1.0 Introduction

1.1 Aims and objectives

The aim of this project is to develop an approach to link the research, planning and environmental management requirements for the coastal areas of the Alligator Rivers Region (ARR) that could be affected by climatic and other related changes. The approach is intended to facilitate ongoing assessment of the vulnerability of the ARR to the effects of short-term changes in climate and other environmental factors that occur within planning horizons of approximately 100 years. The project is intended to focus on Kakadu National Park, and the floodplains of Magela Creek, however, its outcomes have wider application to the management of the ARR in general, as well as floodplain environments elsewhere in the wet-dry tropics.

The objectives are to:

- develop procedures for assessing the vulnerability of coastal wetlands in the ARR to predicted future changes in climate;
- assess the nature and extent of potential biophysical change in the wetlands;
- determine likely impacts on the availability of Aboriginal food items resulting from climate and other changes on the coast;
- assess the effects of change on the natural, cultural and heritage values of the region's coast;
- determine management responses to the predicted environmental changes.

The tasks undertaken to achieve the objectives were to:

- establish a scenario for climate change, including assessments of sea level rise, variation in tides and tidal surges, storminess and increased runoff from the catchment, that is based on published research;
- broadly document the physical, biological, cultural and social conditions of the ARR;
- indicate the environmental values of those parts of the ARR that are vulnerable to climatic and associated changes;
- provide information on the climate change scenario for presentation on the digital terrain model of the Magela Creek floodplain;
- compare the ARR with similar systems from elsewhere, where appropriate, in order to determine whether the patterns of change identified provide indicators that could be used in monitoring programs in the wet-dry tropics;
- consult with a range of bodies to determine the issues relating to climate change and the management responses that would be appropriate to the ARR;
- indicate the range of possible management responses including monitoring requirements.

1.2 Background

The project has its beginnings in the international agreements signed by the Commonwealth Government, particularly those related to the United Nations Conference on Environment and Development at Rio (1992) and the workings of the (international) Intergovernmental Panel on Climate Change. These have been translated into action at a state, territory and local government level through the (Australian) Intergovernmental Agreement on the Environment (1992).

1.2.1 International agreements

In the mid-1980s there was general concern about the greenhouse effect, climate change and sea level rise. The concern was expressed at the First World Climate Conference of 1979 and establishment of the World Climate Program—a joint research program initiated by the World Meteorological Organisation (WMO) and the United Nations Environment Program (UNEP). International meetings conducted as part of the program (the Villach Conferences) led to ratification of the Montreal Protocol in 1988. This protocol aimed at reducing ozone and carbon dioxide levels in the atmosphere. At approximately the same time, the CSIRO 'Greenhouse '88 Conference: Planning for Climate Change' was held in Australia.

In 1988 the World Meteorological Organisation and United Nations Environment Program convened an Intergovernmental Panel on Climate Change (IPCC), to serve three functions. These are listed in the First Assessment Report (IPCC 1990):

- assess the scientific information related to the issue of climate change;
- evaluate the environmental and socio-economic impacts of climate change; and
- formulate realistic response strategies for the management of issues related to greenhouse effects.

Under the aegis of the IPCC three working groups were established:

Group I considered scientific aspects of climate change (eg CSIRO modelling work);

Group II examined broad environmental issues (eg those related to mountains, deserts and coasts);

Group III investigated economic issues (eg assessments of socio-economic aspects of impacts, adaptation and migration).

By 1990, Groups II and III were combined and reconstituted as four sub-groups:

Sub-group A energy, industry, transportation, urban issues.

Sub-group B coastal zones, small islands, oceans and marine ecosystems, and impacts of tropical cyclones, storm surges and sea level changes

Sub-group C unmanaged resources and terrestrial ecosystems, mountains, cryosphere, hydrology and terrestrial impacts of climate events; and

Sub-group D droughts and desertification, agriculture, managed forests, land use, health and management of water resources.

Sub-group B, is responsible for coasts and oceans, including coastal zone management strategy (CZMS). It now reports through the Intergovernmental Panel on Climate Change (IPCC) to the United Nations Framework Convention on Climate Change (FCCC) which was convened at the United Nations Conference on Environment and Development (UNCED) at Rio in June 1992. The Convention commits signatory parties, including Australia, to an overall objective, guiding principles, actions and institutions.

Under the United Nations Conference on Environment and Development (UNCED) Agenda 21 Program of Action for Sustainable Development, Chapter 17, the convention required:

- development of an integrated coastal zone management (ICZM) key program for sustainable development of the coast;
- preparation of national action plans by 2000 AD;
- states to co-operate in the development of special measures to:

> Cope with and adapt to potential climate change and sea level rise, including development of a globally accepted methodology for coastal vulnerability assessment, modelling and response strategies, particularly for priority areas such as small islands and low lying coastal areas.

1.2.2 National vulnerability assessments

Responsibility for developing and trialing a globally accepted methodology for coastal vulnerability assessment was given to Working Group II, Sub-group B in 1988. That process is continuing and is one of the reasons for the current assessment of the wetlands of the ARR. There have been four meetings of Sub-group B to date:

- The first was in 1990, when the 'Common Methodology' was developed. At this stage, Australia did not have a 'case study' approach to vulnerability assessment.
- The second was held in 1992 on Marguerita Island, Venezuela. There, the participating nations reported on their 'case studies' of the application of the common methodology for vulnerability assessment This included case studies at Geographe Bay, Western Australia and the Cocos Islands, that were funded by the Commonwealth Government. The IPCC report prepared at the Marguerita Island Workshop (IPCC 1992) was taken to the Earth Summit in Rio in 1992 and became a basis for the United Nations Conference on Environment and Development (UNCED) Agenda 21, Chapter 17, dealing with oceans and coasts.
- The third conference comprised separate meetings of the western hemisphere in New Orleans, July 1993, and the eastern hemisphere at Tsukuba, Japan, in August 1994. Australia contributed to the Tsukuba Conference in which objections were raised to the Common Methodology because it did not take full account of regional diversity in biophysical systems and, particularly, cultural matters in the assessment process. Australia played a significant role in assessment of the Common Methodology.
- The eastern and western Hemisphere meetings were drawn together at the World Coasts Conference in the Netherlands during late 1993 (IPCC 1994).

CSIRO (1994) stresses the Australian interest in coastal management because:

> the present Methodology for Assessing Vulnerability to Sea Level Rise (IPCC Response Strategies Working Group, 1992) places too little emphasis on the role of extreme events such as storm surges, high waves, and estuarine flooding, which are of major concern on the Australian coast.

These concerns have been reported to the relevant international meetings and workshops of Working Group II, Sub-group B, by the Commonwealth Department of Environment, Sport and Territories (DEST). The Commonwealth Government, through DEST, has continued to develop frameworks for vulnerability assessment to meet the specific environmental and socioeconomic needs of its own states, territories and communities by:

- providing funds for Territory, State and Commonwealth agencies to develop flexible, regionally based framework for vulnerability assessment; and
- requesting that the assessment be tied to an Integrated Coastal Zone Management (ICZM) commitment for implementation.

Eight case studies have been undertaken in Australia. Two of these are in the Northern Territory. They are being conducted for the Darwin Planning Region and Kakadu National Park, which are focal points for the ARR.

1.2.3 Regional context

The two case studies from the Northern Territory provide contrasts in coastal management practice as well as representing different environments within the wet-dry tropics. Management of the coast at Darwin, as well as coastal and wetland areas on the western flank of the ARR, is vested in the departments of the Northern Territory Government. Kakadu National Park is managed jointly by the Commonwealth organisation, Parks Australia, and the Aboriginal traditional owners of land in the park, through the Kakadu Board of Management. At the time of writing, the Board is comprised of 14 people:

- ten Aboriginal people nominated by the traditional owners of the park;
- the Director of National Parks and Wildlife;
- the Assistant Secretary, Parks Australia North;
- a representative of the tourism industry in the Northern Territory;
- a person prominent in nature conservation.

The Office of the Supervising Scientist (***oss***) and the Environmental Research Institute of the Supervising Scientist (***eriss***) advise the Commonwealth Government on environmental protection requirements in relation to uranium mining in the Alligator Rivers Region, in which Kakadu is located. ***eriss*** also provides advice and information on wetland management, as requested, in the Alligator Rivers Region.

From an environmental perspective, the case study areas at Darwin include a range of small river catchments with tidal creeks, sandy beaches, rocky coast and, to varying extent, urban development. This contrasts to the ARR, and Kakadu National Park in particular, where there are extensive tracts of swampland on floodplains bordering the principal rivers of the region. Although the floodplains within the park have been used for grazing in the past, they are now essentially natural areas that are currently used for passive recreation and airborne sightseeing tourism purposes. Both areas, but especially the ARR, are highly dynamic environments that are subject to extreme rates of change due to seasonal and interannual variation in climate, storm incidence, sea level fluctuation, and river discharge. Since management has had to take account of this variability its principles and policies may differ from those applied to management of the less variable, temperate environments of the southern coasts.

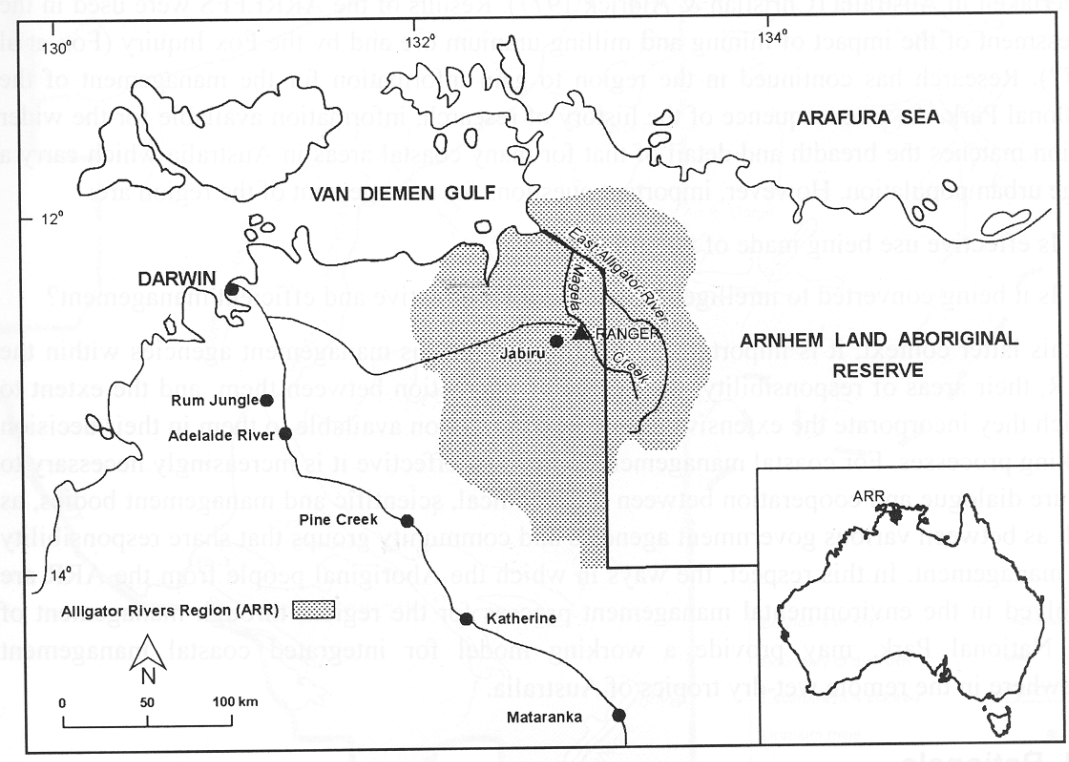
1.3 The Alligator Rivers Region

The Alligator Rivers Region (ARR) encompasses the catchments of rivers draining into Van Diemen Gulf between Point Stuart and the eastern bank of the mouth of the East Alligator River, including Love Creek (Bijibiju) and the Wildman, West Alligator (Marangarrayu), South Alligator and East Alligator Rivers. The ARR is part of a biophysical region which encompasses all of the coastal wetlands from Cape Hotham to the Ilamaryi River on the western flank of the Coburg Peninsula. The region lies to the east of Darwin (map 1) and includes all of Kakadu National Park. The ARR and Kakadu National Park are shown in map 2.

The coastal lands of the region are low in elevation, which makes them susceptible to sea level fluctuation. Below the more elevated Koolpinyah Surface, the floodplains (Williams 1979; Woodroffe et al 1986) generally lie between 3 and 4 m above Australian Height Datum. This makes them only 0.2 to 1.2 m above mean high water level. Arguably, a change in climate would substantively affect the physical and biological conditions of the coastal wetlands that constitute the greater part of the coastal zone, especially if significant rise in sea level occurs. In turn, changes to the physical and biological conditions are likely to have cultural, social and

economic ramifications. Ultimately, any changes in the environmental conditions will affect the way in which the natural resources of the region are managed. The challenge is to ensure that management recognises and can cope with such change.

The major part of Kakadu National Park is drained by the South Alligator and East Alligator Rivers with the smaller West Alligator and Wildman Rivers draining the north-western portion of the region. The Mary and Katherine Rivers drain a minor portion of the south-westerly part of the region and they are not considered further. The rivers are fed by a network of ephemeral creeks and drain into Van Diemen Gulf, in the north. The combined catchment area of the four major rivers is approximately 28 000 km^2 (about 8000 km^2 greater than the size of Kakadu National Park). In describing the hydrology of the region, reference is made to three of the major physiographic land surface units: i) the plateau and escarpment; ii) the lowlands, and iii) the floodplains. Much of the information on the hydrology of the region comes from Chartres et al (1991), Kingston (1991), Nanson et al (1990) and Roberts (1991) and is summarised by McQuade et al (1996).



Map 1 The biophysical region

Kakadu National Park has outstanding natural, cultural, recreational and tourism values. The importance of its natural and cultural heritage values is recognised internationally, and it is listed as a UNESCO World Heritage Area. About half of the park is Aboriginal land under the *Aboriginal Land Rights (Northern Territory) Act 1976*. The Aboriginal land in the park is leased to the Director of National Parks and Wildlife, and the whole park is managed jointly by the Aboriginal traditional owners and Parks Australia.

Uranium is mined within the catchment of Magela Creek, a tributary of the East Alligator River. The mining lease areas and nearby townsite of Jabiru have been excised from Kakadu National Park. Mining operations and provision of residential and urban services at Jabiru, together with recreational and tourist activities, have direct and indirect effects on the environmental values of the park. However, management of mining, urban and tourist activities is intended to minimise

any adverse impacts and maximise the opportunities to conserve the physical, biological and cultural heritage values. This has been pursued through a comprehensive research and monitoring program along the channel and floodplains of Magela Creek downstream of the Ranger uranium mine site at Jabiru East. The Environmental Research Institute of the Supervising Scientist (eriss) independently, and in collaboration with other agencies, undertakes and promotes research relevant to the environmental effects of mining operations in the ARR and minimisation of these effects after decommissioning and rehabilitation. Although the coastal component of the research has focused on downstream effects of mining, much of the information gathered is applicable as a baseline to assess the effects of climatic and other changes on the catchment environment. It also provides a sound basis for comparison with other parts of the region.

Significant and voluminous scientific research has been undertaken on the ARR. This commenced in the early 1970s with the Alligator Rivers Region Environmental Fact Finding Study (ARREFFS) which, at the time, was the most comprehensive study of its type ever undertaken in Australia (Christian & Aldrick 1977). Results of the ARREFFS were used in the assessment of the impact of mining and milling uranium ore and by the Fox Inquiry (Fox et al 1977). Research has continued in the region to gain information for the management of the National Park. As a consequence of the history of research, information available for the wider region matches the breadth and detail of that for many coastal areas in Australia which carry a large urban population. However, important questions for management of the region are:

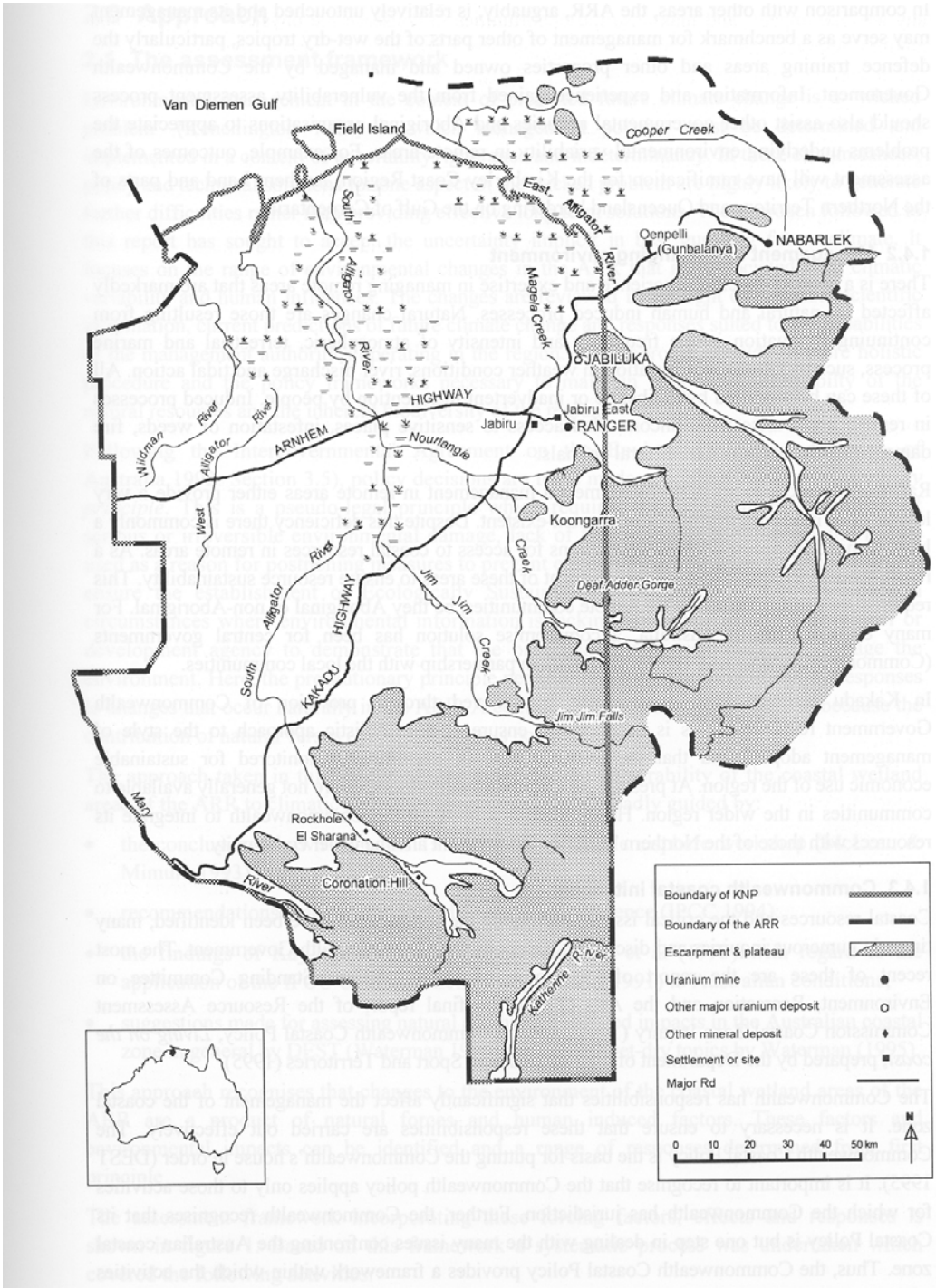
- Is effective use being made of the information?
- Is it being converted to intelligence that supports effective and efficient management?

In this latter context, it is important to identify the various management agencies within the ARR, their areas of responsibility, the degree of interaction between them, and the extent to which they incorporate the extensive scientific information available to them in their decision making processes. For coastal management to be most effective it is increasingly necessary to ensure dialogue and cooperation between the technical, scientific and management bodies, as well as between various government agencies and community groups that share responsibility for management. In this respect, the ways in which the Aboriginal people from the ARR are involved in the environmental management process for the region, through management of the National Park, may provide a working model for integrated coastal management elsewhere in the remote wet-dry tropics of Australia.

1.4 Rationale

1.4.1 Selection of the Alligator Rivers Region as a case study area

Selection of the ARR as a case study area for analysis of coastal vulnerability to climate change, sea level rise and associated environmental change was due to two major factors: the significance of Kakadu National Park as a major regional resource in the wet-dry tropics, and its management by Aboriginal people and the Commonwealth Government for the purposes of conservation and tourism. Other major Commonwealth properties in the wet-dry tropics are defence training areas. These are located at Shoalwater Bay in Queensland, and at Yampi Sound in the Kimberley Region of Western Australia. Management of the defence training areas requires special management prescriptions that are implemented following preparation of environmental management plans relevant to defence needs (Waterman 1995). These plans may not be entirely appropriate to other government and community agencies. However, the types of problems occurring, and the management solutions implemented in the ARR may also be applicable to the defence training areas in similar environments.



Map 2 The Alligator Rivers Region (ARR) including Kakadu National Park

In comparison with other areas, the ARR, arguably, is relatively untouched and its management may serve as a benchmark for management of other parts of the wet-dry tropics, particularly the defence training areas and other properties owned and managed by the Commonwealth Government. Information and experience gained from the vulnerability assessment process should also assist other governmental agencies and Aboriginal organisations to appreciate the problems underlying environmental variability in remote areas. For example, outcomes of the assessment will have ramification for the Kimberley Coast Region, Arnhem Land and parts of the Northern Territory and Queensland bordering on the Gulf of Carpentaria.

1.4.2 Management in a changing environment

There is a need to develop experience and expertise in managing remote areas that are markedly affected by natural and human induced processes. Natural changes are those resulting from continuing fluctuation in the frequency and intensity of atmospheric, terrestrial and marine process, such as interannual variation in weather conditions, river discharge and tidal action. All of these can be modified by deliberate or inadvertent intervention by people. Induced processes in remote areas arise from uncontrolled access to sensitive places, infestation of weeds, fire damage and the introduction of feral animals.

Rateable resources to support environmental management in remote areas either provide a very low level of funds to government or are non-existent. Despite this deficiency there is commonly a large demand by non-residential populations for access to coastal resources in remote areas. As a result, there is a requirement for management of these areas to ensure resource sustainability. This requirement cannot be met by the remote communities, be they Aboriginal or non-Aboriginal. For many coastal areas in Australia, a compromise solution has been for central governments (Commonwealth, State and Territory) to work in partnership with the local communities.

In Kakadu National Park management is achieved through provision of Commonwealth Government resources. This is necessary to ensure a more holistic approach to the style of management adopted and that the resource base is scientifically monitored for sustainable economic use of the region. At present, the Commonwealth resources are not generally available to communities in the wider region. Hence there is a need for the Commonwealth to integrate its resources with those of the Northern Territory Government and the wider community.

1.4.3 Commonwealth coastal initiatives

Coastal resources and the critical issues confronting the coastal zone have been identified, many times in numerous inquiries and discussion papers by the Commonwealth Government. The most recent of these are the report of the House of Representatives Standing Committee on Environment, Recreation and the Arts (1991), the final report of the Resource Assessment Commission Coastal Zone Inquiry (1993), and the Commonwealth Coastal Policy, *Living on the coast*, prepared by the Department of the Environment, Sport and Territories (1995).

The Commonwealth has responsibilities that significantly affect the management of the coastal zone. It is necessary to ensure that these responsibilities are carried out effectively. The Commonwealth Coastal Policy is the basis for putting the Commonwealth's house in order (DEST 1995). It is important to recognise that the Commonwealth policy applies only to those activities for which the Commonwealth has jurisdiction. Further, the Commonwealth recognises that its Coastal Policy is but one step in dealing with the many issues confronting the Australian coastal zone. Thus, the Commonwealth Coastal Policy provides a framework within which the activities of Federal Government departments and agencies that may have an impact on the coastal zone will be developed and implemented. Management of the coastal wetlands of Kakadu National Park is a Commonwealth activity that falls within the ambit of the Commonwealth Coastal Policy.