.6 CONCLUSION

The videography technique developed in the current study was useful in combination with other sampling techniques, but is logistically difficult and time-consuming. The combination of techniques makes stock estimation difficult but until safe methods and high-resolution equipment is available the data provided in this study is optimal in the circumstances.

Broad-scale survey would be expedited by conducting research from a larger vessel or mother ship travelling along the coastline and deploying a dingy at the appropriate sample points, rather than operating from a land base. Collaboration with commercial fishers under this scenario would be a useful strategy for data collection.

Sandfish abundances are highly variable, with no trends seen with diurnal, tidal and lunar variables. Other factors which influence presence and absence of Sandfish
such as daylight illumination are necessary to increase precision of estimates generated by broad scale survey. In this study densities range widely and are unpredictable, as found in other areas of the world.

Sandfish in Northern Territory waters occur in a array of microhabitats, probably selecting for calm areas as the limiting factor. Within these bays the water circulation and currents probably also play a major role in influencing Sandfish distribution and further analysis of Sandfish habitats should investigate the influence of coastline configuration and hydrodynamics on Sandfish density. Future habitats to be surveyed should exclude areas open to offshore sea conditions.
SECTION 2: REMOTE SENSING AND MAPPING TECHNIQUES

Objective 2: Apply remote sensing techniques to identification of suitable trepang habitat and provide maps of both verified and potentially suitable habitat for the Gurig and Maningrida study sites, and areas outside them for which relevant imagery are available.

2.1 INTRODUCTION: COASTAL REMOTE SENSING

Satellite remote sensing is a rapid and cost effective technique for mapping and monitoring intertidal and shallow marine habitat (Quinn et al. 1985, Zainal et al. 1993). Remote sensing applications in fisheries biology are now also common (Preston 1991, Green et al. 1996), with applications including bathymetry and shallow marine habitat mapping, resource monitoring, vessel monitoring, aquaculture, sedimentation studies, prediction of larval movements and interpreting upwellings, primary productivity and coastal currents (using dissolved organic compounds and chlorophyll). In one study, categorically ranked potential prawn and pearl-shell habitat identified from satellite images was shown to be highly correlated with catch per unit effort within the respective fisheries (Scoones & Hick 1990) despite the crude image processing techniques of visually assessing panchromatic rectified and stretched imagery. Satellite imagery was confirmed in that study as a particularly useful and cost-effective technique where the distribution of a target species in a developing fishery is unknown or where bathymetry is uncharted.

Major difficulties with mapping the coastal zone by remote sensing techniques relate to water turbidity, variations in depth and tide, mixels resulting from heterogeneous substrates, inadequate and tidally-varying depth of penetration by incident radiation, backscatter from the atmosphere and from sun glint, obtaining ground control for image rectification, and effects of poor sea state on backscatter and depth of penetration conditions (Lyzenga 1978, 1981, Quinn et al. 1985, Bierworth et al. 1993). For example, sand substrate typically shows a higher reflectance than mud, silt, clay or organic substrates, but will frequently be confused by the signal resulting from water depth differences (Lyon et al. 1992). Despite these potential constraints,
the trade-off of a cost-effective means of obtaining information, particularly where large-scale surveys are necessary, is deemed to outweigh the costs involved (Green et al. 1996).

Based on these considerations this section evaluates remote sensing as a benthos habitat mapping technique in the Gurig and Maningrida study areas, with particular application to the mapping potential for trepang habitat. The technique is evaluated for its potential to stratify habitats in ecological applications. The difficulty of obtaining imagery which is simultaneous with data obtained from shipboard sampling regimes is also discussed.

**Depth-invariant habitat mapping**

In coastal applications the main component of the signal received is the result of water depth, bottom type and water optical properties (Maritorena et al. 1994), and unless water depth and horizontal mixing is uniform across an image it is not possible to calculate bottom reflectance directly (Quinn et al. 1985). Reflectance from underwater substrate is modified by absorption and scattering in the water column and by the sediment load. This effect is represented by the coefficient of water attenuation ($K$) which varies with wavelength (Lyzenga 1981, Bierwirth et al. 1993, Maritorena 1996). Atmospheric backscatter and water surface reflectance may also add noise to the radiance received at the sensor (Maritorena et al. 1994).

Many early studies researched individual water properties in isolation (e.g. bathymetry studies, studies on salinity, suspended sediments or phytoplankton) without considering the interaction of ecosystem components and the combined effect on the digital radiance value (Bierwirth et al. 1993). These studies have generated empirically-derived relationships between image data and field measurements. Such studies are scene-specific and field measurements must be collected at the time of overpass, so that empirical models are only good for one-time analyses of the data (Lyon & Hutchinson 1995). This type of analysis is inefficient in marine applications as water characteristics vary greatly.

However, there has been some modelling of interacting water properties. Deterministic radiation transfer (RT) models which simulate water resources and associated properties have been applied to the coastal zone. For example, Lyon et
al. (1992) first used unsupervised classification to generate a map of 50 classes with separate bottom type and water depth, using the assumption of minimal variability in water quality. They identified bottom type using field data and scatterplots, and stratified the data based on these cues. They then calculated the attenuation of light coefficients with a Secchi disk and input these values into the RT equation over a series of 5 depth layers. Brightness values of bottom classes were discriminated using the proportion of the brightness value range which represented water depth so that different depth classes were generated over the same bottom type. However, they pointed out that this method is not useful where suspended sediments occur and consequently is not useful for the Gurig and Maningrida study areas.

The use of linear mixture models (e.g. Yates et al. 1993, Donoghue et al. 1994) is one way in which the confounding of water depth and reflectance has recently been overcome. Linear mixture models assign a proportion of the variance within each pixel to various constituent “endmembers”. This typically gives very precise results because estimates are made to include sub-pixel variability. Two different types of unmixing endmembers can be used, that is, a library of reflectance spectra, or training spectra extracted from the image (Donoghue et al. 1994). Using image endmembers negates the problems associated with atmospheric correction (Donoghue et al. 1994).

The disadvantages of mixture models are that they require knowledge of the spectral signature of targets; endmembers are difficult to precisely identify; and the number of endmembers must be less than the number of spectral bands used in the analysis. Donoghue et al. (1994) used a maximum likelihood classifier and a linear mixture model to classify exposed areas of the intertidal zone (from low tide images). However, to use linear mixing models, the surface cover types must be distributed in large discrete blocks within the pixel’s coverage. If cover types are mixed intimately, more complex non-linear mixing is required, presenting a problem in applying this technique to the intertidal zone when images are not captured at low tide and for the sub-tidal zone where water mixes with sediments.

Lyzenga (1978) reviewed early ratio algorithms in water reflectance models with constants which did not account for the changes in bottom reflectance or water
attenuation usually occurring throughout an image. Other water depth algorithms were constrained by assumptions that the ratio of bottom reflectance in two wavebands is constant \((R_b = r_{A1}/r_{A2} = r_{B1}/r_{B2})\) etc. where \(R_b\) is bottom reflectance, \(r_A\) the reflectance in band A and so forth) over an image and that the difference between attenuation coefficients \(K_1 - K_2\) is constant. As he pointed out, it is difficult to find wavebands where both criteria can be satisfied. When deriving bottom reflectance (rather than water depth) it is essential that bottom types have different reflectance ratios in the wavebands selected. This is not useful where substrates such as sand and mud have similarly shaped reflectance spectra since the two bottom types generate nearly equal reflectance ratios across a range of wavebands and cannot be readily distinguished. These earlier algorithms were also restricted to two operational wavebands, and did not allow for the maximum data from multiple wavebands which could potentially be used in such analyses.

Lyzenga (1978) found that water scattering had the same depth dependence as bottom reflectance and improved early models to derive an apparent bottom reflectance (incorporating water scattering). His technique depends on the assumption that bottom-reflected radiance is approximately a linear function of bottom reflectance and an exponential function of water depth. Radiance values are transformed according to the equation \(X_i = \ln (L_i - L_{si})\) where \(L_i\) = bottom reflected radiance and \(L_{si}\) = deep water radiance. This transformation produces a linear relationship between bottom reflectance types, and also with water depth. The slope of the linear relationship can be represented by \(K_i/K_j\) (obtained from a least square fit of \(X_1/X_2\)) where \(K_i\) = water attenuation coefficient in band i. Differing bottom types fall on a parallel line, with the amount of line displacement representing the change in bottom type, which is depth-invariant. Non-linearities are caused by internal reflection from the water surface and are significant only in very shallow water and where bottom reflectance is high. By measuring the amount of displacement, \(Y_i\), a variable related to bottom reflectance is produced.

The equation can be rotated and used in an N-band system to produce one depth dependent variable, \(Y_N\), and \(Y_{N-1}\) depth independent variables, which are functions of bottom reflectance. The \(Y_N\) variable is used to derive depth zones. The advantage of this model is its capability of using bands with the smallest attenuation
(since ratio methods give increased noise with decreasing attenuation differences). However, depth errors are greater in this model and the algorithm is complex to use.

The problem with all these models is that they require knowledge of water attenuation coefficients, or an ability to empirically derive them using regression analyses over uniform bottom types. Lyzenga (1981) improved the applicability of early models by suggesting that only the ratio of water attenuation coefficients (rather than coefficients themselves) was required for waveband analyses, giving relative water attenuation coefficients. Again this method produces only relative bottom changes, and does not detail the substrate spectral characteristics. However, an index can be obtained from the imagery itself, using a somewhat subjective supervised procedure. The method requires taking training sets from areas of homogenous bottom type but varying depth, and assumes the ratio is constant over the image. Training site values from channels are regressed to give a correlation between \(X_i\) and \(X_j\), with the correlation showing the ratio of attenuation coefficients. Homogeneity of training sites can be assessed from scatterplots of channels, or from statistics generated which minimise the perpendicular deviation from the regression line. Parameters can be input into a bottom cover index, expressed as:

\[
Y = C_1X_1 + C_2X_2
\]

where \(C_1 = (K_1/K_2)/\sqrt{1+(K_2/K_1)^2}\) and \(C_2 = 1/\sqrt{1+(K_2/K_1)^2}\)

and \(X_1 = \ln (L_1-L_{s1})\) and \(X_2 = \ln(L_2-L_{s2})\) etc. [see Khan et al. (1992) for this interpretation].

In the method described by Bierwirth et al. (1993), substrate reflectance and depth parameters can be unmixed in a single algorithm. The exponential effect of water depth is unmixed, leaving a residual related to substrate. However, this technique was developed using relatively clear water and cannot be assumed to apply to coastal waters, which are typically high in suspended sediment concentration. Instead, they suggest deriving water attenuation estimates using the method described by Lyzenga (1981) as input parameters where appropriate.
Alternatively, Khan et al. (1992) successfully applied a principal components transformation using axes rotation to reduce the effect of water depth variation on bottom type. The assumption was that the principal variation in water reflectance in the visible bands is due to changes in water depth, while the secondary orthogonal variation is due to changes in bottom reflectance. The first PC contained the variance common to both bands, which was water depth down to x metres. The second PC contained orthogonal variance, mainly related to bottom variability.

Based on the above review, Lyzenga’s (1978, 1981) method and a Principal Components Analysis in combination with algorithms designed to discriminate suspended sediments, were selected to apply to the turbid coastal waters of northern Australia (see study area section) and discriminate depth and habitat patterns.

**Inorganic sediments and dissolved organics**

It is possible to map sediment size classes occurring in the intertidal zone using images obtained at low tide (Yates et al. 1993). These sediments can be spectrally unmixed from those found above high water mark by the occurrence of surface water, especially if images are obtained during a neap cycle. Maktav & Kapdash (1994) mapped zones of a beach profile in Turkey. One of the premises of their study was that sediments were graded along the beach and could be detected by satellite imagery due to the differential thermal conductivity (with sediment size) and differential thermal resistivity (with water content). Reflectance decreases as sand size increases, and water content can define high water mark on the beach. However, subtidally the situation is more complex. Absorption and scattering by suspended materials cannot be generalised since suspended materials vary in their nature and quantity depending on the season and flow conditions (Bhargava & Mariam 1990). In macrotidal regions, sediment distribution is altered by tidal mixing and mass transport of water, friction, reversing acceleration and deceleration of tidal currents with depth, intense vertical mixing with turbidity, upwelling bottom sediments, and by temporal combinations of these factors, making remote sensing applications in macrotidal environments difficult (Amos & Alfoldi 1979).
Amos & Alfoldi (1979) mention that logarithmic transforms of the red waveband can be linearly related to freshwater turbidity. However, turbidity cannot be related directly to suspended sediment concentration (SSC). Han et al. (1994) showed that increasing SSC increased reflectance values, particularly as more fine grained particles were added, presumably increasing scattering. However, increasing SSC did not eliminate the primary spectral response of chlorophyll, that is, an NIR reflectance peak and red absorption trough. Of the two commonly used algorithms, NIR/red was found to be independent of SSC while NIR-red showed a slight positive relationship to concentrations of SSC. More fine grained particles increased reflectance values faster. However, the spectral bands used in this analysis do not correspond to the broad bands of Landsat TM data and may be difficult to isolate.

Amos & Alfoldi (1979) explain the chromaticity transform which removes brightness information and leaves Landsat hue and saturation, indicating water quality, suspended sediment and chlorophyll concentrations. Amos & Alfoldi (1979) applied the chromaticity transform \( X = N_i^4/\Sigma N_i \) and \( Y = N_i^5/\Sigma N_i \) and an additional calibration which accounted for varying scene-specific noise differences \( (X' \text{ and } Y') \) to relate seawater radiance to absolute surface suspended sediment concentration. This surface value is typical of the entire water column. High correlations were found between the chromaticity transform, its calibrated data and the log (SSC). Thematic maps quantitatively delineated a variety of sediment types and were used to determine circulation patterns, sources of material and volumes of suspended sediment. They suggested that their methods would be successful in any marine environment. Given that assertion, and the objectives of this research to map habitat, it would be thought useful to apply those algorithms in combination with depth-invariant habitat algorithms described above. However their work was dependent on concurrent field sampling and satellite overpasses; thus a large amount of field work was devoted entirely to determining that relationship, with many dinghies (up to 13) deployed to sample a number of points simultaneously. The algorithm relies on collecting field data at the time of satellite overpass and the logistics of the current field sampling program did not allow verification of this technique. This technique could be investigated for its utility in the northern Australian environment at a later stage.
Most estuarine and nearshore coastal waters are Case 2 waters (Pattiaratchi et al. 1994), which means that sediments, phytoplankton (indicating chlorophyll), mineral suspensions, organic particulates and bottom reflectance combine to confuse the signal to varying degrees (Estep 1994, Han et al. 1994). The amount of chlorophyll $a$ is frequently used to indicate primary productivity, nutrient loads and pollution of coastal surface waters (Johnson 1978, Han et al. 1994). High chlorophyll $a$ concentrations are associated with inflows from sewage, industry and eutrophication, while low concentrations may be from the presence of toxic substances, but indicate a reduction in nutrient load. The technique of relating empirically-derived sea truthed data to imagery with algorithms has been used to map chlorophyll $a$ concentrations (e.g. Johnson 1978, Harding et al. 1995). The seasonally varying nature of water properties makes determination of chlorophyll algorithms difficult, and increasing the amount of suspended sediment decreases the depth of penetration (Whitlock et al. 1978 in Menges 1998).

Several researchers have found a correlation with the red band or a green/red ratio and SSC (Amos & Alfoldi 1979, Lavery in Pattiaratchi et al. 1994) for mapping SSC or chlorophyll concentrations in estuarine eutrophic systems. Bierwirth et al. (1993) also suggest obtaining ratios of substrate reflectance $R_{b2}/R_{b1}$ and $R_{b3}/R_{b1}$ to enhance the presence of chlorophyll and show better discrimination of sea-grass areas, microbial mats and organic ooze. Mitchelson et al. (1986) in Pattiaratchi et al. 1994 used the logarithm of visible band ratios for detecting chlorophyll $a$ in Case 2 waters. Menges et al. (1998) and Bhargava & Mariam (1990) both used NIR in a density slice to look at algae and turbidity. Menges et al. (1998) mention that NIR may be particularly useful where a substrate such as mud has low reflectance.

Where water depth is greater than 5 m or turbidity lower than 5 ppm fine particles, only small variations in the signal from Landsat TM band 4 exist. In these cases multi-date imagery may help to discriminate depth and water masses within the water body (Jupp et al. 1994). In areas where no component of the radiation is confused by bottom reflectance, other seawater properties may be analysed (Quinn et al. 1985).
Jupp et al. (1994) explain that surface layers of water masses can be classified by variations in turbidity and chlorophyll concentration (of cyanobacteria) using airborne scanner data. They used a ratio of the red edge (the transition waveband between red and near infra-red, approx 710 nm) with red visible light reflectance, (approx 680 nm) since red light is strongly absorbed by chlorophyll *a*. In grey-scale images of data transformed by this ratio the brightest areas would show highest ratio values, that is, areas of algae and other organic matter containing chlorophyll *a*. Other studies have used the ratio of NIR:red and obtained useful results. For example, Han et al. (1994) found that of the two approaches commonly used to separate chlorophyll and SSC, the NIR/red ratio was totally independent of SSC, while the NIR minus red showed a slight positive relationship to SSC.

However as Jupp *et al.* (1994) point out, algae reflectance models are still functions of turbidity and the presence of other species with varying amounts of chlorophyll *a*. We still need to know the spectral properties of the turbidity in the image and other species present. He suggested using a multi-step process to remote sensing of algae whereby water masses with algae are first detected, then broad species classified, and finally water properties measured.

Based on the above review, various ratio and difference algorithms and the logarithm of (blue/green) and of the visible bands were chosen to apply to the images and best interpret the effects of suspended sediments and organic particulates present in the study area.

### 2.2 DATA SELECTION AND EXPERIMENTAL DESIGN

In theory, monitoring by Landsat TM can occur at a temporal resolution of 16 days. However, in the humid tropics, cloud cover is the major constraint to using passive remote sensing techniques (Green *et al.* 1996) and suitable imagery is in reality only obtained from overpasses occurring during the dry season, that is, between April to October.
Another major problem with data selection and experimental design is the variability associated with tidal and lunar cycles. Quinn et al. (1995) suggested that temporal comparisons of multi-date imagery may reflect changes in area of habitats and spectral response of pixels which result from tidal level and movement. Zainal (1993) used a sequence of eight Landsat TM images acquired during different tidal conditions to detect change in coastal habitats in Bahrain. He used the same time each year to minimise the effect of sun angle differences and differing classification procedures but found relatively high misclassification of habitats, except where subscenes of habitats were first spatially masked and then classified. This procedure is only useful where habitats are already known.

In the current application, then, the choice between spring and neap tides, or lunar phase, is the first consideration for data selection and experimental design. Imagery acquired during a spring low tide would presumably allow larger amounts of exposed substrate to be classified than imagery acquired during a neap low tide. It might be imagined that a greater area of subtidal environments could also be classified during the spring tidal phase, since the water mark commences from a lower point. However, during neap tides water movement is minimal which decreases suspended sediments and improves optical water properties and the depth of penetration of incident radiation. This means that water penetration capabilities of light during neap tides may result in a greater range of subtidal habitats being discriminated. Another way of looking at the choices for imagery is to consider that during a spring high tide, all sediments are closest to the shore, rendering subtidal waters much clearer than at any other time. How all these considerations affect the choice of imagery is unclear, and the choice of lunar-varying phases for image acquisition is difficult.

Data selection is further complicated by the hydrological properties of water. Sediment load and distribution will vary with water circulation due to incoming and outgoing tides. Sediment load and distribution will also vary with local wind conditions. Ideally, a range of images should be studied so that the effects of lunar, tidal and meteorological variables can be interpreted.
This section details the methodology used to select appropriate images, and apply the most appropriate algorithms reported in the above literature to a time-series of images in the study area (Maningrida). Thus, pair-wise analyses were necessary for spring vs neap, incoming tide vs outgoing tide, and wind vs no wind. At Maningrida, Landsat overpasses occur around 10.00 a.m. Perusing Landsat overpasses and tidal prediction charts revealed that no times coinciding with a spring low tide were available for the study area. The most suitable images to represent variability in tidal, lunar and meteorological conditions were covered by five quarter scenes (Table 8).

**Table 8: Images selected under differing biophysical conditions.**

<table>
<thead>
<tr>
<th>Image</th>
<th>Lunar phase</th>
<th>Tidal phase</th>
<th>Wind direction</th>
<th>Wind speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 Jul ’93</td>
<td>spring</td>
<td>outgoing</td>
<td>SE</td>
<td>1m/s</td>
</tr>
<tr>
<td>25 Jul ’95</td>
<td>transitional</td>
<td>outgoing</td>
<td>ESE</td>
<td>2.1 m/s</td>
</tr>
<tr>
<td>20 Jun ’94</td>
<td>neap</td>
<td>low</td>
<td>0</td>
<td>0 m/s</td>
</tr>
<tr>
<td>4 Jun ’94</td>
<td>neap</td>
<td>low</td>
<td>SE</td>
<td>1 m/s</td>
</tr>
<tr>
<td>23 Oct ’93</td>
<td>neap</td>
<td>incoming</td>
<td>SE</td>
<td>1 m/s</td>
</tr>
</tbody>
</table>

A general methodological framework to address the combined issues of appropriate techniques and appropriate imagery under differing biophysical conditions is proposed (Fig 11). The major steps involve:

(i) Data selection  
(ii) Pre-processing of images selected  
(iii) Apply techniques to control image and evaluate optimal techniques  
(iv) Apply optimal techniques to experimental images  
(v) Transfer technique to different environment
Fig 11: Methodology proposed.

SELECTION OF IMAGES UNDER DIFFERENT BIOPHYSICAL CONDITIONS

PREPROCESSING (GEOREFERENCING, SUBSETTING, RADIOMETRIC CALIBRATION)

MASK OUT LAND VALUES

CONTROL IMAGE: UNSUPERVISED CLASSIFICATION USING VISIBLE BANDS; OTHER TRANSFORMATIONS BASED ON EXISTING LITERATURE

EVALUATE CLASSIFICATION

UNDERSTAND ECOLOGY OF TARGET SPECIES AND EFFECT ON ACCURACY ASSESSMENT

APPLY OPTIMUM TECHNIQUES TO EXPERIMENTAL IMAGES

EVALUATE CLASSIFICATIONS UNDER DIFFERING BIOPHYSICAL CONDITIONS USING CHANGE DETECTION TECHNIQUES

TRANSFER TECHNIQUES TO A DIFFERENT LOCALITY

CHOOSE OPTIMUM SET OF BIOPHYSICAL CONDITIONS TO PLAN FOR FUTURE IMAGE OVERPASS TIME

INSITU BIOPHYSICAL MEASUREMENTS AND AQUIRE SIMULTANEOUS IMAGE

RECLASSIFY IMAGE USING ABOVE TECHNIQUES AND DEVELOP CORRELATIONS WITH IN SITU MEASUREMENTS

DETERMINE DIFFERENCES OBTAINED FROM IMAGE CLASSIFIED UNDER KNOWN BIOPHYSICAL CONDITIONS
Step 1 has been discussed in the previous section. Steps (ii) – (v) are presented and discussed in this section. Theoretically, once the optimum techniques and sampling time are known in situ measurements can be planned and correlated with satellite data. The accuracy of habitat mapping will also need to consider the ecology of the target organism on the interpretation is necessary and will be discussed in other sections of this report.

2.3 DIGITAL IMAGE PRE-PROCESSING

The five Landsat TM quarter scenes were obtained and three 1:100 000 topographical maps were used to obtain ground control points to which the July 1993 image was registered and resampled (georeferenced), using microBRIAN Version 3.41 (MPA 1995), a PC-based image processing package. Rectification of known and unknown distortions was processed with nominal and polynomial transformations within the module in this software. This resampled image (reference image) was then used as the base image to which all other images were registered and resampled. Affine transformations were selected for all image resampling procedures so that pixels values from each channel were linearly combined with the offset factor to shift data values by the same amount.

Subsets of 2330 x 1640 pixels were taken to give the maximum area common to all images. The cloud that was present on the July 1995 image could not be spectrally separated from areas of sand. The small amount of cloud in that image was retained with the expectation that classification would identify cloud as a spectral class. Deep water statistics were taken from each image (given in Appendix A) and were used to atmospherically correct the subsets.

Statistics showed high variability in cover types between images, e.g. areas with fire scars had lower digital values than deep water statistics. For this reason land areas were spatially masked from all subsets, using NIR band 4 to best delineate the land/water boundary, prior to radiometric correction. The intertidal zone would
presumably retain a film of moisture to aid the land masking and where difficult to discern the visible bands were displayed.

The subsets were then radiometrically corrected so that variations in incident and reflected energy resulting from differing solar zenith angles, atmospheric scattering and sensor decay were standardised. Such variations relate either to sensor-related effects such as calibration and de-striping or to scene-related effects such as illumination, atmospheric conditions, topography, and target reflectance characteristics (Teillet 1986). Relative calibration deals with sensor-to-sensor, band-to-band and time-to-time variations and their absolute calibration. It may even be necessary to correct for within-scene variations.

The method of regressing histogram percentiles described by Harrison & Jupp (1990) was used, since insufficient mid-range targets could be located in order to use the invariant targets approach (Hall et al. 1991, Hill & Aifadopoulou 1989, Campbell et al. 1994). While Donoghue et al. (1994) used this approach and found satisfactory calibration using “control sets” of pixels from deep water and urban areas in multi-date imagery, they mention that seasonal differences such as temperature and sediment content could have affected the spectral properties of deep water pixels. Since the only way that the range of biophysical variables could be analysed was to obtain images captured under differing seasonal conditions, this method was not appropriate. Visual analysis confirmed differences in spectral response from common pixels. Furthermore, simply taking dark target statistics does not account for differences in sensor calibration, that is, between sensors or sensor-decay differences with time (Hall et al. 1991).

Histogram percentiles of the contrast ranges were obtained for all image subsets. Channels from the June 20 1994 image were used as the independent variable on which the corresponding channels from images taken during other overpasses were regressed. Scatterplots suggested there were no outliers which required deletion. Regression statistics are shown in Appendix B. Images were then rescaled using an affine transformation based on the respective beta coefficients and intercepts from the regression equations as the gain and offset values.
2.4 TECHNIQUES APPLIED TO CONTROL IMAGE

The methods used in the following approach rely primarily on digital image processing algorithms and techniques. Images were purchased prior to the sampling schedule, negating the possibility of collecting real-time data to correlate with the imagery.

Methods
The June 20 1994 image was devoid of wind effects (presumably lowest in SSC) and was chosen as a control image so that the other four images (experimental images) could be compared and evaluated at a later stage. In this way any differences in results could be interpreted with respect to the changing biophysical parameters present during capture of the experimental imagery.

Other than analysing the raw data (visible and NIR wavelengths), techniques (a), (b), (c) and (d) respectively, the following processing techniques were applied, based on the suggested optimal techniques described in the literature review:

(e) Unsupervised classification
Three depth-invariant equations based on Lyzenga (1978)

(f) \[ Y_{1,2} = \ln(L_1 - 53.12) - 0.84 \ln(L_2 - 12.61) \]

(g) \[ Y_{2,3} = \ln(L_2 - 12.61) - 0.73 \ln(L_3 - 8.21) \]

(h) \[ Y_{1,3} = \ln(L_1 - 53.12) - 0.69 \ln(L_3 - 8.21) \]

(i,j,k) Principal components analysis using the three visible bands

(l) NIR – red

(m) Red/NIR

(n) Blue/green

(o) Green/red

(p) Green – red

(q) Blue – green

(r) Blue + green

(s) Log blue/green

(t) Log blue
These techniques resulted in four raw data channels and 20 transformed channels to evaluate against field data, totalling 24 channels of data. Techniques applied to produce transformed channels are described in more detail below:

### Unsupervised classification
A useful aspect of satellite image processing is its capacity to stratify potential habitats rapidly, on the basis of which field work can be designed. Based on this capacity the unsupervised classification was applied, using the visible bands as input bands. An initial 250 classes were generated at a 15% tolerance level, using the visible wavebands and four iterations of the nearest neighbour classifier. Four iterations of the nearest neighbour classifier were run to migrate the means. Class statistics were inspected and 138 classes containing ≤100 pixels were deleted. The remaining 112 class statistics were used to define 112 categories which were then used in a rerun of the classification, with a slightly looser tolerance of 16%, generating 112 classes. The looser tolerance was used so that pixels originally grouped in very small classes could be amalgamated with larger classes. The residual image suggested that classification was satisfactory.

The spectral similarity and spatial contiguity of the generated spectral classes were evaluated using a dendrogram and minimum spanning trees canonical variates analysis (based on the Mahalanobis distance). Classes were grouped into a range of possible broad cover types; eventually 12 broad classes were chosen to adequately discriminate between coastal and offshore classes, maximise detail and optimise the logistics of field work. The painted image representing each of the 12 broad classes in a distinct colour was then smoothed using a filter radius of k = 1; as no differences could be noticed visually the original clusters were retained.
**Depth-invariant equations**

Determination of the ratio statistics for the three depth-invariant equations involved selecting digital values from a range of pixels of homogeneous bottom type but varying depth (Appendix C). The values were used in regression analyses of channels 1 vs 2, channels 2 vs 3 and channels 1 vs 3. Correlation coefficients giving attenuation ratios (Lyzenga 1981) are shown in Table 9.

**Table 9: Correlation coefficients for regression analyses of channels used in depth-invariant equations.**

<table>
<thead>
<tr>
<th>Ratio</th>
<th>multiple R</th>
<th>slope</th>
<th>intercept</th>
<th>P-value</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1/K2</td>
<td>0.84</td>
<td>1.22</td>
<td>33.98</td>
<td>n.s.</td>
<td>53</td>
</tr>
<tr>
<td>K2/K3</td>
<td>0.73</td>
<td>0.39</td>
<td>16.04</td>
<td>n.s.</td>
<td>53</td>
</tr>
<tr>
<td>K1/K3</td>
<td>0.69</td>
<td>0.53</td>
<td>52.67</td>
<td>n.s.</td>
<td>53</td>
</tr>
</tbody>
</table>

The correlations are somewhat higher than those derived by Lyzenga (1981), probably the result of suspended sediments and organic particles typical of Maningrida waters. Attenuation ratios were used in the depth-invariant equations derived by Lyzenga (1978) along with the deep water statistics derived from single images as follows:

\[ Y_{1,2} = \ln(L_1 - 53.12) - 0.84 \ln(L_2 - 12.61) \]
\[ Y_{2,3} = \ln(L_2 - 12.61) - 0.73 \ln(L_3 - 8.21) \]
\[ Y_{1,3} = \ln(L_1 - 53.12) - 0.69 \ln(L_3 - 8.21) \]

**Principal components, ratios, summations and difference channels**

The principal components analysis, ratios, summations and difference channels were relatively straightforward.

**Parallelepiped classifications**

For the parallelepiped classifications, minimum and maximum values were defined in each band using depth data collected during field survey and the corresponding digital value. Forty-eight categories were defined from the various combinations of pixel ranges over three bands; however, 21 classes were deleted because they contained <0.1% of the data (see Appendix D). A further seventeen classes were amalgamated to the closest class (spatially) because they contained very little data.
Three other classes represented offshore sediments and were amalgamated as one offshore sediment class. Deepwater values were given the same value as land and masked out of the analysis.

**Data integration**

Each raw band or transformed image described above was imported into ArcInfo (via ERDAS IMAGINE; exported as a single band in .lan format) and georeferenced to the AUSLIG 1:100 000 coastline data. Rectified image bands were imported to ArcView and converted to grid themes to preserve raster information.

All raw data and transformed images were sea truthed, using a stratified design for sampling depth and habitat. A confusion matrix was generated with random numbers indicating a distance along the coastline to travel for sampling. Cultural restrictions on access to country and biophysical constraints such as rocks, sandbars and extensive shallow tidal flats constrained sampling (see objective 1 for details of sampling strategy) and sample points were adjusted accordingly.

Differential GPS locations were recorded for 63 depth soundings and 47 habitat types (trepang density was also recorded as described in objective 1) identified during field survey. Initial field experimentation showed a Secchi disk was easily dragged from alongside the boat by strong currents. Since water quality was not being mapped this technique was discarded in preference to obtaining data on depth, habitat and trepang density.

Depth soundings were transformed using data from the National Tidal Facility and standardised to a depth below Lowest Astronomical Tide. Depth soundings were placed into intervals of 500 mm, being categories of 0m (intertidal), >0 – 0.5 m, >0.5 – 1 m, >1 – 1.5 m, >1.5 – 2 m, >2 m – 2.5 m, >2.5 m – 3 m, >3 – 3.5 m, >3.5 m – 4 m, and >4 m. Habitat types were categorised according to dominant substrate type following mechanical particle size analysis, using the categories of med/fine sand, fine sand and fine-grained substrate (described in detail in objective 1). Supplementary data interpreted from nautical charts allowed an additional 22 habitat types of islands, reefs, rocks or sandbars occurring in the area’s coastal waters (between the coastline and three nautical miles from Australia’s territorial baseline).
along with corresponding geographic co-ordinates. The most recent nautical charts for the area are Aus 17 (Entrance to Liverpool River, surveyed 1866, scale 1:72,000) and Aus 442 (Cape Don to Cape Wessel, unsurveyed and inadequately surveyed areas, surveyed 1869 and 1956, scale 1:500,000).

All geographic coordinates and information for the 63 depth soundings and 69 habitats (and trepang information) were input to a database. Co-ordinates were transformed to a point coverage using the generate command in ArcInfo and converted to a shape theme in Arcview. The database of field measurements was joined to the point coverage attribute table based on the geographic co-ordinates identity label.

The nautical charts were scanned and georeferenced to AUSLIG 1:100 000 coastline data in ArcInfo, then added to ArcView as image files. From these charts the low water mark and the 3 fathoms (6 metres) contour were digitised and added to ArcView as line features.

Each raw satellite image band or transformed image, except for the parallelepiped classifications, were then tested against the independent data from field survey in the database and nautical charts for accuracy. ArcView was used to extract the raster value recorded for each raw satellite image band or transformation, and values were compared to depth or habitat type.

**Accuracy assessment**
The confusion matrix for assessing accuracy was based on known points and only errors of commission are therefore included in the accuracy assessment. In other words it was impossible to work out the number omitted if all sea-truth points were generated from known data of that category. Errors of omission cannot be assessed.

Each raw band and technique applied is shown in Figs 12a-12x:
Figs 12 (a) - 12(x): Raw bands and techniques applied.
The blue band showed very poor discrimination of depth differences with an overall mapping accuracy of 18%. The same pixel values were found throughout the intertidal and subtidal zones so that the zonation pattern is not indicative of depth categories. In other words, the delineated zonation pattern did not reflect the input depth categories. Pixel values in the intertidal and subtidal zones were also confused with what appeared to be offshore sediments (in the northeast of the image scene).

Green light discriminated depth classes of 0m (intertidal); up to 0.5 m; up to 1 m; and >1 m to 4 m with an overall mapping accuracy of 62%. The depth classes of >0 - 0.5 m and >0.5 m – 1 m are amalgamated as one zone for display purposes at the chosen resolution. The intertidal zone was poorly discriminated in the Junction Bay area (large bay in the western sector of the scene) and pixels, particularly those from the subtidal zones, were confused with offshore sediments. The seaward subtidal zone of the green band showed a high correspondence with the 6 metre contour on the nautical chart.

Red light was the most accurate of the raw bands, discriminating 3 depth classes as 0 m (intertidal); up to 0.5 m; and >0.5 m – 4 m with an overall mapping accuracy of 64%. The intertidal zone in Junction Bay was more accurately discriminated and offshore sediments were mainly confused with only one zone - the seaward subtidal zone.

The NIR band discriminated the intertidal zone and shallow water, probably surface sediments as found by Menges et al. (1998) at an overall mapping accuracy of 24%.

Because of the poor mapping potential of the blue band, algorithms that had involved the blue band were not used in further accuracy assessment (except the unsupervised classification and PCA transformation because it was thought that a combination of the bands may prove useful). However, the results are presented and discussed. Visual analyses of other transformed images also showed that the techniques had not been useful and accuracy of those transformed images are not given.
The unsupervised classification produced a low level of accuracy when evaluated against field data, although a zonation pattern is clearly evident. Although a mapping accuracy of 18% was obtained, there was some discrimination of the intertidal zone across the whole scene, and the nearshore subtidal zones were also well separated from offshore sediments.

The depth–invariant ratios were intended for habitat mapping and were not analysed for depth discrimination. However, the habitat mapping was not useful (see below) and a zonation pattern was produced using the green and red wavebands only. Using blue light either discriminated nothing (in combination with green) or generated spectral confusion with sediments (in combination with red).

PCA1 mapped many deep water values with the same value as land, suggesting terriginous-derived matter was probably discriminated on the first axis. Other axes did not show meaningful categories with spectral confusion between sediments and the intertidal and subtidal values.

NIR-red confused the intertidal zone with the first subtidal zone and all values with deep water. This algorithm, however, successfully discriminated offshore sediments.

Red/NIR mapped most deepwater values with the same value as land, suggesting a high degree of terrigenous matter in the deepwater area. The intertidal and landward subtidal zone was reasonably well discriminated.

Blue/green showed poor detection of the intertidal and landward subtidal zone, however, successfully discriminated offshore sediments.

A useful transformation was the ratio of green/red visible light. This transformation appeared to correspond quite well with the intertidal zone digitised from the nautical chart if the 0 - 0.5 m depth class is used as the intertidal zone. However, reefs and rocky areas were also mapped as intertidal areas and discrepancies in the intertidal zone also appeared in Junction Bay. This
transformation produced only two discernable depth classes, i.e. 0 - 0.5 m; and >0.5 m with an overall mapping accuracy of 79%. The transformation was not able to discriminate beyond the intertidal zone for subtidal zones.

(Fig 12p) Green – red confused all depth zones with sediments.

(Fig 12q) Blue – green could not discriminate depth zones, however, discriminated offshore sediments.

(Fig 12r) Blue + green discriminated only one depth zone which appeared to amalgamate intertidal and subtidal zones.

(Fig 12s) Log (blue/green) confused the intertidal and subtidal zones with offshore sediments.

(Fig 12t) Log (blue) was unable to distinguish any depth zonation.

(Fig 12u) Log (green) discriminated a small amount of the intertidal zone but did not adequately cover all areas.

(Fig 12v) Log (red) was better than log (green) for distinguishing the intertidal zone but still did not adequately represent all areas.

(Fig 12w) The parallelepiped classification shows one deepwater, one sediment class, one mixed class, one intertidal class and 4 subtidal classes. This classification retained reasonable discrimination of the intertidal zone and the 4 subtidal zones down to the 6 metre contour. It also discriminated offshore sediments. Although a reasonably successful technique, no mapping accuracy is given as the work was generated from the sampling points rather than using the sampling points to assess the accuracy.

(Fig 12x) The parallelepiped classification using only green and red bands produced poor discrimination of the intertidal and subtidal zones and mixed pixels in the subtidal zones with offshore sediments.
The successful techniques (green/red and parallelepiped with visible wavebands) were assessed for their accuracy against habitat data. A supervised approach (rather than unsupervised) was applied because the unsupervised approach was promising but probably required some additional field knowledge. The red/NIR, and green – red transformations were also evaluated for their habitat mapping potential because there was some discrimination of intertidal zonation patterns.

All techniques assessed for habitat discrimination produced poor results. Generally, reefs and rocks could not be distinguished, mapping as the same values as intertidal and/or shallow water zones. These results are similar to those of Menges et al. (1998), who found that submerged reef flats in this environment could not be successfully discriminated due to the large amount of suspended sediment.

2.5 APPLICATION OF OPTIMAL TECHNIQUES TO IMAGE TIME-SERIES

Methods
To understand whether the experimental images were useful for habitat mapping, training sites were taken from each of the experimental images in an attempt to discriminate reefs (coral, rocky) and seagrass in a supervised approach to classification.

The two most useful techniques for the control image were applied: the ratio of green/red and the parallelepiped classification using all bands and the same pixel ranges as the control image.

The parallelepiped classification of each image grid theme (1 control image and 4 experimental images) was reclassified so that deep water values beyond the 6 m mark were masked out and only intertidal and depth classes up to 6 m retained their value. The green/red grid data was also reclassified on the control image and the four experimental images so that all pixel values in the intertidal zone were given a value of 0, while other data (excepting land) was given a value of 1.
Each image channel was again input to a GIS (via ERDAS Imagine; then georeferenced to AUSLIG 1:100 000 coastline data in ArcInfo) and added as grid themes in ArcView. The techniques applied were assessed against field data and relevant nautical charts.

The values in the reclassified green/red grid data were multiplied with the values in the reclassified parallelepiped layer using MapCalculator in the Spatial Analyst extension of ArcView. In this way, any intertidal pixel would eventually have a value of 0 (being multiplied by a factor of 0) and values between the low water mark and 6 metres would have the value of the parallelepiped classifier (being multiplied by a factor of 1). Values beyond the 6 metre mark would be masked out (multiplied by a value of 255).

The percentage of pixels falling within each class was then calculated and a test for the correlation coefficient between each image applied.

Results

In all experimental images the supervised classification spectrally confused (known) coral and rocky reefs with the intertidal zone, sediments and deep water generating a poor mapping accuracy. Depth mapping provided the basis for accuracy between images.

The parallelepiped techniques (Figs 13a-d) showed depth zonation but were not assessed for accuracy because depth categories were developed from field survey data. The green:red techniques (Figs 13e-h) showed some discrimination of the intertidal zone but accuracy was poor.

Multiplying the reclassification of green/red (values of 0 for intertidal and 1 for subtidal classes) with the parallelepiped classification for the control image resulted in one deep water, one offshore sediments, one mixed, one intertidal and 4 subtidal
Figs 13 (a) – 13 (m): parallelepiped, green:red ratio and multiplied layers
zones as shown in Fig 13i. No data represent the land masked out. Overall mapping accuracy is not given as classes were derived from field data.

Correlation coefficients between images for the percentage of pixels in each zone (using the final multiplication of layers) are given in Table 10. Image 2 had the highest correlation with Image 1; however, Image 2 was much more highly correlated with Image 4 than with image 1. The results are visually displayed in Figs 13 (j-m). Overall mapping accuracy is not given as classes were derived from field data.

Table 10: Correlation coefficient of images selected.

<table>
<thead>
<tr>
<th>Image</th>
<th>Image 1</th>
<th>Image 2</th>
<th>Image 3</th>
<th>Image 4</th>
<th>Image 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image 1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Image 2</td>
<td>0.822309</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Image 3</td>
<td>0.709535</td>
<td>0.933074</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Image 4</td>
<td>0.737012</td>
<td>0.957299</td>
<td>0.920829</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Image 5</td>
<td>0.573716</td>
<td>0.862214</td>
<td>0.786932</td>
<td>0.859247</td>
<td>1</td>
</tr>
</tbody>
</table>

2.6 TECHNIQUE TRANSFER TO A DIFFERENT LOCALITY

Methods

The transferability of methods to a different locality (the Gurig study area) needed to be assessed. An image acquired on the 16th June 1996, captured during a neap low tide and at a wind speed of 1.1 m/s, was selected. A subset comprising an area of 4063 pixels x 2521 lines was taken and the same preprocessing techniques as used for the Maningrida images were applied. That is, the image was radiometrically corrected to the Maningrida control image by regressing histogram percentiles so that the optimum techniques found for the Maningrida region could be assessed for their suitability at the Gurig study area. Visual inspection showed that the radiometric correction was suitable. The image was georeferenced to AUSLIG 1:100 000 coastline data.

The same image processing techniques applied to the experimental images. Training sites from homogeneous areas were also taken in a supervised classification
procedure, with the aim of discriminating potential depth zonation and/or habitat type.

A parallelepiped classification and a ratio of green:red were applied to the Gurig scene. Both resulting image channels were input to ArcView (via ERDAS Imagine and ArcInfo) and added as grid themes. The green/red channel was reclassified so that all pixel values in the intertidal zone were given a value of 0, while other data (excepting land) was given a value of 1. The parallelepiped values were reclassified in the manner described above so that deep water values were masked out and only intertidal and shallow depth classes retained their value. The reclassified channels were then multiplied together.

The supervised classification was assessed against field data and relevant nautical charts using ArcView to extract the pixel value. The charts used were Aus 18 (Port Essington, unsurveyed and inadequately surveyed areas and surveyed 1839 and 1967-1995) at a scale of 1:75,000; Aus 721 (Port Essington to Snake Bay, unsurveyed areas and surveys in 1965, 1938-40, 1945 and 1988) and Aus 308 (Goulburn islands to Melville Island, unsurveyed and inadequately surveyed areas and surveys to 1968).

Results

The supervised classification showed some depth zonation pattern (Fig 14a), although an overall mapping accuracy of only 49% was achieved. Depth classes discriminated were the intertidal zone, up to 0.5 m, 0.5m - 1 m, and >1 m. The supervised classification produced very poor discrimination between habitat types. All pixel values appeared erratically, probably confused by sediment load. Rocky areas were spectrally confused with areas of fine-grained substrate and coral reefs tended to be confused with fine sand.

The green/red techniques and the parallelepiped technique are visually displayed in Figs 14 (b and c respectively), however, accuracy is not assessed as the classes were derived from field data. The resulting map using the multiplied and reclassified channels showed no meaningful categories when applied to the Gurig study area.
Figs 14 (a) – 14 (d): Techniques transferred.
(Fig 14d) and again the accuracy is not assessed as the classes were derived from field data.

2.7 DISCUSSION

Mapping potential of techniques applied
Some of the techniques described above were useful for depth mapping but no techniques were useful for habitat discrimination. The most useful techniques were a supervised classification, the ratio of green/red and the parallelepiped classification.

Results of mapping accuracy may have been due to signal confusion caused by suspended sediments, since sediments appeared to be discriminated on the first principal component of the principal components analysis. Zainal *et al.* (1993) also obtained misclassification and spectral confusion when mapping marine habitats in Bahrain. The magnitude of tidal fluctuation in that environment was around 2 m for extreme highs and lows, and many locations showed signs of heavy sedimentation and recent pollution. Both the Gurig and Maningrida study areas have a greater tidal difference than Bahrain area so the results reported for this case study are not surprising. Menges *et al.* (1998) also mapped zonation patterns of inshore fringing reefs in a macrotidal area of northern Australia, and found features greater than 2 m depth could not be characterised because of the sediment load of the water.

Technical constraints to accuracy also complicates the effect of sediment load. Visual analysis showed georeferencing displaced the geographic co-ordinates with respect to the image, with the difference between raster (image) and vector (AUSLIG 1:100 000) data unable to be compensated for in some areas. Further difficulties of obtaining ground control points for image rectification (see introduction) in both marine and remote environments compounds the effect. Secondly, although differential GPS readings were taken, the readings are accurate to $\pm 2$ metres (68% of the time) and $\pm 5$ metres (95% of the time). Given the intimate mixing of sediments and water, pixels were frequently isolated from other pixels of that class so that a reading taken on the boundary of one pixel may in
reality have been the reading for the adjacent pixel (of another class). The spatial resolution of Landsat TM cannot improve this technical hitch.

It is also possible that the depth zonation patterns which appear are in reality reflecting suspended sediments which are indicative of the underlying bathymetry and hydrodynamics of the area. In other words, sedimentation patterns may correspond with bathymetry and other processes such as water circulation so that the sedimentation patterns correlate with depth in some techniques applied. This means that sediment reflectance is constituting the majority of the signal rather than water.

Several researchers working in the intertidal and subtidal zones have used the visible bands for classification (e.g. Hill & Ahmad 1992, Armstrong 1993, Bierwirth et al. 1993, Michalek et al. 1993, Zainal et al. 1993, Ahmad & Neil 1994) presumably because of the water penetration characteristics of these wavebands. However, this study has found that blue light showed spectral confusion within depth zones and between depth and sediments in all of the depth zones mapped in the Maningrida study area. Depth classes in the present study were placed into 50 cm intervals, and the limited ability of the blue band to discriminate depth differences (in the Maningrida study area) may have occurred because it penetrates clear water to a greater depth than other bands (Jupp 1988) and conversely may not discriminate small depth differences in shallow areas. Results may also be compounded by varying levels of sedimentation additionally affecting the response of the blue band.

However, blue light was found to be useful when combined with green and red light (in the parallelepiped classification at Maningrida.) The blue band was also useful for discrimination between offshore sediments and inshore depth zones using blue/green, blue-green and the parallelepiped classification of visible bands (NIR-red also discriminated offshore sediments and inshore depth zones).

In the parallelepiped classification, higher values in the green and red (in comparison with the digital signal emitted by other depth classes) represented the intertidal zone, while the blue band represented the intertidal zone on any of the intervals chosen. A combination of relatively high blue reflectance and relatively low red light, with any green light interval, best discriminated offshore sediments.
Relatively low-medium values of red light, with any blue values were required for shallow water mapping. Therefore the combined spectral response of the three bands offers far better interpretation than can be interpreted from the raw data.

The differences found for the intertidal zone across the scene (e.g. Junction Bay intertidal zone compared with other intertidal zones) may be due to tidal differences across the image because areas sampled for depth data started at the next bay (Rolling Bay) and continued eastward. In other words, the time of low tide at Maningrida would be different from low tide elsewhere on the image. Junction Bay was closed for cultural reasons during the field trip to evaluate that area so no data for that area could be collected. Furthermore, in one part of the Maningrida study area relatively high green light was required for subtidal mapping, whereas low-medium values of green light were required elsewhere. This again may have been because of the tidal differences that appeared spatially in the image.

Habitat mapping was almost certainly being confused by depth mapping because the areas surrounding known intertidally exposed reefs were being mapped as the intertidal zone, rather than discriminating a habitat difference. Even the depth-invariant techniques should have given habitat rather than depth but the zonation pattern was more alike depth zonation.

Zainal et al. (1993) also found that error in habitat classification was related to tidal height, where shallow sands of reefs and other shallow and emergent features were misclassified. In that study misclassification occurred between seagrass and deep sand, shallow coral and deep coral classes; between dense algae and shallow and deep coral classes; between deep sand and deep coral; and between shallow sand/sparse algae and rocky habitat and bright sand classes. Even under water at low tides the optically dark marine habitats became spectrally similar and difficult to separate, particularly with dense vegetation bearing habitats (seagrass and algae), dense corals and deep sand. They suggested spectral similarity may result from shared reflectances of chlorophyll a in vegetation, such as algae, coral and seagrass. However, it is more likely in this environment that suspended sediments were primarily responsible because of field knowledge about the study area. Field
knowledge suggests that on many occasions winds and tidal flow (both diurnal and lunar) generate turbid conditions.

A source of error in this study is the difference between age of nautical charts and the date of other data collected and analysed. Bathymetry maps produced by Maktav & Kapdash (1994) for the nearshore environment in Turkey used images less than ten years old, however, were not accurate because of the active bathymetry and variable character of that environment. They found that the coastline in general was more uniform (less variable) than bathymetry, although sand accumulation occurred in some areas along the coastline. Likewise, Michalek et al. (1993) produced change maps for areas of intertidal mangrove, shallow lagoons, coral, algae and seagrass. They found nearshore areas appeared to change more rapidly and over a wider area than sites further offshore, probably because of human activity (fishing, boating, habitat damage or growth) and associated water quality differences. Zainal et al. (1993) also found coastal development changes, dredging and water level changes affected sedimentation and habitat changes in the nearshore environment. While the areas sampled in the present research probably did not experience the same level of human activity as those areas, the difference in the age of the nautical charts was far greater allowing more time for natural environmental changes to occur.

**Differences in variables and implications for image selection**

Green et al. (1996) discuss cloud cover and other physical constraints to the availability of good satellite data in the humid tropical coastal zone. They remark that cloud cover has the potential to substantially limit the number of images and the areas able to be processed within an image. However, they only allude to the problems of tidal, meteorological and other biophysical conditions, and have not reviewed any literature that deals with these issues.

In the Maningrida study area Image 1 appeared to be useful for discriminating the intertidal zone and depths up to 6 metres. The neap low tide with no wind effects was a reasonably useful combination of biophysical variables for mapping depth, given the constraints of the environment. However, substrate could not be discriminated, despite the seemingly optimal conditions of a neap low tide. Yates et
al. (1993) found better discrimination of mud substrate compared with sand substrate and suggested a veneer of muddy sediment frequently covered some sandy areas. Their image was acquired during a neap low tide in calm weather conditions when tidal flow and wave action were minimal, increasing the chances of an extensive mud veneer remaining on the surface of otherwise sandy sediments. A layer of fine sediments covering sand substrate has been observed in this study as well at various localities and may increase during neap low conditions, which possible counteracts the presumed benefits of a neap lunar phase.

Image 2 showed the highest correlation generally with Image 1. The largest discrepancies between these images occurred in the intertidal zone; zone 4 (deepest zone mapped); and the offshore sediments and mixed classes. Subtidal classes on the seaward edge (zone 4 and the offshore sediments and mixed classes) may have been affected by wind effects in image 2, as the south-easterlies would hug the direction of the coastline. Depth classes in the sheltered bays would not be affected as easily by wind differences.

Alternatively, these classes may have been affected by the tendency of the outgoing tide (in image 2) to take sediments seaward. Amos & Alfoldi (1979) studied sediment circulation patterns and processes controlling distribution and load in a macrotidal environment, characterised by intense vertical mixing due to water turbulence. Using the chromaticity transform and real-time data collection they found high temporal variability in sediment distribution with tidal phase. Sediment concentrations were high in the intertidal zone on an incoming tide and low in the subtidal zone during an outgoing tide. Fast-flowing tides occurring around mid-tide tended to re-suspend material.

Amos & Alfoldi (1979) found the trend of sediment differences with incoming and outgoing tides was evident regardless of seasonal differences (although there were some local differences in distribution of the sediments because of the differences in magnitude of the tides with season). Although, Zainal et al. (1993) had to reduce the number of images acquired under differing tidal conditions and seasons from eight to three because seasonal differences introduced additional error, they were attempting to identify marine habitat and quantify change in Bahrain. The present
study is attempting to understand trends with different environmental variables and assumes that even if seasonal differences occur, a general trend showing processes should be evident.

Image 5 was more useful than image 2 for intertidal mapping and since both images were captured mid-tide with the same wind effects, the lunar differences (neap vs spring) between images suggest neap tides are better than spring for intertidal mapping. While there is water covering some of the intertidal zone during an incoming tide, the effects of tidal flow may push the sediments landward so that the clarity of the water at this lunar stage helps in discriminating zones.

Obviously a spring low may have produced even better results for intertidal mapping than a neap low. However, since no cloud-free imagery (dry-season imagery) was captured during a spring low for this area during the entire history of Landsat TM overpasses, the value of a spring low could not be analysed. However, a spring low tide needs to be considered for intertidal mapping if it is available for an area.

Image 3 was the most useful image (other than image 1) for discriminating the 6 metre depth zone. The difference between these two images was tidal phase (outgoing vs low) and wind effect (strong vs none). Strong outgoing tides may push sediments seaward so that shallow subtidal zones can be discriminated. However, the spring outgoing tide was not useful for intertidal mapping (as with image 2). It is possible that only clear water from a neap lunar phase (or possibly dead on low tide during a spring phase) is useful for intertidal mapping. Imagery captured during the remainder of the tidal cycle during a spring tide may have too much water movement to clearly discriminate a low water mark.

Image 4 was not useful for discriminating intertidal or subtidal zones and was not highly correlated with the control image. A neap low with wind effects presumably obscures the clarity of the water and counteracts the advantages of clear water usually found on a neap tidal cycle.

Understanding how processes affect image acquisition has been complex. Useful conditions for acquiring imagery are a neap low tide with no wind effects, enhancing
the clarity of water. A spring low tide may also be useful for both intertidal and/or subtidal mapping. Spring outgoing tides were useful for subtidal mapping only, while neap incoming tides were useful for intertidal mapping only. Spring tides (with tidal movement) may have been useful for subtidal mapping because the edge of the water was in closer proximity to the subtidal zone and some penetration could occur, but the intertidal substrate on this image would have held varying degrees of moisture depending on time since inundation. Neap tides (with tidal flow) were more useful for mapping the intertidal zone possibly because shallow water penetration occurred in the intertidal zone.

It is possible that tidal flow causes sediment flow in one direction so that this variable is foremost for consideration of image acquisition, with water depth the remaining factor to then be considered. Combinations of variables may need to be considered rather than selecting any specific variable as being the most influential, since it may be that a combination of interacting variables causes images to differ. For example, a spring low tide with strong winds may create low water clarity; however, a spring outgoing tide with strong winds may work in combination to take sediments further offshore. These variables all need to be understood before any real understanding of how image acquisition affects the interpretation of digital image processing algorithms, and consequently, applications to the coastal environment.

**Potential for technique transfer**

At the Gurig study area the blue band must have been useful because the supervised classification produced more successful results than did the transfer of successful techniques used at a different locality. Zainal *et al.* (1993) suggested that a supervised approach negated the problems of depth by producing depth classes in addition to other spectral classes, and thus yielded better classification because of *a priori* knowledge. The success of the supervised classification approach at the Gurig study area, suggests a supervised procedure at Maningrida may have been successful and generated similar results to the parallelepiped classification used at that locality (because the classification is more sophisticated).
However, areas of probable high sediment load still appeared sporadically throughout all depth classes generated by the supervised approach and probably accounted for the high error.

Ahmad & Hill (1994) were able to successfully transfer techniques used for mapping habitat of *Trochus niloticus* in the intertidal and subtidal zones. However, Menges *et al.* (1998) predicted that results from their inshore reef mapping in northern Australia were not transferable because of changes in substrate characteristics and water quality. This study confirms the predictions of Menges *et al.* (1998) and suggests satellite mapping techniques in northern Australian coastal waters need to be scene-specific and time-specific to account for environmental conditions at the time. Extrapolating across spatial and temporal scales is not useful because of the dynamic nature of the marine environment. However, one-off data collection relating real-time field measurements to satellite overpass data is technically and logistically inefficient.

2.8 ALTERNATIVE MAPPING TECHNIQUE TO DELINEATE TREPANG HABITAT

Preston (1991) described a technique used to map trepang habitat in the South Pacific, whereby satellite images were processed to delineate the 10 m and 20 m isobaths and determine the enclosed coastal area. Although remote sensing techniques were not found to be useful in the present research, the concepts of delineating isobaths were also adopted as an alternative mapping procedure to delineate potential trepang habitat in the present research.

Zainal *et al.* (1993) also experienced substrate misclassification problems, so subdivided habitats and digitised depth contours and spot heights from nautical charts and overlaid this data with the derived habitats. Accuracy was assessed by overlaying the digital sea-truth map with the image habitats using a flickering routine to show qualitative information. They pointed out that successful application of this procedure to other areas required accurate depth information and a good knowledge of the study area.
Given the approaches used by the above authors, a GIS approach using selective digitising of relevant environmental features from nautical charts was therefore chosen as an alternative mapping technique given the results found with remote sensing. Based on the combination of methods used in the research programs, and noting the misclassifications described in the previous sections, trepang habitat maps were generated using GIS techniques in ArcView. *Holothuria scabra* are generally found in low energy environments behind fringing reefs, in bays, close to mangroves, although the species has been reported near strong tidal currents on the edge of reef margin (Shelley 1981). Enclosed bays and optimum depths of between 0 and 4 m in northern Australia (Vail 1989) were used as trepang habitat requirements for *H. scabra* in this instance. Polygon features delineating the coastline were digitised from nautical charts and line features were drawn to enclose bays within headlands. Within enclosed bays, line features were also digitised to delineate the intertidal zone and subtidal zones. Because there were temporal differences in available charts, the 3 fathoms contour was used for the Maningrida study area, but both the 3 fathoms and 5 m contour were used for the Gurig study area. Trepang density was calculated from field survey data and added to the map as a point feature. Final maps are shown in Figs 15 and 16.

### 2.9 CONCLUSIONS AND RECOMMENDATIONS

It is difficult to use remote sensing techniques for mapping bathymetry in northern Australia, although some depth zonation patterns allow an observer to obtain a coarse picture of underlying processes. The most limiting factor appears to be the sediment load in the northern Australian coastal environment. Mapping intertidal and subtidal habitat appears to be impossible.

Algorithms for mapping depth ideally should be spatially and temporally specific, with data collected in real-time to match satellite overpasses. Weather and sea conditions probably limit these times to May/June, or October/November, depending on cloud cover at that time of year. However, collecting in-situ data to correlate with a satellite overpass is logistically inefficient many persons and
Fig 15: Verified and potential trepang habitat, Gurig study area.

The map on this page has been deleted because it contains culturally or commercially confidential material.
Fig 16: Verified and potential trepang habitat, Maningrida study area.

The map on this page has been deleted because it contains culturally or commercially confidential material.
boats would need to be deployed to record data at a number of sample sites across the area covered by the image scene. One-off data analyses are also technically inefficient, because the work cannot be extrapolated to other localities.

In addition to the logistical problems is that of choosing the required lunar and diurnal tidal conditions, wind conditions and probably other biophysical variables. Understanding the interaction of variables is difficult. However, planning a sampling time to coincide with appropriate lunar and diurnal tidal conditions may not be possible on the day because of bad weather, and even suitable weather conditions for boating may further constrain data collection because of sediment load.

Transferability between environments is not possible with a single image because of the variability and unpredictability of the environment. The combination of differing conditions during capture and the consequent outcome that some techniques prove better than others depending on scene-specific conditions make extrapolation of results impossible.

Mixels of sediment and depth alter area estimates for stock assessment; therefore, remote sensing at the current spatial resolution is not useful for these purposes at the Gurig and Maningrida study areas.

Higher resolution hyperspectral data may also offer some benefits not available in the broad-band remote sensing data used in this study. The waveband resolution in hyperspectral data may be able to separate substrate and other water-column parameters; and thus the utility of these data needs to be verified. In particular, wavebands within the mid-infrared spectral bands may offer some potential for discriminating intertidal habitat, as found by Yates et al. (1993).

A better understanding of coastal geomorphology would assist in interpreting satellite data. Hydrodynamic processes (waves and tides) and other geomorphic processes (inundation time of exposed sediments, sediment generation, sorting and transport etc) all need to be studied for their effect on turbidity and potential to confuse interpretations of satellite data in this region. Jacob (1984) pointed out that
we need to know the biophysical variables such as wave climate, tidal flow, silt load and freshwater flow to make qualitative predictions of littoral drift, erosion, accretion and other coastal processes in ecological research. It is recognised that analysis of multi-date imagery can reflect changes in coastal habitat which result from temporal differences of tidal level and movement (Zainal 1993, Quinn et al. 1995). This is particularly important in the dynamic intertidal and subtidal zones which change with diurnal, lunar and meteorological conditions, as well as seasonal changes in current flow and salinity.

Finally, preliminary GIS techniques have proved promising, being easier to implement and not as dependent on variable environmental conditions. Future use of the GIS would aim to spatially mask out reefs, rocky areas and other known habitat features using nautical charts and field knowledge, and then classify images to enhance mapping accuracy. Smaller scale analyses concentrating on single bays with higher resolution imagery, microhabitats (tidal channels etc) and variables such as inundation time (changing spectral response of exposed substrates) would also be useful. Low altitude (higher resolution) imagery may also prove useful input to a GIS. For example, colour infra-red photography captured at low tide may allow individual habitats such as tidal channels to be delineated. It was noted in the field that trepang appear to follow tidal channels and channels could be mapped in the field and input to a GIS with other public digital data such as current work being undertaken by the Coastal Resource Atlas project. The advantage of this approach is that processes can be understood first at a very small scale and then extrapolated to a larger area using the GIS techniques.
SECTION 3: COLLABORATIVE ECOLOGICAL RESEARCH

Objective 3: Collate information from traditional custodians of land or knowledge on trepang distribution and abundance and document the collaborative process and its implications for resource management in Gurig national park and Maningrida area.

3.1 INTRODUCTION

Protection of ecosystems, species, and genetic diversity is increasingly being linked throughout the world to the principles of ecologically sustainable land use and management in a manner that incorporates the needs and concerns of indigenous people, including their responsibilities for management (White et al. 1994b, Walsh 1995, Webb 1996). Not only are there strong economic and ecological reasons for integrating conservation and development, but maintaining cultural sustainability is increasingly advocated in natural resource management because ecologically sustainable development principles suggest that conservation and development need not conflict.

The 1980 World Conservation Strategy initiated integrated conservation and development projects, or ICDPs, described by Alpert (1995). Although as yet largely untested, these programs are thought to be a promising approach to conserving biodiversity in low income nations because of the interdependent nature of conservation and development, since people in low income countries are usually more directly dependent on local natural resources and government agencies frequently lack the means to manage resources in remote areas. The 1991 version of the World Conservation Strategy stressed the need for communities to care for their own environments (White et al. 1994a). Webb (1996) discusses other international conventions to which Australia was signatory, such as recommendations from the 1992 United Nations Conference on Environment and Development Agenda 21, an action plan for the 1990s and beyond to implement environmentally sustainable development in all countries (UNCED 1992). Although these recommendations are
not legally binding, they urge nations to recognise traditional values, to strengthen indigenous peoples’ involvement in policies and programs and to protect indigenous people from socially, ecologically and culturally inappropriate development. Internationally, there are many case studies of collaborative and community based natural resources projects, such as those reviewed by Pinkerton (1989) and White et al. (1994b).

In Australia, recommendations for Aboriginal involvement in natural resource management have been strongly endorsed in several government reports such as the Recognition of Aboriginal Customary Law (Australian Law Reform Commission 1986), the Royal Commission into Aboriginal Deaths In Custody (in Woenne-Green et al. 1995), the Coastal Zone Inquiry (Resource Assessment Commission 1993), the ANZECC Task Force (1993) and by the House of Representatives Standing Committee on Environment, Recreation and the Arts (HRSCERA 1993). Indeed the Uluru National Park Plans of Management require that any research be subject to decisions by traditional owners regarding its purpose, relevance and conduct. These plans and other studies relating to resource management recommend that research into traditional knowledge and management practices be undertaken and that government agencies respond to Aboriginal requests for information and assistance with implementing management activities (Reid et al. 1992a, Rose 1995). One of the purposes of the second Gurig National Park Draft Plan of Management (1998) is to provide a continuing working partnership between the government and traditional owners. In this plan, proposed research and monitoring must be approved by the Board of Management, which has equal representation of both government personnel and traditional owners. The Chair, who is always a traditional owner, has a casting as well as a deliberative vote. It is envisaged that the forthcoming Cobourg Marine Park Management Plans would make similar arrangements and provide for the employment and training of Aboriginal traditional owners in the area.

Aboriginal people have expressed their desire to be involved in nature conservation and management (Walsh 1990), but to date very little progress has been made toward successfully integrating indigenous aspirations in conservation and sustainable use of the environment with those of mainstream government agencies in a collaborative approach. Processes found to be successful in one situation may not
be relevant for another group (Walsh 1995). This paper describes a very generalised framework designed to meet international values (mentioned above) for truly collaborative research with indigenous people. It applies this approach to a survey of *H. scabra*. The purpose of describing this survey as a case study is to measure the research against international values of collaborative research. It is anticipated, at the very least, that improved management of a marine resource will eventuate from a process that involves traditional owners and incorporates their knowledge and practices.

The steps that lead to commencing a collaborative research project will vary. Traditional owners and community rangers, for example, may express an idea that generates a research question and they contact a research or academic institution. Or scientists may wish to work collaboratively with a community in order to gain greater insight to the processes involved. Or government agencies and funding bodies with interest in environmental research may be required to adhere to particular ethical protocols in working with indigenous people. The case study that is presented in this paper describes a project undertaken by a postgraduate student who wished to work collaboratively with an Aboriginal community on a project in the field of ecology. The paper begins by reviewing the literature on collaborative research and setting out the model of collaborative research that she derived from her reading.

**Background to the application/case study**

Much has been written about Aboriginal relationships with terrestrial and marine resources, their management practices and aspirations for management of their resources (e.g. Williams & Hunn 1982, Stevenson 1985, Coombs *et al.* 1990, Johannes & MacFarlane 1991, Smyth 1993, Rowse 1993, Ross *et al.* 1994, Rose 1995, Sinnamon 1997, Peterson & Rigsby 1998). A marine resource of particular importance to many coastal Aboriginal communities in northern Australia (locally referred to as the “Top End”) is trepang. Trepang is considered a delicacy in many Asian nations. In past centuries, certain Aboriginal communities of the Top End were involved with the harvesting of trepang to supply Macassan traders, and their involvement is part of oral tradition in those areas (Macknight 1976).
At the Cobourg Peninsula and Maningrida, in Australia’s Arnhem Land, the traditional owners of Gurig National Park and members of the Bawinanga Aboriginal Corporation (BAC) expressed interest in resuming trepang harvesting in their coastal waters for commercial purposes. An ability to harvest trepang could lead to economic gain and contribute to the process of enhancing economic independence. However, very little relevant biological information was available to guide the development of a sustainable use strategy (Preston & Lokani 1990, Adams et al. 1992, Kerr et al. 1993). Overfishing of stocks has occurred in other localities, and government agencies required that a sustainable use strategy be developed in accordance with ecologically sustainable development principles adopted by the Commonwealth and States/Territories, before any further licences were issued. For some time BAC had been keen to inventory the stocks around their coastline in order to increase their knowledge base and decision-making power in relation to this resource.

3.2 OUTLINE OF TECHNIQUE (THE MODEL USED)

In the accounts of ecological researchers working with Aboriginal people and communities, a recurrent general theme is the need to involve traditional owners in all phases of the research, including planning, data-gathering, interpretation and recommendations (Baker & Muijtjulu 1992, Reid et al. 1992a, Birckhead et al. 1996). A model of collaboration which conceptualises the process by dividing the project life into the four stages mentioned above is proposed (figures 17-20). The key factor determining success in involving indigenous people is the ability to allow flexibility and timing. This model, derived from the literature, outlines general principles which were used to guide the collaborative process of trepang research. Figs 17-20 represent the suggested general framework for collaborative research. The word general is used because a major conclusion is that a specific framework to conduct collaborative research with groups of people cannot be used. Rather protocols and principles should be adhered to and researchers be skilled with the necessary participatory tools and techniques to adapt to the situation.
I approached the community much later in the research process at Cobourg than I did at Maningrida. The case study refers to Maningrida where the approach was participatory from the outset. In order to work to these principles at Maningrida it was necessary to establish a particular research approach. The ecological survey would adhere to scientific schedules of replication and experimental design. At the same time an approach was required for working with a knowledge system that differs from that on which European biological sciences is based.

Ethnography is a social research style that makes sense of differing social situations, actions and cultures using an abductive (or interpretive) research logic (Agar 1986, 1996). Ethnography is a participatory method, placing emphasis on understanding the situation and what has occurred rather than predicting the value of a variable given the knowledge of others. This type of research involves collecting data about everyday situations, conversations, events and observations. The research frequently cannot predict its endpoint because there is no linear movement from hypothesising to data collection then analysis. Data may however be analysed and interpreted through formal tests of falsification and distribution checks, with results and conclusions reached by the emergence and revision of knowledge (Agar 1986, 1996). What is required is a commitment to personal involvement, abandonment of traditional scientific control, an improvisational style and an ability to learn from mistakes. The very nature of ethnographic research cannot depend on a preconceived hypothesis as this in itself can add bias to understanding a situation. Rather, the hypothesis emerges during the course of the research and is then verified by appropriate tests of falsification and distribution checks.

The ethnographic approach was used to frame the project reported in this case study from its initial conception to its completion. In the study discussed below the ethnographic techniques used were informal interviews, conversations and
Fig 17: Planning the research.

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Locate appropriate protocols

Approach community

Community is interested
Community aspirations

Community is not interested
Try elsewhere

Conduct negotiations

Establish relationships
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Fig 18: Gathering the data.

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Establish relationships

Cultural considerations

Engage community

Seek knowledge

Delegate responsibilities

Continued liaison
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Fig 19: Interpreting the data.

Seek interpretations

Present views

Synthesize results

Further clarification

Fig 20: Making recommendations.

Gathering the data

Incorporate ideas

Consent to publish literature given

On-going monitoring

On-going management
observations. They focused on the trepang survey and the collaborative process itself. The stages of planning the research, gathering the data, interpreting results and making recommendations guided by the ethnographic method are described below. The ecological survey is nested within the ethnographic process and given the nature of this paper is only briefly alluded to as background to the case study.

**Stage 1: Planning the research**

During recent years some non-indigenous researchers have realised that their work frequently supports the social order that marginalises indigenous people (Birckhead et al. 1996). More recently a politically informed research culture is aware of power inequities and the effects research may have on communities. In attempting to avoid the past mistakes of researchers, a community based approach was implemented from the outset of the planning phase of the trepang project (fig 17). Some of the principles necessary at this stage include:

1. **Familiarisation with appropriate protocols for conducting the research**

An understanding of the protocols for working within an Aboriginal community must be understood and adhered to. Such protocols exist in printed form and are readily available from Aboriginal organisations, educational institutions and land councils. Land Councils, as statutory representative bodies of traditional owners, will be essential mediators during this phase if a researcher has little or no knowledge of appropriate protocols, or is unsure and needs general issues clarified. In Australia, the few ecological research programs which have involved indigenous people during their entire life have identified the important processes used to achieve desired outcomes for both parties (see Reid et al. 1992a, Baker & Mutitjulu 1992, Walsh 1995, Roberts et al. 1996). Important factors include recognition of intellectual property rights and maximising employment of Aboriginal people, who frequently have a desire for employment near families and country.
2. Approach to the community

Once an appropriate grasp of relevant issues has been achieved, the next step is an approach to the community itself. Walsh (1995) suggests a starting point for developing an appropriate network mechanism is simply to find out whether Aboriginal people are involved or whether they want to be involved in a collaborative project. In undertaking this step, demonstrating and acknowledging the issues of importance to a collaborative work ethic derived from the literature is of paramount importance, because the approach sets the foundation for the working relationship. Appropriate implementation of the process is argued to be more important than the project itself because without the appropriate framework in place the research may not be viable at all (Birckhead et al. 1996, Dale 1996).

3. Work toward community aspirations

Once an agreement for collaborative research has been established with a community, and assuming the community has not already identified a specific need that can be met by research, the question of what to research is the next logical step. In the past researchers have had their own agendas, but contemporary research is conducted in collaboration with communities or to research agendas set by them. Walsh (1995) stresses the need for flexibility and development of plans in conjunction with local people, as their needs require. Starting with the community informing the researcher of community aspirations and needs reduces the tendency of outside agents either to drive change or to misunderstand community perceptions. Research that begins in this way is more likely to succeed because of community ownership, interest, establishment of priorities and control of the project (Alpert 1995, Dale 1996).

4. Conduct negotiations

Dale (1996) suggests that the failure of many projects involving Aboriginal communities is related either to the negotiation process or technical factors. Negotiation with Aboriginal communities and following protocols may be a complex process and may be constrained by social, cultural, historical or political considerations, with the possibility of misunderstandings. However, negotiation should basically require finding and conferring with the appropriate people to obtain
their opinion or advice and should analyse benefits and losses to check that circumstances are equitable (Walsh 1995, Birchkead et al. 1996).

5. Establish relationships

Establishing relationships may require the greatest effort on the part of the researcher. These processes involve personal commitment and regular contact at a number of levels over an extended period of time. Researchers should not be hurried or working to a deadline with little knowledge of the community (Walsh 1995, Birckhead et al. 1996). Knowing someone personally, sharing experiences and engaging in relaxed times are important ground-working techniques. Frequently conveying information requires time for people to be listened to so that misunderstandings do not occur or incomplete information is not given. The ability to listen is important.

Stage 2: Gathering the data

Fig 18 outlines some principles for gathering data during the research project:

1. Incorporation of cultural considerations

To ensure respect for cultural considerations and recognition of differences, flexibility in technique and schedule will be paramount. In many ways the schedule will be imposed upon the researcher, who will frequently be working with an already overburdened community and will be told when and where events important within the community are occurring. Local people will frequently have a variety of roles within the community with other roles being just as important as that of being involved in the research. The qualities that ensure success in networking with Aboriginal communities are open communication, respect, a willingness to change or abandon previously held views and an ability to engage in two-way interactions (Walsh 1995).
2. **Engage local people in the work itself**

Walsh (1995) advocates sharing control in the collaborative process by using skills analysed and discussed by social scientists such as the analysis of power relations. Engaging local people in the data-gathering itself is one way of sharing control. There can be no substitute for sitting down on a day-by-day basis to discuss what is available in the community for that day (cars, boats). In this context, concepts and information not otherwise available to or understood by the researcher are relayed. Establishing equity in the working relationship requires that local participants are employed.

Engaging local people also results in a two-way information flow. For example, Anangu Pitjantjatjara Land Management in Central Australia advocates applied demonstration and work by the researcher to convey scientific skills, while the researcher can frequently benefit enormously by going to an area with the relevant traditional owner and allowing time for them to demonstrate their knowledge in their way. Young people will eventually manage resources at a later stage so particular attention to training young people provides future direction as well as retaining traditional knowledge (Johannes 1989).

3. **Ask appropriate people about their knowledge**

Traditional knowledge does not mean static knowledge, but knowledge which is made traditional because of its firm roots in indigenous culture and local ecology. Continuity of information is important, but so are flexibility and the dynamics of communication. Traditional knowledge tends to be unwritten, based on what has been learnt from elders and what each generation can add to this. Obviously school-based education contributes to change, but new knowledge tends to be incorporated into existing frameworks. Knowledge comes from observation and experience.

Research projects that record and rigorously test traditional ecological knowledge are very limited throughout the world (Johannes 1989). More than that, such knowledge is in danger of being lost as young people leave communities, a factor that generates urgency in collecting traditional ecological knowledge (Burbidge *et al.* 1988). Alpert (1995) suggests that the difficulties of investigating and evaluating
traditional ecological knowledge should not be underestimated, because like any complicated laboratory time-intensive task, collecting the knowledge and talking to people must be valued for the amount of labour put into recording the information.

4. Delegate responsibilities to key persons

Aboriginal people have been used in past ecological research for various tasks such as to collect and identify zoological specimens, to provide knowledge about extinct or declining species or traditional fire use, to gain an idea of the similarities between traditional and scientific knowledge, to evaluate traditional resource management, practices and concepts, and to analyse impacts of subsistence strategies (see Walsh 1990). However, more recently they have been acknowledged as invaluable contributors to ecological survey work in their own right because of their knowledge of the local resource base through both practical and religious affiliations (Burbidge et al. 1988, Walsh 1990, Reid et al. 1992a, 1992b). Based on past experiences the community may have had with research projects, or indeed, to ensure continued interest by the community in a new research proposal, responsibilities for some aspects should clearly be delegated. Delegating responsibilities to key persons shifts the power base. Even the suggestion of delegation implies hierarchy in directing the project, so the outside researcher should take a backseat in the delegating process.

5. Continued liaison with key persons as much as possible

There is always potential for the researcher to encounter unforeseen obstacles along the way. The relationships established early in the collaborative process provide some key people with whom information and behaviours can be checked along the way. It is useful at every stage or change in circumstances to ask these key persons for advice and direction and to sound out a response or action if appropriate. In that way there will be less danger of culturally inappropriate actions and the community remains in control of the process. Continued liaison with these key persons continues to build trust between the interacting parties.
Stage 3: Interpreting the data

Fig 19 outlines some general principles at the interpretation stage:

1. Ask for their interpretations

More complete and effective information is generated by gathering information from all sources. Frequently people volunteer their interpretations during the data gathering stage. It is also important to provide feedback to the community on the results generated from the research. Additional interpretations may come to light when survey results are shared with the appropriate people.

2. Explain your own interpretations

Explaining the researcher’s interpretations should occur after gathering interpretations from key persons. Placing interpretations after those of other community member will ensure that the “scientist’s” interpretations are not first suggested and then accepted as the answer. In other words, a truer response will be elicited by not prompting other words or ideas first.

3. Synthesise results

After the collaborative canvassing of interpretations, results can be synthesised. This may involve comparing similarities in interpretation and contrasting differences. It will then be useful to go back to key persons and inform them of similarities and differences in interpretation so that both parties can re-think results and provide a more complete interpretation.

Stage 4: Making recommendations

Fig 20 outlines some general principles at the final stage of the project life:

1. Incorporate ideas from all sources

After interpretation of results, recommendations and management strategies should also be collaboratively canvassed. Aboriginal management of natural resources differs from western systems in that it has been embodied in complex social and
cultural norms and religious beliefs as a way of ensuring long term sustainability (Ross et al. 1994). Such management may or may not have been consciously planned or intended as a management regime (White et al. 1994a). However, as in any other society, actions are embodied in customs and beliefs, and actions may include attempts to ensure long term sustainability such as through declaration of sacred sites, food taboos or prohibitions against hunting on a dead person’s country, all of which are examples of cultural restrictions on resources in a region. (Conversely however, Dreaming stories are frequently not passed on as a species vanishes.) For this reason, it is logical to canvass ideas from both the Aboriginal and “western” collaborators because such a combination leads to better management of the resource than would otherwise be available (Pinkerton 1989).

2. Community checks publishable material

The community’s involvement in the process as providers of information and as data collectors and interpreters of the results suggests they have the right to be co-authors on any publication. As with any scientific publication, co-authors check and verify written material for accuracy before it is published. Sometimes agreements concerning intellectual property rights may prevent publication of sensitive or confidential material. Likewise, communities may wish to formalise agreements about manuscripts being checked prior to publication. By having the community’s input, the written work itself is collaborative and is truly a product of the collaborative process.

3. Ensure on-going monitoring

Monitoring is particularly important so that predictions can incorporate unforeseen problems and minimise adverse impacts (refer section 4.1). In order to successfully achieve sustainable use of natural resources which may provide a livelihood for users, both the research process and on-the-ground results must be monitored and evaluated (White et al. 1994b).

The potential advantage of people who have already been involved on the project will be of vital importance to the on-going ecological monitoring of the resource by the community. The actual ecological results require monitoring; however, socio-
economic indicators should also be included as measures of success. For example, changes in socio-economic status, livelihood patterns, and legal and institutional instruments for management are indicators of the impact of a project. The project itself can be evaluated through community meetings, and adjustments to the process implemented (Buhat 1994). The levels of community participation in planning, implementation and monitoring effort, the degree of community awareness and empowerment, the sophistication of community organisations, and the smoothness of collaboration with government and outside organizations are also potential indicators of effectiveness. Evaluating and monitoring of the project can be achieved by periodic visits by persons with requisite expertise and experience.

4. Ensure on-going management

Differences in perceptions about management strategies drawn from differing knowledge systems may arise; these differences are culturally-based and can cause conflict between the management strategies imposed by governments and those used by Aboriginal people (Nugent 1988). Local management often occurs where alternative livelihoods not based on western knowledge systems occur, for example, those based on ecotourism and sustainable subsistence fisheries. Customary marine tenure is the basis of a form of adaptive and locally appropriate fishery management strategies which have the potential to monitor stocks, provide surveillance, regulation of effort, community education, and resolution of conflict e.g. commercial fishing (White et al. 1994b, Hviding 1996, Peterson & Rigsby 1998). These strategies are enforced by community rangers or local authorities. The government role in these programs is usually limited to local support. Small, self-contained areas provide prime examples of where success with locally appropriate strategies has occurred in the past.
3.3 Supporting Information and Equipment Requirements

The model described above was used in Arnhem Land to conduct a trepang survey. The aim of the research was to determine sustainable use levels of trepang, and a major objective was to determine the distribution and abundance of trepang stocks.

In acquiring these data the environment in which northern Australian Aboriginal communities exist poses particular problems. Communities are mostly remote, sprinkled across vast and inaccessible areas. Equipment needs to be maintained and operated within these remote communities and this in itself presents many difficulties and frustrations. Care must be taken when selecting equipment and the research techniques because of the problems which may arise when equipment fails, or when users have little experience with its operation, or when community resources such as boats are shared and may not always be available. Dale (1996) suggests that technical factors can inhibit project success, so that new techniques may need to be devised for old problems and for adaptations to particular environments.

The process of trepang data collection during the field survey was the phase of most interactive research collaborative activity. Other parts of the trepang research did not involve two-way interaction. These activities included data analyses conducted in the laboratory at university. Although the community was aware that some analyses were being conducted solely by the researcher, this did not prevent the larger picture of the trepang project being considered as collaborative as opposed to other forms of participation such as consultation or contractual research. A collaborative process of greater integrity, meaning a research project where the principles of collaboration were applied in the interactive manner described above during the entire life of the research project, would have involved local people at all of these stages, but time and resource constraints resulted in limiting collaborative activity at some stages. Since part of the research project necessitated obtaining data to satisfy the objectives of a funding agency the strict principle of collaboration was not adhered to in some instances.
The case study below outlines how the principles were used when conducting the trepang survey. Examples of some data collection activities are also given (situations, observations, conversations). It should be noted that the planning phase of the research constituted a larger proportion of the total project time than was expected.

### 3.4 APPLICATION OF TECHNIQUE: CASE STUDY

A complete presentation of the application of the principles described above in this case study is not given here; detailed analysis of the process is the subject of a forthcoming publication. However, the following section provides examples of representative activities that occurred during the four stages of the collaborative trepang research as outlined in the model above.

In following the principles outlined above, the process was characterised by flexibility, testing initiative in unexpected circumstances and refining procedures where necessary. It is suggested that this will be the case in all situations where protocols for collaborative research have not been developed in detail before commencement of the research project. This is because the general principles offer a guide, but some aspects/stages may not be appropriate or may need to be added for the particular community and its circumstances. Thus principles may be redefined to apply to specific situations.

The case study is presented in the first person (Jenny Carter). Carter recorded the field data, and it is important to include the role of the recorder in describing the research. It is essential to understand how that role contributes to the conduct and outcome of the research.
Stage 1: Planning the research

Planning the research involved reading international and national literature relating to aspirations of indigenous people and community-based planning as well as the biological literature about trepang. Advice from government agencies, land councils and other personnel experienced in cross-cultural activities was also sought at this stage.

The Bawinanga Aboriginal Corporation (BAC) was approached by way of a letter that introduced myself as researcher and my qualifications. The letter requested information on two points: whether community members were interested in collaborative research, and if so, the nature of community research priorities. Asking for direction on the research topic itself was thought to be the an appropriate way of initiating indigenous involvement in planning the research. In this introductory letter I also set out a number of points I thought were pertinent to the nature of collaborative research, for example, ensuring that intellectual property created from indigenous knowledge would be jointly authored, that community agreement would be sought before publication, and that employment for Aboriginal people as assistants on the project would be sought.

After BAC told me that trepang was their priority research area, a number of meetings were held to establish relationships and goals. For example, one goal of the community was that formal training for assistants be incorporated into the research program so that assistants would gain recognised qualifications.

Establishing relationships was also a part of the planning stage. Formal relationships were established because I became involved in additional activities requested by the community, such as providing input and advice at a meeting to establish a regional fisheries committee. Informal relationships were built on an individual basis through the people contacted on a day-to-day basis and with people who assisted in the research itself.
Stage 2: Gathering the data

When conducting the research on-site, cultural considerations had high priority. For example, I called on traditional owners and explained the research, then requested access to their area. On many occasions the community made cultural considerations their first priority. On some occasions I discovered that events such as clan meetings or ceremonial activities were occurring in the community which required altering the schedule accordingly.

Local people were employed as assistants during the data-gathering phase of the project and were able to offer invaluable information such as detecting slide marks of trepang, showing localities of trepang or providing explanations for trepang absence. I always verified trepang counts in this instance so that there was no error introduced by additional observers.

I sought to record traditional ecological knowledge about trepang by formally interviewing people identified by community members as appropriate. Questions used and responses recorded are presented in Appendix E. The training component was taken over by another community member, which freed me to plan activities, arrange for people to accompany me (which became necessary) and to gather data. When changes to the project seemed to be required I checked on the appropriateness of my suggestions in an attempt to continue working in a manner the community considered desirable.

Stage 3. Interpreting the data

At the time of writing this paper, the next two stages were yet to be formally conducted. However, people had already tended to offer explanations and interpretations while conducting the trepang survey or during conversations in the community. There was an opportunistic element to gathering these data because I realised that it might not be possible to locate people at a later stage for a formal interview. For example, on one occasion I explained to an old man that I had carried out his instructions of the day before but still found no trepang at the place he had told me to survey, and asked him why he thought there might be none there. I then
recorded his response. Likewise, when checking the appropriateness of changes to the research schedule I sometimes offered my own interpretations on alternative ways in which to carry out the research, and answers were provided which I recorded.

A formal presentation of results within the community is still to occur and it is envisaged that similarities and differences between the model and the actual process will be identified during this phase.

Stage 4. Recommendations from the research

This stage has yet to be formally conducted; however, some recommendations were made during previously completed stages. For example, when recording traditional ecological knowledge data, one man provided his own management strategies: he said he would like to show people how to boil and cook trepang properly, and use a special mangrove wood to smoke the flesh so that there was no waste. (Waste occurred in the 1970s when the community had attempted to establish a trepang enterprise but the product was rejected because of its low quality.)

Some of the literature generated from the trepang research has been collaborative. Key individuals have provided written input or said they would convey further views for incorporation into joint publications.

Involving local people on the survey itself and as much as possible with all other aspects of the research was an attempt to work collaboratively. It also established a basis on which the community may be able to monitor (in the western scientific sense) the resource in the future. Local people may visit areas and either apply the same techniques or report observable changes in the resource base to the community. Continued monitoring of the resource creates opportunity for the community to adjust harvest levels, should they notice local declines from harvesting or from natural perturbations.
3.5 CASE STUDY CONCLUSIONS

The case study outlined above demonstrates use of the principles which were developed for the collaborative study of trepang. The Commonwealth Ecologically Sustainable Development Working Group on Fisheries noted that government agencies should:

find ways to engage indigenous communities in all aspects and levels of management ... an appropriate framework must be found to work within the customary tenure systems which extends over the land-sea interface, and coastal waters by the indigenous groups in much of Australia (Commonwealth of Australia, 1991).

This case study suggests that not only should appropriate frameworks be constructed for working with indigenous people in resource management, but that collaboration in all phases of the resource research is also important.

3.6 RELEVANCE OF METHODOLOGY

The method described above demonstrates cutting-edge techniques for expanding environmental science to more fully embrace all related issues. While there is a wealth of literature dealing with community-based planning and participatory methods, there is very little literature dealing with the application of collaborative concepts to ecologically-based research projects. Furthermore, at the time of developing the project there was no literature which analysed the results of applying collaborative concepts to such research projects.

Alpert (1995) points out a lack of papers describing ICDPs in the ecological literature and suggests that the limited information within the ecological community
contributes to the difficulty of implementing such programs. He suggests that ecologists must assume some responsibility for ensuring success of projects which integrate conservation and development by reducing their concern for complete experimental design and concentrating on studies which are multi-disciplinary, occur at a single locality, and link ecology with the social sciences. White et al. (1994c) suggest that data collection may take only a few months whereas true integration and project presence in the community may take much longer. Pinkerton (1989) stresses the effectiveness of a multi-disciplinary approach and Johannes (1989:6) reiterates that view:

for a small but growing number of environmental researchers, scientific interviews and participant observation - activities more often associated with social scientists - have become research tools.

Quite clearly some of the principles of collaboration were sacrificed in order to meet funding agency objectives including timelines. This is because institutional building is often cited as of prime importance in international literature (e.g. Schramm & Hubert 1996, Claridge & Claridge 1997, Razaak 1998). The tradeoff necessary between obtaining biophysical data and following an appropriate participatory process also makes the reconciliation of principle and practice difficult. Dale (1996) mentions this issue in his discussion about the reasons for wildlife project failure in the past. There is other literature which also suggests that process should be as important, if not more important, than the ecological work (e.g. Alpert 1995, Walsh 1995, Dale 1996) because without this integral component of the work, the research may not succeed at all.

Walsh (1995) predicts that in Australia the issues relating to the use and management of Aboriginal land and seas will emerge because of the amount of country owned by Aboriginal people, the need for sustainability of resources and the equity of recognising Aboriginal interests in natural resources. She also suggests that positive collaborative links are required to ensure success and that there should be:
a balance between process and outcome, achievable by greater emphasis on
doing things appropriately and reduced emphasis on getting results. (Walsh

This view is supported by White et al. (1994b) in their review of approximately
thirty case studies of collaborative and community-based coastal resource
management.

The principles which guided success during this research have linked ecology and
the social sciences as suggested. However, they are merely a starting point and the
methodology will need to be refined in the future through the work of other
researchers doing work in the same vein at differing (or the same) localities.

3.7 HUMAN ACTIVITIES

Development is a goal as well as a process (White et al. 1994a). It seeks to achieve
economic equity, social justice, cultural integrity and ecological sustainability. Any
degradation of the natural environment has repercussions on related components.
For environmental scientists and managers, it may be necessary to make a greater
attempt to incorporate human activities into decision-making about research on
fauna and flora because of the interdependence of each component.

Many Aboriginal people are linked for the entirety of their lives to specific areas by
custodial responsibilities to Dreaming places and totems and by their personal life
history. Official recognition of traditional responsibilities is necessary so that
people can use and benefit from a resource according to their laws and to
accomplish self determination. It is also recognised by western science that both
traditional and western styles of resource management must be linked to other
contexts while respecting traditional perceptions and control of the resources as well
as modern development issues. By appropriately incorporating study of human
related activities into environmental science, another dimension is added to the study
which enhances the research.
3.8 MANAGING ENVIRONMENTAL CHANGE

Environmental change may refer to the human component of the system studied. Certainly when attempting to link cultural, social, environmental and economic issues for decision-making and management there is a need to clearly understand human activities that change the system as a whole. If researchers are serious about maintaining cultural sustainability as well as environmental sustainability it may be necessary for scientists to change within the environmental system. In other words, if concerns for cultural sustainability are to include incorporating the concerns and aspirations of indigenous people it will require a shift in research thinking so that research programs are designed to this end.

There are a number of international cases where indigenous communities have been involved in collaborative management of natural resources (in White et al. 1994b). Community initiatives are usually implemented to manage and monitor trends in natural resources. However, the involvement of community members in the research itself is far less frequent. Buhat (1994) describes socioeconomic, demographic and traditional resource-use data gathered from local fishers for a fish yield study. She also describes the process used to assess community needs, train local people and share results. White et al. (1994b) summarise a number of community-based projects and their reviews into a framework for collaborative management.

The model presented above expands those stages and analyse stages in more detail. With government agencies and funding bodies placing pressures on researchers to achieve objectives, keeping the objectives modest is deemed to be appropriate because if objectives need to be re-worked for the particular situation then the research program can presumably continue (White et al. 1994b). Collaboration has been brought about by setting modest objectives which were able to be re-worked. The challenges are to continue to create new approaches for determining environmental change to the system as a whole.
SECTION 4: HARVEST MODELLING AND MANAGEMENT CONSIDERATIONS

Objective 4: Employ available log-book data from commercial harvesters to draw inferences regarding harvest dynamics.

Objective 5: Provide recommendations on further research and/or activities required as a basis for a management strategy for sustainable harvest of trepang.

4.1 INTRODUCTION

In the past, fisheries management decisions were based on predictions from static, single quantity calculations such as maximum sustainable yield (MSY). In a developing fishery effort was monitored as it increased, yields were also monitored, and a yield-effort relationship curve plotted. The point at which yields decreased (the curve dropped) was considered the point of maximum sustainable yield.

The problem with using this approach is that the potential yield cannot be predicted at the early stages of the fishery development, which means that the stock must firstly be overexploited before MSY can be determined. If the data are noisy the curve must be plotted well beyond the point of optimal effort before the point of MSY can be recognised. Furthermore, once the yield-effort relationship curve has gone beyond this point of optimal yield the effort in the fishery must be reduced to return to the optimal level. Reducing effort is very difficult in practice to implement because licenses must be terminated or catches reduced over all licenses.

These methods are no longer considered appropriate because fisheries systems are dynamic in nature (Hilborn & Walters 1992). Past management decisions did not consider the variable nature of fishery stocks, in particular, their abundance in years (or other time-series data) where adverse conditions cause a lower than expected abundance. Current fisheries management models are designed to respond to the inherent natural variability faced by the fishery as a system and to predict stock
response in the face of uncertainty. Alternative options for managing this uncertainty are then considered when developing management strategies.

Formal stock assessment is the use of statistical and mathematical calculations to quantitatively predict the response of fish populations to alternative management choices. For each option, possible outcomes and their probabilities are assessed and the optimal outcome is then incorporated into management strategies. In a developing fishery an important role of stock assessment is to firstly define requirements for a monitoring program. Other stock assessment methods are used at a later stage to make more precise measurements and to fine tune existing management arrangements.

**Biomass dynamics modelling**

Biomass dynamics (or surplus production) models are a stock assessment method for analysing population dynamics of a fishery. Although this method is the simplest fisheries assessment tool, it is an important and frequently-used method.

The characteristic of biomass dynamics models is that the stock dynamics are described in terms of biomass, rather than by the numbers of individuals of various age classes, and biomass is used as an indicator of population size. Data from the fishery describe the changes in the exploitable biomass and thus the dynamic behaviour of the exploited population (QTUF, nd). Such models are advantageous when sufficient baseline data on growth, recruitment and differential vulnerability to fishing gear, necessary in age-structured and size-structured models, are not available. Furthermore, in tropical fisheries individuals are frequently difficult to age and past research has shown that biomass dynamics models provide the same answers as age-structured models (Hilborn & Walters 1992).

Biomass dynamics models are a variation on the logistic model, but are extended to include catch rate. Increases in a population result from recruitment of new individuals (birth) and gain in weight of present individuals. Decreases in the population result from the catch taken and natural mortality.
Surplus production can therefore be considered to be reproduction + growth - mortality - catch (ignoring immigration and emigration, an assumption on which the model is based). However, surplus production of a population can also be considered as the catch taken plus the net change in biomass over a finite time period, or alternatively, the net change in biomass (new biomass - old biomass) is equal to surplus production - catch taken. Changes in biomass between years can therefore be written as:

\[ \text{Next biomass} = \text{last biomass} + \text{recruitment} + \text{growth} - \text{natural mortality} - \text{catch}. \]

In the absence of fishing and combining recruitment and growth into a single term changes in the population can be described as:

\[ \text{Next biomass} = \text{last biomass} + \text{production} - \text{natural mortality}. \]

Surplus production represents the difference between production (i.e. natural production) and natural mortality and is the amount the population will increase in the absence of fishing mortality. Surplus production is also the amount of catch that can be taken to maintain a constant biomass.

The equation can then be written as:

\[ \text{New biomass} = \text{old biomass} + \text{surplus production} - \text{catch} \]

Or:

\[ \text{Surplus production} = \text{new biomass} - \text{old biomass} + \text{catch}. \]

**Theoretical models**
The model estimates sustainable harvest and effort required and takes into account the overall effect of recruitment, growth and mortality. If an index of abundance is used then using the equation is more complex and the relationship between stock
biomass and surplus production must be indicated and a parameter which relates the index to actual abundance must be specified.

There are three approaches for estimating parameters for the equation from real data: the Schaeffer model, the Pella and Tomlinson model and Difference models. According to the Schaeffer model, described by Schaeffer (1954 in Hilborn & Walters 1992) the relationship between surplus production and stock biomass is a symmetric curve. Surplus production (or stock size) is low when biomass is low (= zero) because there are few individuals to grow and reproduce. Surplus production/stock size is also low at high biomass (= k or carrying capacity) because individuals have slower growth, higher mortality rates, and there are limitations on recruitment. Surplus production is maximised at a biomass of $k/2$.

Pella and Tomlinson (1969 in Hilborn & Walters 1992) extended this model to allow the shape of the curve to be skewed to the left or right which allows for surplus production to be asymmetric with stock size. However, in practice it is difficult to estimate the asymmetry of the relationship from most data sets.

Difference models proposed by Walters & Hilborn (1976) in Hilborn & Walters (1992) used a difference equation of the Schaeffer model:

$$B_{t+1} = B_t + rB_t(1 - B_t/k) - C_t$$

where  $B_t$ = biomass of the stock at time $t$

$r$ is an intrinsic rate of population growth

$k$ is a parameter which corresponds to the unfished equilibrium stock size

$C_t$ is the catch during time $t$ and is defined as:  $C_t = qB_tE_t$

where $q$ is a parameter that describes the effectiveness of each unit of fishing effort (the proportion of the stock taken by one unit of effort).

and $E_t$ is fishing effort over year $t$. 
The properties of this model are similar to that of the Schaeffer model, however, if \( qE \) is greater than 1 then predicted catch can exceed the population. Furthermore "chaotic" behaviour will occur for high \( r \) values. The assumption of the model is that the catch rate is proportional to stock size and to fishing effort.

**Estimation procedures**

Estimating parameters for use in the biomass dynamics models is more complex than the theory of the models. Parameter estimation (using an index of abundance rather than a direct measure) can be based on three approaches: assumption of equilibrium conditions, transformation of equations into linear form and Observation Error/Time-series fitting.

The recommended approach is the Observation Error/Time-series fitting methods (Hilborn & Walters 1992) as it most closely reflects reality. The approach was first proposed and used by Pella & Tomlinson (1969 in Hilborn & Walters 1992). An initial estimate of the stock size at the beginning of the time series (\( B_0 \)) must be taken and the model is then used to predict the remaining biomass values for the time-series. Values of the additional parameters (\( r, k \) and \( q \)) are adjusted to provide the best fit of the predicted-to-observed time-series of relative abundance (catch data).

Usually parameters are confounded by the model and estimating the starting biomass adds to the confounding effect. For this reason we may assume that \( B_1 = C_1/(E_1q) \). For situations where data are available from the start of the fishery it may be reasonable to assume that \( B_0 = k \), which eliminates \( B_0 \) from the estimation. There are no rules for dealing with \( B_0 \). A wide range of time-series fitting options, using both the observed and simulated data and different values of the parameters should be tried (Hilborn & Walters 1992).

Nonlinear parameter estimation techniques are necessary to find the best fit of the predicted biomass time-series to the observed biomass time-series, given the observed catches. The usual fitting criterion is to minimise the squared deviations between the observed and predicted CPUE, although an alternative approach is to maximise the likelihood of the logarithm of squared residuals.
**Harvest strategy**

A harvest strategy is an annually adjusted plan detailing how stock will be harvested. Strategies may be based on harvesting a constant rate of the population (constant-exploitation-rate strategy); harvesting for a fixed escapement goal so that a constant number of individuals reach spawning (constant-size-strategy) or harvesting a fixed quota (constant-catch-strategy). In a developing fishery the strategy may need updating every year (Hilborn & Walters 1992). Once a harvest strategy has been decided, harvest tactics, or regulations, are used to enforce the strategy. Common tactics include annual catch quotas, effort limits, season lengths, gear restrictions and limitations or size limits.

Strategies which depend on stock size involve annually setting the target catch to be some linear function of population size. However, such strategies require knowledge of the population size. The harvest strategy can be graphically viewed and compared with other harvest strategies by recognising that the strategy is a linear function of stock size:

\[
\text{catch} = \text{intercept} + \text{slope} \times \text{stock size} \quad \text{(Hilborn & Walters 1992)}.
\]

Constant-stock-size strategies will be manifest as a straight line with a slope of 1 and an intercept of the negative desired escapement. Constant stock size strategies are rarely appropriate because they require objective estimates, perfect knowledge of stock size, and because variability is as important as catch to indicate sustainability (Hilborn & Walters 1992). Constant-exploitation-rate strategies have an intercept of zero and a slope equal to the exploitation rate. Constant catch strategies have a slope of zero and an intercept equal to the catch.

Alternative harvest strategies which do not depend on stock size include periodic harvest sex-specific harvesting or size limit harvesting, and those based on economic considerations. Pulse fishing (periodic heavy exploitation of stock) is optimal when economies of scale exist (i.e. it is more economic to take a large catch every few years rather than a small catch every year) or when the economic value of older individuals is greater than that of younger individuals. This strategy may be
implemented by rotation of effort so that different areas are visited periodically. However, the annual variance of the harvest is increased by spatial differences in the region.

Size limit strategies are set on the basis that individuals are harvested at a size which is greater than the age at which females (usually 50% of the population) first commence reproduction.

**Harvest tactics**

Tactics for implementing these strategies are more likely to be based on pragmatic considerations. For example, although the optimal strategy may theoretically be to maintain a fixed spawning stock a seasonal or annual monitoring program to achieve this target may prohibit such a strategy being implemented and in the end an alternative strategy may be chosen based on easily implemented harvesting tactics. Common tactics include season lengths, gear restrictions and limitations, effort limits, annual catch quotas and size limits.

Seasonal limits are best employed when fixed escapement is the desired harvest strategy. Fixed season lengths have the advantage that fishers may be drawn to alternative fisheries or other activities during periods when stock abundance is low (or price poor) which keeps fishing mortality low. When stocks are high (or price high) then increased harvesting effort occurs and the exploitation rate is higher. Fixed season lengths generally show a desirable relationship between realised exploitation rate and stock size. They are also the easiest tactic to implement because there is no need to monitor the number of vessels operating, nor to sample the amount of catch onboard, total number of landings and average catch per landing. However, in the past, season limits have generally not been effective because fishers tend to increase effort during the open season and annual catch in reality is not reduced (Hilborn & Walters 1992).

Limits on effort are best employed when the desired harvest strategy is a fixed harvest rate (Hilborn & Walters 1992). These tactics are generally easy to implement as there is no need to sample the catch per landing, although monitoring of fishing effort (boats at sea, boats landed etc) is required.
Annual catch quotas are the best tactic when a fixed quota is the desired harvest strategy (Hilborn & Walters 1992) because in principle there is a ceiling on total catch taken. Total allowable catch (TAC) is frequently used and is simply the desired exploitation rate multiplied by stock size. If the strategy is to maintain a constant exploitation rate then the TAC is a constant fraction of the stock size, which is assessed annually, so that TAC then needs to be adjusted annually. Monitoring and enforcement may vary annually as well.

4.2 METHODS

With the assistance of the NT Department of Primary Industry and Fisheries, permission was obtained from individual commercial trepang licensees to model logbook data. For confidentiality reasons, the data are pooled in the analyses and no specific reference to any data which could be categorised by licensee is given.

Log book data were obtained for 1462 records coded as Echinoderms, presumably Sandfish as the fishery is based predominately on this species (NTDPIF, 1994). Data were standardised so that records which were entered as the number of Sandfish caught (rather than kg taken) were multiplied by a conversion factor of 0.36 (the standard number to gutted weight conversion factor used by NTDPIF for sandfish, supplied with the logbook data) to present all data in kg. Records which were entered as the whole weight rather than the gutted weight were converted to gutted weight by multiplying by a conversion factor of 31% (the standard whole weight to gutted weight conversion factor used by NTDPIF for sandfish, supplied with the logbook data) of the whole weight. Final catch analyses were therefore performed on the gutted weight of Sandfish caught. All catch data were summed for each year, giving a time-series of catch data for the years 1991 - 1998.

Effort was initially derived from the number of days fished per month by each licensee and summed for each year of the time-series 1991-1998. The observed CPUE was calculated for these years (catch/effort).
Data were inspected in three areas which showed some degree of continued effort for a period of at least three years. However, effort was not consistent in any of the areas and a time-series could not be reliably constructed. Quite clearly spatial dynamics of the fishery and the harvest is a major problem in a simple production model assessment. Additional analyses of the available fishery data would have been highly desirable. These would have included information summarized over different time and spatial scales.

The data was inspected at finer spatial and temporal scales, but either did not show a sufficient time-series length or did not show consistent effort over time. No area in the entire fishery (examined by grid cell) contained sufficient data to generate a time series for finer spatial and temporal scale modelling. For this reason, the role of these dynamics in a future harvest strategy cannot be assumed when it is not known. Because of the limited number of records for specific study areas it was elected to analyse records for the region as a whole.

Along with the observed data, a range of initial biomass estimates (greater than the catch data for each year) and of other parameter values \((r, k, q)\) were input to a spreadsheet (Microsoft Excel). The equation representing the model was entered to generate a simulated biomass for the time-series 1991-1998. Estimated (or predicted) CPUE for the time series based on the simulated biomass data multiplied by the catchability coefficient \(q\). Squared deviations between observed and predicted \((\text{obsCPUE}_t - \text{pCPUE}_t)\) were also calculated.

Parameters \(r, k, q\) and \(B_0\) were initially input after a visual inspection of the data, but after each iteration were estimated and refined by the model. The model was run to simulate changes in the exploitable biomass for each trial parameter value, using the Microsoft Excel Solver function with 100 iterations, assuming a Gaussian probability distribution. Simulated data for each trial parameter value were fit to the observed data by maximising the log likelihood for each pair of observations (squared deviation of \(\text{obsCPUE}_t - \text{pCPUE}_t\)). The best fit produced from the approach was retained.
After the MSY was generated for each parameter value best fit scenario, the predicted CPUE was extended to predict the fishery response to the year 2013, based on a value slightly lower than MSY. The model was re-run with those parameter values which best fit the data and the predicted CPUE's until the year 2013 obtained. Estimated CPUE was plotted against observed CPUE.

Quantities of interest to fishery managers (identical to Schaeffer model), were then generated using:

- Maximum surplus production (also MSY) \( rk/4 \)
- Stock size for MSY \( k/2 \)
- Rate of exploitation at MSY \( r/2 \)
- Effort required to achieve MSY \( r/2q \)
- Maximum rate of exploitation \( r \)
- Effort at maximum rate of exploitation \( r/q \)

and based on the parameter values which best fit the predicted fishery response to the observed data.

Using the density estimates from field survey and the GIS developed (section 1), sites showing various trepang densities within the two study areas were displayed which give an indication of the current resource level.

### 4.3 RESULTS

Table 11 shows the observed catch and effort data used to fit the biomass dynamics model.

Annual catch data for the pooled fishery ranged between 3.7 t (at the start of the fishery in 1991) to a peak of 87.3 t (in 1994) after which catch declined. Annual effort ranged between 17 days fished (at the start of the fishery in 1991) to a maximum of 423 days fished in 1998 (which excluded Nov and Dec as there were no data available for these months at the time of analysis).
Table 11: Pooled data obtained from fisher's logbooks and observed CPUE.

<table>
<thead>
<tr>
<th>Year</th>
<th>Catch (kg)</th>
<th>Effort (d)</th>
<th>CPUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>3710.39</td>
<td>17</td>
<td>218.2582</td>
</tr>
<tr>
<td>1992</td>
<td>30993.06</td>
<td>150</td>
<td>206.6204</td>
</tr>
<tr>
<td>1993</td>
<td>18658.26</td>
<td>175</td>
<td>106.6186</td>
</tr>
<tr>
<td>1994</td>
<td>87346.31</td>
<td>199</td>
<td>438.9262</td>
</tr>
<tr>
<td>1995</td>
<td>41644.6</td>
<td>340</td>
<td>122.4841</td>
</tr>
<tr>
<td>1996</td>
<td>55428.72</td>
<td>278</td>
<td>199.3839</td>
</tr>
<tr>
<td>1997</td>
<td>56643.34</td>
<td>249</td>
<td>227.4833</td>
</tr>
<tr>
<td>1998</td>
<td>72298.38</td>
<td>423</td>
<td>170.9182</td>
</tr>
</tbody>
</table>

Parameter values which best fit the data, based on the estimation procedure used (maximum log likelihood) are:

\[
\begin{align*}
  r &= 2.766413 \\
  k &= 244657.5 \\
  B_0 &= 213636.4 \\
  q &= 0.001 \\
  \text{loglike} &= 23.98268 \\
  \text{SumSq} &= 35514.22
\end{align*}
\]

The best fit of the data to the biomass dynamics model occurred at \( r = 2.77 \) and \( k = 244656 \).

Table 12 presents predictions for a sustainable use strategy based on these parameter values which best fit the data for the two fitting procedures. However, the MSY figure is misleading and dangerous because substantially different values could generate the same likelihood with radically different management implications. There is considerable uncertainty about what annual harvest should be, the most important attribute of this analysis. The data were not sufficiently robust to apply 90% confidence intervals to obtain conservative and optimistic scenarios for parameter values so only the best fit scenario is presented.
Table 12: Predicted values for sustainable yield in the trepang fishery, based on observed data.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Formula</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum surplus production (also MSY)</td>
<td>$rk/4$</td>
<td>169205.9</td>
</tr>
<tr>
<td>Stock size for MSY</td>
<td>$k/2$</td>
<td>122328.8</td>
</tr>
<tr>
<td>Rate of exploitation at MSY</td>
<td>$r/2$</td>
<td>1.38</td>
</tr>
<tr>
<td>Effort required to achieve MSY</td>
<td>$r/2q$</td>
<td>1383.2</td>
</tr>
<tr>
<td>Maximum rate of exploitation</td>
<td>$r$</td>
<td>2.77</td>
</tr>
<tr>
<td>Effort at maximum rate of exploitation</td>
<td>$r/q$</td>
<td>2766.4</td>
</tr>
</tbody>
</table>

Fig 21 shows observed and predicted CPUE. Observed CPUE has fluctuated since 1991 with the peak returns per unit effort occurring in 1994. Estimated CPUE flattens out around a surplus production of 173.2 t per year.

It is not reliable to model data at a finer temporal scale because in the life cycle of trepang, recruitment occurs around 2.5 years of age and spawning is biannual. This means only a time-series based on yearly catch should be modelled to reliably account for natural variability on an annual basis. Preferably fisheries data should be monitored in more than 1 study area e.g. a control area where stocks have not been harvested and other areas harvested to varying intensities. However, to draw inferences about possible scenarios the biomass dynamics model was applied to one area, where there was some evidence of a useful time-series of data. This area was fished very lightly between 1991 and 1995. No fishing occurred for the year prior to March 1996, after which intensive fishing occurred. Estimated and predicted CPUE is shown in Fig 22. In this instance the sum of squares approach was used to fit the simulated data to the observed data.

Trepang densities from the 1997 field survey for the two study areas (Cobourg and Maningrida) are shown in Figs 23 and 24.
4.4 DISCUSSION

The results of the modelling exercise should only be used with extreme caution as input to management strategies. Given the relatively short time series and the fact that effort has shifted between areas good fits to the data could be obtained with a wide range of parameters. Although strategies are presented (below) based on the...
Fig 23: *Trepang density, Gurig study area.*

The map on this page has been deleted because it contains culturally or commercially confidential material.
Fig 24: Trepang density, Maningrida study area.

The map on this page has been deleted because it contains culturally or commercially confidential material.
results, the nature of the data and model assumptions show that the strategies should be kept in mind, however, other tactics (also below) are probably a more pragmatic solution until the model more closely matches the assumptions on which it is based, or further research allows for other models to be applied. The assumption of a closed population may or may not be appropriate. Even though trepang have been seen to move, there may be no nett migration to or from the population under consideration. The degree of migration and question of larvae need further research before their impacts can be determined.

**Harvest strategies**

Biomass dynamics modelling yielded parameter values of $r = 2.8$ and $k = 244658$; optimum escapement ($k/2$) of 122329; optimum exploitation rate ($r/2$) of 1.4; and deterministic sustainable yield ($rk/4$) is 169206. Combining these results with the fixed rule strategy gives alternative harvest strategies:

- **Constant-stock-size strategy:** $H_t = B_{t-1} - 122329$
- **Constant-exploitation-rate strategy:** $H_t = 1.4*B_{t-1}$
- **Constant catch strategy:** $H_t = B_{t-1}$.

These harvest strategies would be updated on a yearly basis as extra data refines the harvest rule. ($B_{t-1}$ is the previous year's biomass - see Appendix F and G.)

Fishery managers should be conservative when applying these results to manage the existing fishery because of the assumptions of the biomass dynamics model in this instance. CPUE is assumed to be proportional to abundance, however, in reality this assumption frequently does not hold (Hilborn & Walters 1992). Secondly, fishing methods were not standardised which introduces another source of error.

Finally the data which was input to the biomass dynamics model was pooled for the entire region of the Northern Territory fishery. Although the trepang fishery is a single-species fishery, pooling the data assumes that biomass is equally distributed across this region. Sandfish are notoriously variable in density and the survey conducted in this study confirms high variability of stocks in the Northern Territory (see sections 1.4 and 1.5). Species which aggregate are difficult to manage and
particularly vulnerable to collapse because the high densities which occur in some localities can mask a decrease in total stock abundance for the region. Surplus production (including the biological parameters of recruitment, growth and mortality) can also vary within a species and over a restricted geographic range.

Fishing effort, too, is usually nonrandom and nonrepresentative in time, space and the characteristics of the fish population which are harvested (Hilborn & Walters 1995, Lokani 1995). Little is known about how overfishing in one area may have effects on another sector. Under the single stock assumption, overfishing in one sector would lead to depletions of stock elsewhere (Ramm, 1995).

Both catch and CPUE in this exercise fluctuate over time while effort generally increases. It is difficult to tell the exact relationship between catch and effort without a longer time-series because at the start of a fishery CPUE will usually increase as did the first few data points in this instance. Any number of scenarios could be fit to this data with similar outcomes so that results are not robust and there are a large number of possibilities for what has been observed. The exploitation history of the stock is still too short to precisely determine what is happening with CPUE for the fishery.

A far more accurate result would be obtained by analysing data at a finer spatial scale, although the time-series available and data, given the developing nature of the fishery, suggests that again that results are only preliminary. Data from one grid cell (area dimensions of 1 degree latitude by 1 degree longitude) was input to the biomass dynamics model, with the same parameter values for $r$ and $q$ applied that were found to be optimal for the pooled data analysis. This area has primarily been targetted by one fisher since early in 1996, and catch shows marked increase from that time as effort became intensive (Appendix H). In the early years of the fishery there was a much lower effort per year (and catch per year) in that grid cell so that effort expended produced a relatively high CPUE. However, after serious fishing commenced, the fishery lasted around 2.5 years (which corresponds to the recruitment age of trepang). Fishers did not record catch from other grid cells during this period. The biomass dynamics model shows that after 2.5 years intensive fishing estimated CPUE stabilises to a level much lower than that at which these
fishers first commenced seriously targeting the area in 1996. The model corresponds to the fact that these fishers moved elsewhere because returns were no longer considered worth the effort and that after around 2.5 years, stocks were depleted beyond the level at which CPUE was economically viable.

Figs 23 and 24 give some indication of the existing density and spatial distribution of stocks. At Cobourg (where there is a harvesting history - NTDPIF 1994) there was no apparent link between densities and effort, because trepang occurred stands of mature individuals and stands of individuals less than harvesting size appeared at all density categories (very low, low, medium and high). The areas of high density existing at the time of field survey, suggests some local areas within regions still contain unexploited stocks and may sustain further catch. However, it would be important to monitor these areas closely as they may contain breeding stock for nearby areas which are harvested. At Maningrida there are populations which have not been subject to fishing and these give an indication of the natural population structure in the absence of fishing mortality.

The sustainability of alternative harvest strategies is also inconclusive. Preston & Tanaka (1990 in Uthicke 1996) describe trepang fisheries as following “boom-and-bust” cycles where local areas are fished while economically viable, after which fishers move to another area. The decision for management is based on whether to continue the fishery at a lower level of catch or to wait for stocks to rebuild in depleted areas. Holothurians are sedentary, easily collected species and stocks can be rapidly exhausted or significantly reduced easily. If nearby populations replace fished areas rapidly then pulse fishing may be useful, however, there is a danger that populations cannot restock “fished” areas. Recovery time for a depleted area is also unknown and requires research. Although higher immediate monetary returns to fishers will be gained if all individuals at any one time are collected, rather than gradual fishing, long-term economic returns from a managed “steady-state” fishery are higher than unmanaged opportunistic “boom and bust” fisheries (Adams et al. 1992). Gradual fishing also encourages permanent rather than transient investment.

Sex-specific harvest strategies are not possible as sex discrimination in trepang can only occur by microscopically examining gonads. Holothurians generally have a 1:1
sex ratio (Shelley 1981) and it is assumed that this ratio is maintained during harvest.

Size limitation strategies theoretically maximise the yield per recruit and therefore should prevent "recruitment" and "growth" overfishing. Although size limit strategies are widely used in invertebrate fisheries, the fluid body shape of holothurians makes measurements imprecise and precludes size-based harvesting as a useful strategy (Adams et al. 1992, Battaglene and Bell). Alternatively, Uthicke proposes that size limit should be length at first maturity plus 20% to overcome problems of inaccuracy and fluid nature of the animals.

Theoretically the market should regulate size collected as small sea cucumbers are not economically worth harvesting, as mentioned by commercial fishers, because the quality and price of the end product is lower, but this strategy has not worked in the past in other localities (Adams et al. 1992, Shelley 1981, 1985a, 1988). Size limit after processing is a possible harvest tactic (see below).

Harvest strategies based on economic considerations (such as fixed and variable harvesting costs) are not analysed in this study. Nor are social and political indicators of fishery performance (such as total employment, income distribution to rural communities and maintenance of traditional rural/urban living patterns - Hilborn & Walters 1992) discussed and remain open to further research.

**Harvest tactics**

*Annual catch quotas*

A maximum sustainable yield (and maximum surplus production) of around 169.2 t/yr was estimated using the biomass dynamics modelling technique and a standing stock size for this MSY of 122.3. Upper and lower confidence regions were not derived because of the paucity of the data and therefore it is not possible to present conservative and optimistic scenarios, as in Ramm (1995). However, a conservative scenario would be a lower annual catch than the best fit scenario, so that catch should be lower than 122.3 t/yr.
Current catch in the Northern Territory fishery is around 86.8 t/yr (72.3 t taken in 10 months during 1998) which is below the best fit scenario derived from the biomass dynamics modelling.

However, annual catch quotas are only preferable to seasonal or effort limits if the stock size is known perfectly. Quotas require knowledge of optimum harvest rate, population biomass and recruitment variation, most of which is not known for trepang. The biomass estimates in this study are subject to error, and simple tactics may be preferable at this stage to maintain a stable harvest rate (Hilborn & Walters 1992).

Setting a Total Allowable Catch (TAC) is expensive and difficult to implement and errors may arise from sampling parameters such as catch onboard vessels or number of landings which are required to implement TAC. Furthermore, TAC does not account for additional mortality resulting from fishing-induced mortality and discards.

ITQs (individually transferable quotas) have been used with varying degrees of success in the past and may reduce effort and introduce economic stability. Generally ITQs are not considered suitable for tropical multi-species fisheries but trepang occurs in monospecific stands. This eliminates one of the major problems with ITQs where individuals of a species which have already been collected to full quota are inadvertently collected (and then discarded) during fishing for another species. ITQs can also result in under-reporting which jeopardises the value of logbook data and removes small operators (Kearney 1995 in Ramm 1995). In the trepang fishery there is currently one small and one large operator so that this may not be an equitable management solution.

Quotas allocated on an area basis may lead to reduced competition and lower prices and are difficult to enforce (Adams et al. 1992). Quotas set on buyers may be more effective because controlling effort limits the number of licenses and competition, allows the few licence holders to become more profitable, and still may not control exploitation.
Effort limits

Adams et al. (1992) argue that reducing effort rather than implementing measures such as closed areas or imposing size limits are a more useful tactic for trepang management because protecting stocks is only useful if genetic drift between populations occurs (which is unknown at this stage), and because of the difficulties with imposing size limitations. Likewise Uthicke (1996) also argues for controlled fishing effort, suggesting no more than 50% of adults individuals of a population at a given area should be harvested per year until further information about biological parameters of trepang is available.

Limited effort is occurring in the trepang fishery and licenses are not fully utilised at present (Grey 1995). The trepang fishery was re-opened in the Northern Territory in 1992, and declared closed the following year, with 6 transferable licenses issued in 2 zones (W.A. border to Cape Grey and Cape Grey to Qld border). A maximum of six collectors are permitted per licence, four of whom may dive (NTDPIF 1994). Perusal of the raw log book data shows that all 6 licences have never been utilised at any one time. For the years 1992, 1993, 1994, 1995, 1996, 1997 and 1998 an average of 1.9, 1.9, 1.9, 2.2, 1.6, 1.2 and 2.2 licences per month were utilised. This is well below the amount of effort which could be input to the fishery if all licensees were operating consistently at a greater effort. Any increase in effort may alter estimates in this study and their implications for maintaining catches at or below sustainable yields. While there may be scope for increased catch in the fishery, it is a different issue altogether if effort increases and inactive licence holders are replaced by motivated licence holders (Ramm 1995). It would probably be optimal to retain the number and method of collection, vessel and licensing arrangements as is in case of increased effort by existing licensees. No new entrants should be permitted, and any transfer of licences to those engaging in increased effort should be monitored closely. Alternatively licensees who are not fishing could be asked to transfer their licence to increase effort, and then effort monitored closely.

Another option is use individually transferable effort quotas (ITEs) which allow vessel owners a maximum number of days fished and an additional allocation for nonfishing or breakdown periods. These fisheries are less likely to be overfished
during poor years because limits are set on effort rather than catch, so that in poor years lower catches result for the same effort. However, ITEs are probably difficult to enforce in this region due to the remote areas involved.

**Seasonal closures**

Closed years (every second year) or closed seasons for collection of trepang have been proposed as harvest tactics in other parts of the world (Shelley 1985a, Adams *et al.* 1992, Uthicke 1996). Closed years involve a 12 month moratorium on fishing (when fishers may swap to alternative fisheries or activities). In a closed season collection only occurs after the breeding season to ensure stock continuity provided quality does not deteriorate at this time (about which there is no information).

Although Shelley (1981) found ripe gonads year-round in Papua New Guinea, there appears to be a spawning peak there and in eastern Australia and New Caledonia between December and January, with a second spawning peak around August - September (Harriott 1980, Shelley 1981, Conand 1988 in Preston *et al.* 1988). Uthicke (1996) suggests that where biannual spawning cycles occur, a month either side of each spawning peak is recommended. In the Northern Territory it may be useful to close the fishery for at least one of these peaks to protect breeding stocks.

**Closed areas**

The introduction of protected areas is useful for research and can be integrated into management plans. Protected areas may be useful (if local communities can enforce protection) to protect breeding stocks in selected areas, however, this depends on the degree to which adjacent populations replenish depleted areas. For locally-seeding, sedentary species, individuals in a reserve may only replenish that population rather than surrounding areas (Adams *et al.* 1992, Uthicke 1996). It is therefore appropriate to determine the extent of genetic exchange between populations which are geographically isolated. Genetic studies to determine larval drift between populations and larval survival, mortality and settlement induction are required. Should areas be locally depleted they could be declared closed for at least two years.
Size limits

Body length after processing is less variable than size measured on a live individual, and could be used to monitor changes in the fishery. If a constant average size of a catch is maintained then it is an optimally managed fishery with the catch at equilibrium. However, other than processed size, limitations on size collected are considered to be of little value to trepang fishery management because of the fluid nature of holothurians.

Gear limits

Elsewhere in the world it is thought that the use of S.C.U.B.A. and hookah gear may increase the likelihood of local overharvesting (Preston & Lokani 1990, Preston 1993 in Uthicke 1996), and other methods sometimes employed such as weighted hooks on a line or trawling may also pose threats to a population. Restrictions on S.C.U.B.A. and hookah are also thought to maintain breeding populations because larger, more mature individuals generally occur in deeper waters (Adams et al. 1992). However, Sandfish only inhabit shallow waters (<20m) so this is not a useful tactic for this species. Collection techniques in the Northern Territory at present are hand harvesting either by wading in shallow waters or diving. Given the possible scope for increased catch (but not effort) in the Northern Territory, it would be best to retain these tactics as they currently stand.

Traditional management strategies

There are many advantages to biology, industry and society from utilising traditional marine resources management strategies where a local community sets and enforces conditions for harvesting. Government administration costs are decreased, and management is locally-adaptive with decisions based on fine-scale knowledge which can be quickly implemented (Adams et al. 1992). Such local management is more effective because adverse effects on a resource are frequently disguised by broad-scale commercial control. Furthermore, experience in Fiji shows that local ownership of a resource, frequent in many traditional customs, is more likely to ensure sustainability of a resource because control measures are adopted to prevent the owner suffering (Adams et al. 1992). In other parts of the world, traditional management strategies are used for fisheries (e.g. Petelo et al. 1995).
Traditional strategies include periodic taboos (closed seasons) where the resource is experiencing significant depletion. However the strategy cannot be applied to control fishers outside the community. Traditional management strategies applied elsewhere require government support (usually a government liaison officer) and local enforcement by persons with powers to investigate, board and refer cases to authorities. Co-management systems where governments may set overall quotas for export and combine traditional management strategies to split the quota (refined with experience) have also been implemented. Local issues are dealt with at a community-level so that overall management goals are adhered to.

In the Northern Territory there are no Aboriginal licensees so that traditionally-enforced regulations would probably not be effective. However, given the long history of involvement by Aboriginal people with harvesting this resource (firstly with Macassan traders and periodically throughout the 20th century with non-Aboriginal Australian fishers) there would probably be a wealth of untried management tactics which could be applied to management of the resource.

Artisanal fisheries have been recommended elsewhere in the world because the fishery requires only low technology collecting, no refrigeration (can hold until transportation) and simple (although labour intensive) processing procedures, all of which keep costs to a minimum (Shelley 1985a, Preston & Lokani 1990). In fact, most fisheries are in countries where labour costs are low. In many places the fishery may be used only as a partial source of income. Collection is suitable as an individual or group activity and probably of interest to community-oriented social organisations. The produce is income-producing for remote areas with poor communications and infrastructure. The majority of the trepang fishery activity in the Northern Territory is based in Arnhem Land (NTDPIF 1994), either on or adjacent to Aboriginal-owned land. There would be scope for community harvests of trepang to be practiced or encouraged in the future.

**Future research recommendations**

There is little biological information, especially long-term fluctuations, about growth, recruitment, mortality and migration and/or large scale changes in the carrying capacity of the environment which can be input to more sophisticated
models (Shelley 1985a, Ramm 1995, Uthicke). Improved results and harvest strategies could be devised by having *a priori* knowledge of some of the parameters $r$, $k$, $q$ and $B_0$. However, the current study shows that $B_0$ is difficult to obtain by alternative means such as field survey methods (see section 1.5).

Population parameters such as growth, mortality and migration are frequently obtained from tagging studies, however, tagging is difficult to apply to holothurians. In the past attempts have included glueing, scratching, colouring agents, burning, and wire but most tags were rejected or induced necrosis (Shelley 1981, Conand 1991) which have produced some information on growth and mortality. Conand (1991) found a few tagged *H. scabra* specimens in the study area up to 2 years after tagging suggesting a sedentary behaviour, however, migrations in other species have been found by other researchers (Harriott 1994). Shrinkage of holothuria in captivity prevents growth measurements in aquaria (e.g. Wiedemeyer 1992 in Uthicke 1996) although a pilot experiment with internal tags shows promise (Lokani 1992 in Uthicke 1996).

Best estimates for sustainability of the fishery are probably obtained from a longer time-series of data from fisher's logbooks. A research program developed in conjunction with a commercial fisher has the potential to provide very useful data and a clearer understanding of fishing effort to ensure sustainability of the fishery.

It is most important to continue to monitor and analyse the perturbation history at a number of single localities over an extended time-series of data, beyond that which is available to date. A depletion experiment is probably not logistically enforceable because of commercial activity. Areas closed to fishing such as the Castlereagh-Milingimbi sea closure could be maintained as a control area but it would be a large investment of effort to monitor depletion in other areas. Ideally, fishers should be encouraged to regularly fish to varying intensities in a few localities (a suggested medium - apparently sustainable fishing pressure and other pressures such as 25% and 75%) with onboard monitoring occurring. Logbook data could then be added to the existing fishery for a longer perturbation history, as well as the modelling the scenarios of differing fishing intensities. Continued exploitation and monitoring

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would assist with modelling or determining recovery time for the area after heavy depletion.

Sandfish is the only tropical sea cucumber species commercially produced and farmed in India and Indonesia. Stock rebuilding and restocking programs are occurring elsewhere to enhance biomass of depleted populations and raise juveniles (produced in hatcheries) in sea ranching conditions. Although there is probably enough stock to continue wild harvest in the Northern Territory, aquaculture and restocking research has commenced elsewhere in the world including larval rearing and grow-out areas in enclosures. If high demand for farmed species continues it may be possible to establish aquaculture ventures in the Northern Territory to supplement existing stocks and making trepanging a worthwhile venture. However, aquaculture stocks may affect the current price of wild stocks and economic analyses would also need to be taken into account in any such venture.

It is also appropriate to determine the extent of genetic exchange between populations which are geographically isolated. Genetic studies would provide information on larval drift between populations and larval survival, mortality and settlement induction.

Little is known about juvenile holothurians because of their epizoic nature and the fact that they are not frequently not found with adults and it is difficult to measure growth because of their fluid nature (Shelley 1985a). However, juvenile ecology is also important to understand.

Further information about the impact of active feeding by holothurians upon sediment turnover and on the meiofauna of the sediments is necessary so that the impact of removing a large proportion of the population on the environment can be determined.

Current uses of holothuria include medical purposes, fertilizers and compounds of use to industry. Further uses for holothurians could also be explored.
**Recommendations**

Management strategies should bear in mind the relatively slow growth, low recruitment and ease of overfishing of Sandfish (Shelley 1985a). The fact that high variability in density occurs and that the species may aggregate should also be considered, which makes conservative management more important than for non-aggregating species.

The trepang fishery stock size is unknown as is its vulnerability and expected effort. Optimum tactics depend on uncertainties so that the most important strategy is to implement and compare different tactics and continue logbook data modelling as the fishery continues. Recommended tactics to implement and compare include:

- A possible increase in catch, but there are concerns that increased effort by existing licencees may more than compensate for any increase in catch.
- No new licences to be issued. It appears that one fisher can deplete an area of one grid cell size in 2.5 years (where stocks were probably of high density), after which fishing the area is not sustainable. It would be preferable to ensure that stocks were sustainable in any area so that after any number of years of fishing breeding stock remains. One licensee could be encouraged to fish at least two grid cells over 2.5 years. Six licencees operating two grid cells each over a period of 2.5 years requires at least 12 grid cells of similar density to be present in Northern Territory waters, which is probably severely constraining the current fishery.
- Continued monitoring of fished areas, preferably with fishing to varying intensities in a few localities (such as 25%, 50% and 75% of current fishing pressure) and comparison with a control area where no commercial fishing occurs. This could be enforced in areas such as the Castlereagh-Milingimbi sea closure or future areas set aside for scientific research in Cobourg Marine Park.
- Monitor severely depleted areas for recovery time.
- GPS fixes for fishery catches should be included in logbook records. This will be useful where continued fishing at the same area produces a lengthy time-series of data.
• Enforcement of closed seasons around January-February (or greater duration) when harvesting is pragmatically difficult (because of bad weather) to protect breeding stocks during at least one of the spawning times.

• Quotas set on buyers and exports; combined with local or regional management strategies, particularly those concentrating on fine-scale area management.

• Size limits are not useful because of the fluid nature of the individuals and because there is contention over the size of first maturity. Estimates for this biological parameter range between 16 cm and 22 cm which also suggests severe caution with the currently existing size limits.

As Uthicke (1996) says, the necessary information to develop a detailed strategy for a sustainable fishery is not available and further research (see above) to obtain these parameters is necessary for more robust strategies.
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Appendix A: Deep water statistics. (Sample size is small due to heterogeneity of water column.)

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Appendix B: Regression summary for masked images (Jun 20 image = independent variable in each case) which were used as transformation algorithms for the masked image data.

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<td>.99</td>
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Radiometric calibration using histogram percentiles
A least squares regression fitted between the reference image (June 4 1995) and other images, for each channel was used. The regression line defines the conversion for rescaling values to match corresponding values in each image. Similarity between images is given by the coefficient.

The October 1993 appeared quite different from the other images and a number of other procedures were applied to improve calibration. Subsequently fire scars on this image were spectrally digitised but could not be spectrally distinguished from shallow river areas. A section of the image was spatially digitised to remove very bright areas on the land which probably represented very dry areas. However, no improvement was found. Cloud was also spectrally removed from the image and the image resampled to the reference image.

Finally, water values were obtained from the frequency histograms and stretched to the full data range, masking out land. These values were then regressed against the water values of the reference image, and the regression then applied over the entire set of pixels. Again no noticeable improvement in the image standardisation was evident, and the image was retained based on original calibration technique described. Differences evident (in the land) were assumed to be seasonal vegetation differences, so that the image did, in fact, reflect standardise reflectance values.
Appendix C: Training site statistics taken from varying depths of the same bottom type.

<table>
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<tr>
<th></th>
<th>Rbay1</th>
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<td></td>
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<td>deep</td>
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<td></td>
<td>S.D.</td>
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<td></td>
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<tr>
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Appendix D: Parallelepiped classification.

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TOTAL PIXELS TESTED = 610 985. Deleted classes with less than 0.1% (<6109.85 pixels) = 1966 pixels deleted, = 27 classes left)
Appendix E: Questions and answers used during unstructured interviews.
Information not related to trepang is not recorded.

Q. Where is your country?
A. Answers are summarised as: Nangak (1), Yirrkala (1), Nardelmuk (2), Yilan (2), Numaladja (2), Maningrida (1), Rolling Bay (1), Navy Landing (1), old barge landing (1).

Q: Do you know where there are trepang?
A. Djudda Pt (3), Gurundi (Liverpool River) (2), Karddjarrama (2), Gurabu (Rolling Bay) (3), Junction Bay (2), King River (1), Milingimbi (2), Cape Stewart (2), False Pt (1), everywhere (1).

Responses usually related to people’s country, for example, the two people from Yilan talked about Milingimbi and Cape Stewart which are close to their country. A couple of people had worked with trepang or were the descendants of people who had worked with trepang and were able to name places further afield than their country, for example, King River.

On some occasions this lead to further questioning about what the ground looks like with responses given as:
good place is seaweed, coral, reefs (1), seagrass, sand, rock (1), mud, rock (2), mud, rock a little bit, not sand (1), not rock, too hard (1), white always buried, brown on coral and reefs (1).

There appears to be a mixture of whether trepang were the “brown” ones or other species. Most responses probably referred to all species of trepang and not just the species I was surveying. I was also confused because white may be brown and brown may be black to some people, for example, the last response I would have said brown always buried, black on coral and reefs.

other information included:
- not enough seaweed at Kupunga (Blyth River, this side) (1), no trepang at Rocky Point, Crab Creek, because reef but different sand, washed up too quick on the beach, no seaweed, coral, seagrass, just rocky reef, harder sand; they’re in behind where it’s sheltered (1), Judda Pt, must be very low tide (1), Karddjarrama is calmer but Liverpool River - mud too deep near the mouth (not in the middle?) (1), Milingimbi there is a Dreaming painting – circles for freshwater springs (submarine springs) (1), Karddjarrama mudflats (extensive with springwater and seagrass) (1).

Q: How much trepang is there?
A: Lots (4), big mobs (1), maybe same, maybe less now (1).

The last response was a follow up question asking whether he thought it was the same today as it was a long time ago (he had answered “lots”).
Q: Are trepang there in the dry season or the wet season?
A: All year (7), don’t know (1).

Three people who had responded with the “all year” answer were then asked if trepang were there in the day or the night. Two respondents answered day and night (2) and one said they did not work at night because a “Mangadjarra” (Macassan) was eaten by a crocodile in the Liverpool River near West Point (1).

Q: What is the best tide for trepang?
A: Low (7).

Further questioning also gave answers:
At full moon the low tide is late and new moon low tide is in the morning (2). Neap tide is no good although sometimes dive to chest high on half moon (1). High tide dive, low tide collect (1).

Q: When did the Macassans come?
A: Don’t know (1), stories (1).

Q: How often did the Macassans come?
A: don’t know (2), every year (1), during the mission every year, 3 or 4 years (1), Japanese in dry season, from March, sometimes wind (1).

The final two responses probably refer to trepang collection during the 1930’s when there was a mission on Goulburn Island and trepang collection on a small scale by a mixture of balanda, Japanese and Aboriginal people, sometimes working in the same team.

Q: How long did the Macassans stay in one place?
A: don’t know (1), 5 days, sometimes 10 days (1), 2-3 months (2), lots of days (1), one week each place (1), worked together but Aboriginal people speared Japanese, said “go away” because Japanese never traded tobacco (1), worked every day and sometimes went back to Malay with trepang, come back empty, others stay 4 or 5 days to work (1).

Some of these responses were asked through the translator, who told me she could translate between the numerical concepts and the Aboriginal way of quantifying terms.

Q: How much trepang did the Macassans take?
A: don’t know (1), lots (1), 4-5 bags in one area (1), 11-12 bags took back, (demonstrated: shoulder height x 1.5 m wide) (1), 10-20 “garrung” (big bag), twice as big as a flour bag, over 3 months (2), worked morning to afternoon (1), took them in a big bag, nearly as big as a small man (drew size in the air), takes two people to carry the bag (1).

Q: What colour trepang did they take?
A: Black, brown (3), black, brown, white (1), black, brown, white, red (1), brown (2), no black (1), big ones (1).
Q: How many Macassans were there?  
A: Don’t know (1), lots of boys (1), lots of Aboriginal people with 2 Japanese people before the war (1), 7-8 Mangadjarra/Malay at a time (1).

Q: Do you any animals that eat trepang?  
A: mud crab (1), shark (1), porpoise (1), “Marrumbena”, big headed turtle (loggerhead turtle) loves it, eats trepang and jellyfish (3), sometimes green turtle (1), barracuda eats baby ones (1), eats mud, sand, seaweed, cockles, shrimps, rot away and little bit of shell left (2).

The last response refers to trepang diet rather than trepang predators.

Q: What things should we know if Aboriginal people want to collect trepang and sell them for money? (I sometimes said “manage trepang”)  
A: use a stick to get the guts out, fill the flour drum with water on fire (1)  
- mangrove root bark for boil, morning until lunch, hang out to dry (2)  
- big pot boiling on island, leave until lunch (1)  
- no waste of trepang or money, need to do it properly and boil with special mangrove that the respondent would show us (1).  
- worked at night with paperbark branches and fire to make torch, hold the torch up high and collect trepang, other people collect trepang in the day time (1)  
- no good walking or diving because of sea wasp (1)  
- they breed all the time, “that’s nature’s way” (1)  
- the Macassans left the smaller ones to breed (1)  
- the Macassans took all of them in the one place (1)  
- the Macassans took medium and large ones, not small ones (1)  
- leave some big ones there (1)  
- no sacred sites/spiritually important areas, “all clear” (1)

Other information that emerged from the conversations included:  
- wet season, strong winds, cyclone, waves bring trepang to the beach/shore, tidal waves  
- wind is okay but floating, rolling (1).  
- they move very slow, on sand and rocks, slower than a snail (1)  
- after a few days in the sun they are dead (1)  
- taste like bailer shell (1)  
- taste like rubber (1)  
- brown ones taste better, like bailer, white takes longer to cook (1)  
- good idea for employment (1)
Appendix F. Data modelled and values generated, maximum log likelihood best fit scenario.

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Appendix G: Selected grid cell biomass dynamics model.

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APPENDIX C: LETTER SENT TO COMMUNITY REPRESENTATIVES

24th August 1995

…. Name…. 
…..Organisation…

Dear Sir

I spoke to you on the telephone recently concerning my enrolment for a Ph.D. at the Northern Territory University. At this stage I would be interested in research for the thesis using both traditional knowledge and western science to help in understanding relationships between fauna and the land, and to guide activities for the future. I was hoping you could give me some ideas on whether the project would be possible, and useful. I would also be interested in knowing of any other projects which you consider would be more worthwhile than the current ideas I have, and which I may be able to assist with.

The specific information I had thought to research would be:
- finer habitat requirements of species
- declines/increases in abundance and distribution
- interdependencies between species
- Aboriginal land management practices and their impacts on species
- harvesting levels of species and future predictions on their abundance.

I envisage that this work would be useful to land councils, communities and Aboriginal people in conserving the resource base for the future. I also see that western science would gain greater understanding of species, related impacts and appropriate management methods.

The research program would be developed more fully in conjunction with Aboriginal people and community rangers. Feedback and development of future management activity with Aboriginal people would also be a part of the research process. Appropriate payment for Aboriginal informants would be given and any publications resulting from this work would be co-written by the Aboriginal community and the researcher.

Selected species of biological significance (such as indicator/rare etc) could be used as case studies. The information could be incorporated with future biological surveys to be conducted by CCNT personnel.

Involvement by two different aboriginal communities would be useful so that a comparison between the two areas (one which has experienced a lot of land use changes, and the other being relatively unimpacted) could be conducted.

Use of remote sensing/gis technology could be incorporated at the later stages of the approach to analyse the impacts of past and present land use, to give a regional overview to the interpretation and to predict/model future trends.
I am unsure of where this work should be conducted and am open to suggestions. I am also open to suggestions on the type of research which is important for Aboriginal people (as well as western scientists), and am prepared to adapt research in any way that you would suggest. Please let me know whether you would be interested in this research proposal at Maningrida or elsewhere, and any other thoughts you may have.

Yours sincerely

Jenny Carter.

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