INDIGENOUS SUBSISTENCE FISHING AT INJINOO ABORIGINAL COMMUNITY, NORTHERN CAPE YORK PENINSULA

Thesis submitted by

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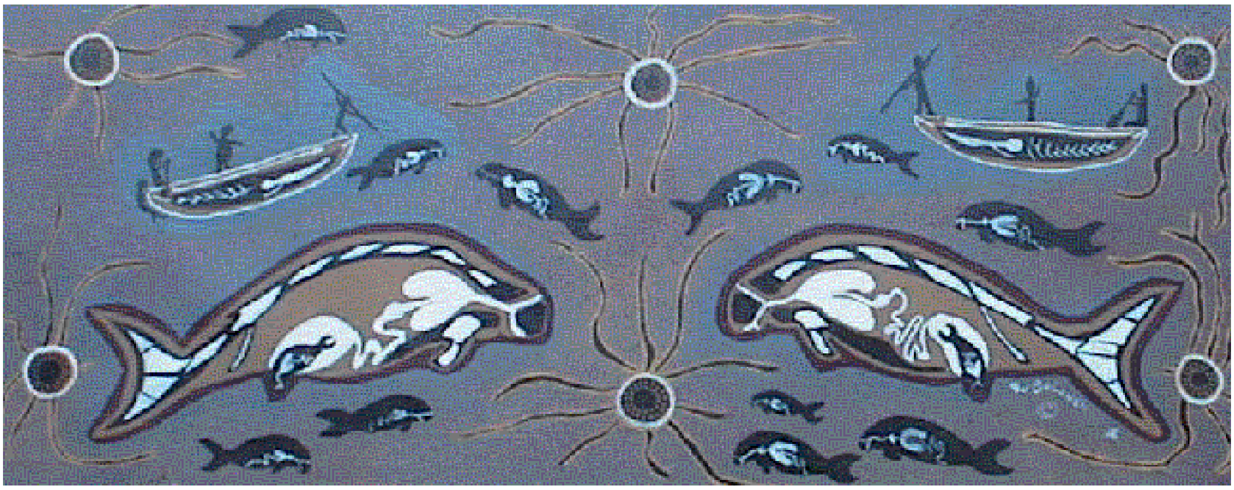
in the School of Tropical Environment Studies

and Geography, James Cook University

INDIGENOUS SUBSISTENCE FISHING AT INJINOO ABORIGINAL COMMUNITY, NORTHERN CAPE YORK PENINSULA



"This is a story of how Aboriginal hunt for dugong in the early days. The markings tell of how dugong feed and bear their young offspring."

Artist: Roy Solomen, Injinoo Aboriginal Community

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Firstly, Chris Roberts instigated this study after hearing the concerns of the people of Injinoo Aboriginal Community (10° 55’ S, 142° 22’ E: see Figure 1.1). If it was not for his drive, this study may not have become reality. I am indebted to Chris for providing me with this opportunity, and for maintaining the constant support over the years that followed. Thanks also to everyone else at Balkanu who contributed.

Dr Neil Gribble and Rod Garrett also provided endless support and advice throughout the life of this study. I feel honoured and privileged to have two great mentors. Thanks also to everyone at the Fisheries Research and Development Corporation, not just for providing the funding that made this study possible, but also for the professional and friendly support that you always provide.

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ABSTRACT

This study responded to concerns expressed by Elders from Injinoo Aboriginal Community regarding the apparent increase in fishing effort targeting aggregations of black jewfish (*Protonibea diacanthus*) in the waters of Northern Cape York Peninsula. In addition to studying black jewfish, I also examined the harvest of all aquatic resources utilised by the Indigenous subsistence fishers of Injinoo Aboriginal Community. This dual approach was adopted to help alleviate the deficit of data on Indigenous subsistence fishing in Australia.

The Indigenous subsistence fishing survey

This component of my study was guided by the Indigenous Subsistence Fishing Survey Kit developed by Balkanu Cape York Development Corporation, Queensland Department of Primary Industries and Fisheries, and the Queensland Environment Protection Agency. Background surveys were conducted in December 1998 and revealed that the vast majority of households at Injinoo regularly harvested marine or freshwater resources for subsistence purposes. Most participated in subsistence harvesting activities on a weekly (64%) or daily (13%) basis, with fishing, hunting and gathering effort extending from Shelburne Bay (11° 49’ S, 142° 58’ E: see Figure 1.1) on the east coast, to Vrilya Point (11° 23’ S, 142° 12’ E: see Figure 1.1) on the west coast.

Interview surveys were also conducted in December 1998. They revealed the residents of Injinoo held a clear preference for Indigenous members of their Community to undertake the monitoring surveys. Subsequently, several members of the Community were trained according to the survey kit. The monitoring surveys commenced in January 1999 and continued through to August 2000**.** Each month, between three to five days was randomly chosen for surveying, providing a total of 70 survey days.

The monitoring surveys revealed that the Indigenous subsistence fishers of Injinoo harvested a diverse range of resources. Survey facilitators recorded the harvest of 75

marine and freshwater animal taxa. The five most frequently harvested taxa were mullet (Family Mugilidae), sweetlip (*Lethrinus* spp.), stripey (*Lutjanus vitta*), snapper (*Lutjanus* spp.) and black jewfish. While seasonal trends were evident, it was not possible to define the start or end of these periods, or to demonstrate any annual variation.

Ten different types of harvesting activities were identified during the monitoring surveys. Handline fishing was the most frequent activity (57% of 491 hours recorded), followed by dugong hunting (15%), turtle hunting (9%) and netting (9%). The mean duration of harvesting trips varied between 0.5 hours when collecting turtle eggs or molluscs, to four hours when hunting dugong. The mean number of people participating in each type of activity was four, with males dominating vessel-based activities and participating exclusively in hunting activities.

Harvest rates were highly variable, with netting resulting in the greatest return to the individual fisher (2.7 fish/person hr^{-1}). Fishers often worked as groups in harvesting activities targeting crustaceans (4.6 crustaceans/boat hr^{-1}), molluscs (34.3 molluscs/boat hr^{-1}), and turtle eggs (3.4 nest/boat hr^{-1}). The catch rate for turtle hunting (0.42 turtle/boat hr^{-1}) was higher than that for dugong hunting (0.2 dugong/boat hr^{-1}).

This study demonstrated the willingness of an Indigenous community to participate in monitoring programs assessing their use of aquatic resources when the research is conducted in an appropriate manner. Opportunity should be taken to replicate this program in other coastal Indigenous communities of Queensland and beyond. This survey should be repeated at Injinoo Aboriginal Community as soon as possible to assess if any changes have occurred in the fishery.

Black jewfish assessments

In 1999 and 2000, over eight tonnes of black jewfish were harvested from the waters of the Northern Cape York Peninsula. During that period, the mean total length (TL) of the harvested fish decreased significantly (P<0.001) from 70-80 cm in 1999 to 59-

69 cm in 2000. Historical accounts collated during this study revealed that black jewfish close to their maximum size (150-180 cm TL) were last caught in 1994.

Sexually mature black jewfish composed only 4.4% of fish in a sampling program biased towards the largest individuals (n = 270). Sexually mature ovaries were observed in specimens sampled from aggregations in the period between May and September 2000. However, no ripe or spent gonads were found, so the timing and location of the spawning season in northern Australian remain unknown.

Food items observed in black jewfish included a variety of teleosts and invertebrates; supporting the ‘opportunistic predator’ description of Rao (1963). The limited data gained in this study presented no evidence to support the notion that the seasonal migration of black jewfish is related to the increased availability of prey items in the inshore waters, as is suggested by Thomas and Kunja (1981).

Tag returns revealed that some of the fish remain at, or return to, the aggregation site at least into the following day, and revealed the movement of a fish between two aggregation sites. If this behaviour is normal for black jewfish, this activity may increase their susceptibility to capture. Since tag returns were scant (2.6%), this interpretation must be treated with caution. The low tag return rate contrasted with the 100% retention of tags in the captive tagging trial.

DNA fingerprinting using the amplified fragment length polymorphisms (AFLP) technique revealed no significant genetic variation in fish sampled from adjacent aggregation sites at Muttee Head (10° 54’ S, 142° 13’ E: see Figure 1.1) and Peak Point (10° 43’ S, 142° 25’ E: see Figure 1.1). On a larger scale, black jewfish sampled from Northern Cape York Peninsula and the Northern Territory were found to comprise one homogeneous population (G_{ST} 0.046).

In response to these findings, the Injinoo Land Trust self-imposed a two-year ban on the harvest of black jewfish in the area from Crab Island (10° 58’ S, 142° 06’ E: see Figure 1.1) to Albany Island (10° 43’ S, 142° 36’ E: see Figure 1.1). This initiative developed into a regional agreement, and amendments to the *Fisheries Regulation 1995*. However, the closed water amendments were not applied to Indigenous fishers, even though the Chairman from each of the Communities in the region had requested this arrangement.

The significance of this voluntary closure was acknowledged by the project's principal funding agency, the Fisheries Research and Development Corporation (FRDC). The inside cover of the agency's 2001-2002 Annual Report lists this outcome as one of the four most significant of the year from a total of 768 projects under FRDC management (FRDC 2003). The Fisheries Research and Development Corporation also provided additional funding to continue monitoring the status of the black jewfish stock.

All parties to the regional agreement recognised that the two year closure was unlikely to provide for the complete recovery of the proportion of adult fish in the population. Hence, they requested further studies be undertaken. Further sampling in 2002 and 2003 revealed the size of black jewfish in the study area had increased significantly (mean size 103.5 cm TL). However, in contrast to previous years, black jewfish were difficult to catch, and so concern for the future of the fishery remains warranted.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 5. BLACK JEWFISH ASSESSMENT: 1999-2000

CHAPTER 7. GENERAL DISCUSSION

LIST OF TABLES

LIST OF ACRONYMS

AFLP	Amplified fragment length polymorphisms
CCL	Curved carapace length
CW	Carapace width
CPUE	Catch per unit of effort
DNA	Deoxyribonucleic acid
TL	Total length

THESIS FLOW CHART

CHAPTER 1. INTRODUCTION

Chapter One sets the context for this thesis by explaining the genesis of this project. In this chapter I introduce the users and custodians of the subsistence fishery, and explain the situation that lead to the development of this project.

In summary:

- This project responded to the concerns of the Traditional Owners of Northern Cape York Peninsula regarding the amount of effort targeting aggregations of black jewfish.
- This study was implemented to profile the biology and harvest of black jewfish.
- Funding was also provided to document the harvest of all aquatic resources utilised by the Indigenous subsistence fishers of Injinoo Aboriginal Community.

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CHAPTER 2. BACKGROUND INFORMATION

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CHAPTER 3. GENERAL METHODS

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CHAPTER 4. INDIGENOUS SUBSISTENCE FISHING SURVEY

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CHAPTER 5. FIRST BLACK JEWFISH ASSESSMENT

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CHAPTER 6. SECOND BLACK JEWFISH ASSESSMENT

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CHAPTER 7. GENERAL DISCUSSION

CHAPTER 1. INTRODUCTION

The Traditional Owners of Northern Cape York Peninsula want to ensure that the subsistence use of aquatic resources purposes is sustainable (the late Daniel Ropeyarn, Anggamuthi Elder, Injinoo Aboriginal Community, *pers comm*. 1999). They are aware of the decline of traditional resources elsewhere along the coast of Queensland, and are keen to avoid the same occurring within their own customary estates (the late Daniel Ropeyarn, Anggamuthi Elder, Injinoo Aboriginal Community, *pers comm*. 1999). The Indigenous subsistence fishers of Injinoo Aboriginal Community make use of a diverse range of aquatic resources and ecosystems, however, the level of harvest and the associated effects had not been quantified prior to this study.

In 1994, Elders from Injinoo Aboriginal Community publicly expressed their concern regarding an apparent increase in fishing effort targeting the aggregations of black jewfish (*Protonibea diacanthus*) that form annually in the waters of the Northern Cape York Peninsula. This perceived increase in effort had prompted concerns from both the Traditional Owners of the area, who have custodial responsibilities for that stock, and from the Queensland Department of Primary Industries and Fisheries, which has statutory responsibilities for managing fisheries in Queensland on a sustainable basis. Black jewfish were being utilised in the region by local Indigenous subsistence fishers, local and transient recreational fishers, and by tourist anglers from all over Australia and the world.

Black jewfish also form an important component of the harvest of the inshore gillnet fishery operating in the Gulf of Carpentaria, which is situated adjacent to Northern Cape York Peninsula (see Figure 1.1). At the same time Injinoo's Elders were expressing their concerns, commercial catches in the Gulf were declining dramatically for reasons that were unclear (Williams 1997). Between 1990 and 1995, commercial landing fell from 37 t to 12 t. The reduction in the Gulf of Carpentaria catches did not appear to be unique, with anecdotal evidence suggesting that catches of black jewfish on the Capricorn and Central Coasts of Queensland had also declined over a number of years (Bowtell 1995, 1998).

Following raised awareness of the concerns held by the Traditional Owners of the Northern Cape York Peninsula, Balkanu Cape York Development Corporation approached the Queensland Department of Primary Industries and Fisheries on behalf of the Injinoo Aboriginal Community and the Injinoo Land Trust. In 1998, they gained funding from the Fisheries Research Development Corporation to initiate a project to respond to the Elder's concerns. James Cook University was approached soon after, and in late 1998 I was accepted for post-graduate studies to be completed on a part-time basis under the supervision of Professor Helene Marsh.

This study represented the first time that the Fisheries Research and Development Corporation had funded research principally devoted to examining an Indigenous fishery (Alex Wells, Projects Manager, Fisheries Research and Development Corporation, Canberra, *pers comm.* 1999). In addition to examining the biology and harvest of black jewfish, funding was also provided to document the harvest of all aquatic resources utilised by the Indigenous subsistence fishers of Injinoo Aboriginal Community. This dual approach was adopted to help alleviate the deficit of data on Indigenous subsistence fishing in Australia. Despite the importance of this information, the Queensland Department of Primary Industries and Fisheries had no reliable datasets for the Indigenous fishing sector (Tropical Fin Fish Management Advisory Committee 1998).

Thus this project had three broad aims:-

(1) to document the subsistence harvest of aquatic resources by the Injinoo Aboriginal community,

(2) to document the historical and current catches of black jewfish in Northern Cape York Peninsula, and

(3) to study the biology of black jewfish harvested by the Injinoo Aboriginal community, with emphasis on its reproduction, diet, movements and genetics

The thesis is arranged in seven chapters as outlined on the blue frontis page of this and all other chapters.

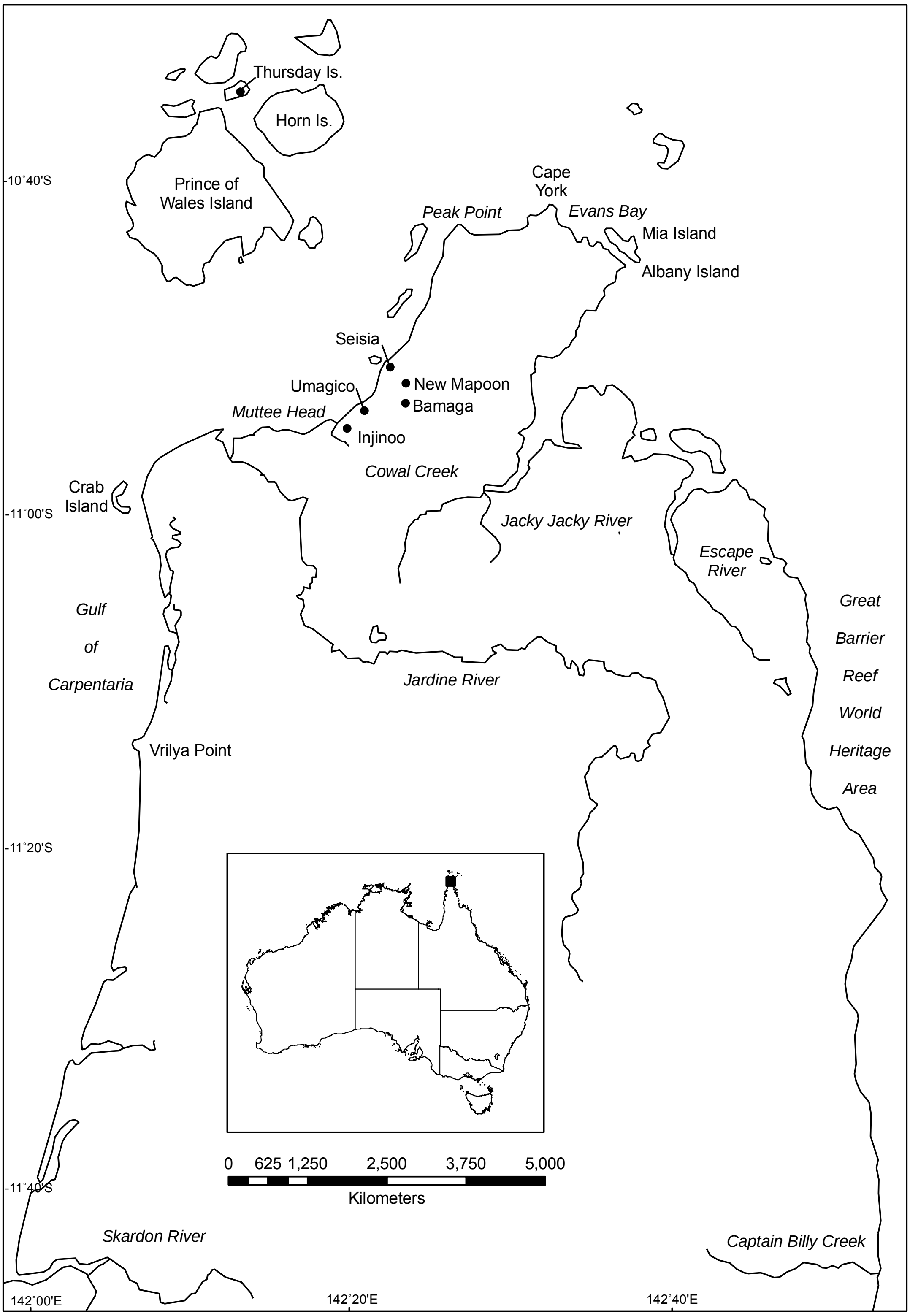

Figure 1.1: Map of Northern Cape York Peninsula

THESIS FLOW CHART

CHAPTER 1. INTRODUCTION

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CHAPTER 2. BACKGROUND INFORMATION

In this chapter, I review available literature relating to Injinoo Aboriginal Community and its subsistence fishery. I have provided this background information so that the reader will be aware of the setting in which the data and outcomes documented in this thesis were produced.

In summary:

- The environment surrounding Injinoo is ecologically diverse and pristine.
- There is an extensive set of legislation regarding traditional fishing, hunting and gathering.
- The subsistence fishery of Injinoo has an extensive history, with early accounts from a variety of sources providing insights into the past.
- The Indigenous people of Injinoo have undergone extensive lifestyle changes over the last 140 years.

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CHAPTER 3. GENERAL METHODS

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CHAPTER 4. INDIGENOUS SUBSISTENCE FISHING SURVEY

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CHAPTER 5. FIRST BLACK JEWFISH ASSESSMENT

↓

CHAPTER 6. SECOND BLACK JEWFISH ASSESSMENT

↓

CHAPTER 7. GENERAL DISCUSSION

CHAPTER 2. BACKGROUND INFORMATION

2.1 The environment of the Northern Cape York Peninsula

Cape York Peninsula is distinguished by its size (180,000 sq km), its low human population (current population <15,000), its remoteness from major population centres (Kennedy 1990, Abrahams et al. 1995, Talyor and Bell 2002). The land area contains some of the least disturbed habitats of all the bioregions in Queensland (Cape York Regional Advisory Group 1997). Cape York Peninsula is recognised as one of the most biologically diverse areas of Australia, with its immense area giving rise to a range of environmental conditions (Danaher 1995).

Northern Cape York Peninsula incorporates the area north of Captain Billy Creek (11° 50' S, 142° 50' E: see Figure 1.1) on the east coast, and Skardon River (11° 47' S, 141° 58' E: see Figure 1.1) on the west coast. This is the northern-most 200 km of Cape York Peninsula. The region encompasses an area of ~8,000 sq km (Roberts et al. 1996), and takes in a diverse set of habitats ranging from rainforests to heathlands. The biological and ecological importance of this region has been comprehensively documented in the Cape York Peninsula Land Use Strategy surveys conducted between 1992 and 1994.

Along the coastline, rocky headlands alternate with extensive sandy beaches. Mangrove forests are concentrated in the tidal reaches of rivers and tributaries. The shallow groundwater from the sandy soils and sandstone within the catchment areas maintain numerous perennial rivers (NSR Environmental Consultants Pty Ltd 1999). River flow in the 27 catchments of Northern Cape York Peninsula is seasonally variable, and is characterised by high-intensity flood events between December and April (Roberts et al. 1996). The Jardine River (10° 57' S, 142° 11' E: see Figure 1.1) has the highest runoff (670 megalitres/sq km) of any river in Queensland (Wagner 1989).

To the east of the Cape York Peninsula, linear reefs of the Great Barrier Reef (see Figure 1.1) runs parallel to the edge of the continental shelf. The Great Barrier Reef

Marine Park and Great Barrier Reef World Heritage Area commence east of the tip of Cape York and extend southwards. Smyth (1991) determined that much of the protected area of the Far Northern Section of the Marine Park lies within identifiable Aboriginal maritime estates. The Gulf of Carpentaria (see Figure 1.1) is positioned off the west coast of Cape York Peninsula. The Gulf is a very large (~400,000 sq km), shallow (<60 m deep) body of water (Brewer et al. 1995), with few islands and reefs.

North of Cape York (the northern-most point of the Australian continent) is the Torres Strait, a 150 km wide passage between the tip of north-east Australia and south-eastern Papua New Guinea. The region incorporates the northern-most section of the Great Barrier Reef. Other extensive reef areas and numerous cays and islands dot the shallow water. Depths average 30-50 m in the east and 10-15 m in the west. The Torres Strait Protected Zone extends from the southern shores of Papua New Guinea to just north of the Prince of Wales Group of Islands.

2.2 The Indigenous peoples of Injinoo Aboriginal Community

Definition of Indigenous, Aboriginal and Torres Strait Islander people

I refer to Indigenous people as:

> Those people which have a historical connection with pre-colonial societies and consider themselves distinct from other sectors of today's society.

I also refer to Aboriginal people and Torres Strait Islanders as:

> Those people who are decendants of an Aboriginal or Torres Strait Islander race, who identify as an Aboriginal or Torres Strait Islander and are accepted as such by the community in which he or she live.

Prior to the arrival of European people in Northern Cape York Peninsula, the region was occupied by numerous small semi-nomadic family tribes that existed as distinct identities (Sharp 1992). While it is suggested that larger conglomerates were formed on the basis of common attributes such as intermarriage and kinship ties (Chase and Sutton 1981), it appears that these family tribes maintained great linguistic diversity

(Smyth 1991). Tindale (1974) had mapped the location of tribal boundaries, though he later acknowledged these fluctuated over time (Tindale 1976, Horton 1994). Social and demographic information from the pre-colonial history of Cape York is limited, and hence Harper (1996) states that inferred relationships between the social groups have been based largely on speculation and knowledge of related cultures.

The first sustained contact with Europeans came in 1844-45 when two vessels, His Majesty's Ship *Fly* and His Majesty's Schooner *Bramble*, anchored at Evans Bay (10° 42' S, 142° 33' E: see Figure 1.1). The published narrative of the voyage compiled by Joseph Bette Jukes, describes both Aborigines and Islanders frequenting Evans Bay during the time the vessels were anchored there (Jukes 1847). In 1848-49, His Majesty's Ship *Rattlesnake* also anchored at Evans Bay. Moore (1979) provides a comprehensive ethnographic reconstruction of the lives of the local Aboriginal and Islander people based on the unpublished journals of the ship's artist, Oswald Walter Brierly.

The first major incursion of non-Indigenous people into Northern Cape York Peninsula occurred in August 1864 with the establishment of the government station at Somerset (10° 41' S, 142° 31' E: see Figure 1.1). The Government of Queensland hoped that Somerset would cater for the increasing maritime traffic in the region and would become 'the Singapore of Australia' (Sharp 1982). It is estimated in Government figures that within the first thirty to forty years of the post-contact period, the Aboriginal population in Northern Cape York Peninsula was reduced from over three thousand to less than a tenth of that number (Meston 1896: in Sharp 1992).

In the early part of the twentieth century, the remnants of the groupings whose customary lands occupied Northern Cape York Peninsula, came together of their own accord and settled at the mouth of Cowal Creek (10° 55' S, 142° 22' E: see Figure 1.1). Cowal Creek is situated about 30 km from the northern-most point of mainland Australia. The establishment of the community brought together people from five major groups; the Anggamuthi (Seven Rivers – west coast), Atambaya (McDonnel – inland area), Gudang (Red Island, Somerset – northern coast), Yadhaykenu (Cairncross - north-eastern coast) and Wuthathi (Whitesand - south-eastern coast). The Community, now called Injinoo, is unique in North Queensland history in that it is the only settlement that was self-formed and self-governed from its inception (Smyth 1991).

Close to a decade had passed before the Chief Protector of Aborigines became aware of the Community's existence in 1915. The Chief Protector of Aborigines, John Bleakley, wrote in 1919, that 'these people support themselves entirely by working their own fishing vessels and gardens' (Q.P.P. 1920: in Sharp 1992). However, the interruption of the Second World War ended the self-sufficiency of the Community, and introduced a period of government dependency to maintain the social welfare of the residents (Byrne 2000). It is a current goal of Injinoo's Community Council to regain self-sufficiency (Kleinhardt-FGI 1999).

In 1985, Injinoo Aboriginal Community was provided with the legal right under the *Community Services (Aborigines) Act 1984* (Qld) to establish its own Community Council. In addition to servicing the community of Injinoo, the Council also administers the community ranger program. The rangers undertake the day-to-day management of much of the area of Northern Cape York Peninsula. Responsibilities of the rangers include land, flora and fauna management, cultural site protection, and development and maintenance of camp facilities and walkways. A levy incorporated into the Jardine River ferry fee contributes to the funding of these services.

In 1988, Injinoo Aboriginal Community joined the Federal Government's Community Development Employment Program (CDEP). The program is currently the main source of employment in the community and typically involves around 150 people (14 January 2000). At this time, less than ten Indigenous residents were employed on a full-time basis outside of the employment program. The non-Indigenous population in the Community fluctuates according to employment opportunities. In January 2000, nine non-Indigenous persons were residing at Injinoo, with employment centred on the administration of Council services.

The Injinoo Aboriginal Corporation operates the Pajinka Wilderness Lodge, which was purchased 1992 with assistance from the Federal Government. The Community Council also administers Injinoo Airport, the Jardine River ferry, a service station, a hearse service, a concrete mixing plant, a Council workshop, and a host of other smaller enterprises. There are presently 48 houses in the community, along with the Council buildings, primary school, church, health centre, women's centre, and a youth centre. The community has a population of approximately 350 people.

Figure 2.1: Aerial photograph of Injinoo Aboriginal Community showing the main community area (bottom left), Cowal Creek (top left) and the beach camp area (top right).

In August 1999, 135 years to the month that Somerset Station was established, the Queensland Government transferred the title to approximately 330,000 hectares of land back to the Anggamuthi, Gudang, and Atambaya Traditional Owner groups. The transfer was the largest inalienable freehold grant to Aboriginal people in Queensland, and was made under the *Aboriginal Land Act 1991* (Qld), which predates the better known *Native Title Act 1993* (Cwlth). The inalienable freehold title is managed by the Injinoo Land Trust Management Committee, which involves equal representation from all tribal groups recognised in the title. The local government responsibilities remain with Injinoo's Community Council.

The Indigenous people of Injinoo Aboriginal Community have undergone major lifestyle changes within the last 140 years. Gone are their semi-nomadic ways, although a growing number of people are returning to outstations and temporary camps scattered across Northern Cape York Peninsula. In examining the Community from a distance it is easy to form the impression that much of the culture and traditional knowledge of these people must have been lost. However, during my stay at Injinoo, I was increasingly exposed to the customs and beliefs of these people, and soon formed the impression that their cultural connection with the sea and land had not been lost. It is my view that this study was conducted in an environment in which cultural values were widespread and highly valued.

2.3 Legislation relevant to traditional fishing and hunting

In 1915, when Queensland's Chief Protector of Aborigines first became aware of the community of people who had settled on the banks of Cowal Creek (10° 55' S, 142° 22' E: see Figure 1.1), the *Native Animals Protection Act 1906* (Qld) permitted Aboriginal people to hunt native animals as long as such activities were conducted for subsistence proposes only. This right was maintained in the *Animals and Birds Act 1921* (Qld), and the *Fauna Protection Act 1937* (Qld). Under the *Fauna Conservation Act 1952* (Qld), Indigenous people were exempted from provisions related to the killing of native animals under the condition that the act was conducted to provide food, and the employment terms relating to the particular Aboriginal person did not relate to the provision of food.

The *Fauna Conservation Act 1974* (Qld) which repealed the 1952 legislation, did not include an exception in favour of Aborigines who killed native animals for domestic consumption. However, the *Community Services (Aborigines) Act 1984* (Qld) and *Community Services (Torres Strait) Act 1984* (Qld) authorised residents of Deed in Grant in Trust (DOGIT) areas to take marine fauna for use on the DOGIT. The

Fisheries Act 1976 (Qld) provided that Aboriginal people who were residents of DOGIT areas or Aboriginal Reserves, were exempted from fisheries restrictions in relation to fish, turtles and dugong (*Dugong dugon*).

In 1975, the Great Barrier Reef Marine Park and the Great Barrier Reef World Heritage Area (see Figure 1.1) were created under the *Great Barrier Reef Marine Park Act 1975* (Cwlth). The Act does not specifically address Indigenous subsistence activities. Such activities have been managed through management tools permitted by the Act (e.g., zoning plans). The *Great Barrier Reef Marine Park Zoning Plan 2003* lists dugongs and turtles as 'protected species' and stipulates that the take of these species requires written approval. However, the Plan allows Traditional Owners to develop 'Traditional Use of Marine Resource Agreements' (TUMRAs).

In 1985, the Torres Strait Protected Zone was established under the *Torres Strait Treaty 1985* between Australia and Papua New Guinea. The Treaty recognises and protects the customary maritime rights of the Indigenous people of the Torres Strait Islands. Fishing activities within the Torres Strait Protected Zone are governed under the *Torres Strait Fisheries Act 1984* (Cwlth). 'Fishery Management Notices' created under the Act, regulate the take of dugongs and turtles within the Torres Strait Protected Zone and 'outside but near areas'. A dugong sanctuary area within the Torres Strait Protected Zone was created under Torres Strait Fisheries Management Notice 65 (23 February 2004).

In 1986, the Australian Law Reform Commission called for an increase in the rights of Indigenous Australians to fish, hunt and gather. Seven years later, the final report of the Coastal Zone Inquiry criticized the lack of action by Governments in regards to the recognition of Aboriginal customary law. Drawing upon the recommendations of the above Inquires, the *Fisheries Act 1994* (Qld) granted all Aboriginal and Torres Strait Islander people the right to pursue traditional fishing practices. Earlier, governance of dugongs and turtles was transferred to the *Nature Conservation Act 1992* (Qld), which replaced the *Fauna Conservation Act 1974* (Qld). The *Nature Conservation Act 1992* (Qld) allowed Indigenous peoples to take turtles and dugongs subject to the provisions of a conservation plan. However, this section of the Act has never been proclaimed.

In 1993, the *Native Title Act 1993* (Cwlth) was introduced following the High Court judgement in *Mabo and Others -v- Queensland, 1992* which recognised the existence of native title on land. Section 211 of the Act removed the need for native title holders to gain a permit to conduct certain non-commercial activities, including fishing and hunting. In 1998, native title of customary sea areas was recognised by the Federal Court in *Mary Yarmirr & Others -v- Northern Territory of Australia & Others, 1998*. The Federal Court determined that native title exists in the sea and the seabed, but did not recognise exclusive title. The decision was upheld by both the Full Federal Court (*Commonwealth of Australia -v- Yarmirr, 1999*) and the High Court of Australia (*Commonwealth of Australia -v- Yarmirr, 2001*).

In 1999, the right of native title holders was affirmed by the High Court of Australia in *Yanner -v- Eaton, 1999*. The High Court found legislation which made taking fauna an offence without a permit was in direct conflict with the s211 of the *Native Title Act 1993* (Cwlth), where native title holders exercised such rights for personal, domestic or non-commercial needs. Hence, while the *Environmental Protection and Biodiversity Conservation Act 1999* (Cwlth) stipulates the need for a permit to take a dugong or turtle, the Act explicitly states that it does not affect the operation of s211 of the *Native Title Act 1993* (Cwlth). This legislation is the latest addition to the list of Acts governing Indigenous subsistence harvesting activities. Since Injinoo was founded almost 100 years ago, the rights of Injinoo's fishers, hunters and gatherers have changed many times, and will certainly continue to change in the future.

2.4 Historical review of the subsistence fishery of Injinoo

Aboriginal people of Cape York Peninsula's coastal zone believe they have been the owners, occupiers and managers of their land and sea country since time immemorial (Monaghan 2004). Dating of archaeological sites suggests that the human occupation in northern Australia spans 40,000 to 60,000 years (Hiscock and Kershaw 1992, Roberts et al. 1990, 1993). Given that sea level stabilised near the present level 5,000 to 6,000 years ago (Davies et al. 1985), the coastal zone of Northern Cape York has always existed in the presence of Aboriginal people, their resource use and management practices (Beaton 1985; Smyth 1991, 1993; Meyers et al. 1996).

From among the first contacts between Europeans and the Indigenous peoples of Northern Cape York Peninsula, come invaluable insights into the historical subsistence practices of the region. The journal records of Oswald Walter Brierly, the ship’s artist on His Majesty’s Ship *Rattlesnake,* describe the possessions of the Indigenous people he observed at Evans Bay (10° 42’ S, 142° 33’ E: see Figure 1.1) during 1848 and 1849. Brierly described organic fishing line with hooks made from turtle shell, and outrigger canoes with mat sails (Moore 1979). Brierly's journals also contain information he obtained from Barbara Thomson. Thomson lived with the Kaurareg people, primarily on Prince of Wales Island (10° 41’ S, 142° 11’ E: see Figure 1.1), for five years after being shipwrecked in 1844 (Moore 1979).

Thomson provided detailed accounts of the subsistence activities of the Kaurareg and Gudang people of Northern Cape York Peninsula. Her accounts describe: (1) women and children collecting numerous types of bivalves, (2) four pointed fish spears neatly made with bone tips, (3) men catching fish, dugong and turtles, and (4) Gudang men using remoras (*Remora remora*) attached to a line to catch turtles (Moore 1979). The Kaurareg had a good relationship with the Gudang people of Cape York, and hence they shared many hunting grounds and practices (Southon et al. 1998).

At Somerset (10° 41’ S, 142° 31’ E: see Figure 1.1), Jardine (1866) noted that turtles formed the principal food of the Aboriginal people from November through to February. Missionary Kennet (posted to Somerset in 1867) documented that ‘their food consists chiefly of turtles, fish, and roots (The Kennet Reports, 1867-1868: in Moore 1979). Kennet describes that ‘from sunrise until shortly before sunset, the men are away from the camps, turtling and fishing’. Kennet stated ‘considerable skill is shown in the manufacture of fishing line and hooks…the former are braided from the fibrous outer shell of the coconut and the latter from tortoiseshell or iron procured from wrecks’.

The reports of the Cambridge Anthropological Expedition to Torres Strait produced by Haddon (1901-1935), record many aspects of the fishing and hunting culture of the Torres Strait and Cape York peoples. In describing the people engaged in turtle hunting along the north-eastern coast of Cape York Peninsula, Haddon (1912) writes of the ‘considerable strength and skill, in addition to remarkable dexterity in diving and swimming that must be possessed'. Haddon (1912) also provides evidence of the encroachment of new materials among traditional hunting apparatus, noting that 'the large, barbless, turtle-shell hooks are never used now, [the Indigenous peoples] employing European hooks when they can get them; failing this they make neat barbless hooks out of wire'.

Recent literature on subsistence activities in Northern Cape York Peninsula is scant. Asafu-Adjaye's (1994) study of subsistence activities in the region had a socio-economic focus, concluding that subsistence production in the region at $2,804 per household per annum. Limpus et al. (1993) notes the limited harvest of flatback turtles and their eggs at Crab Island (10° 58' S, 142° 06' E: see Figure 1.1). Roberts et al. (1994, 1996) monitored the subsistence activities in the community of New Mapoon (10° 52' E, 142° 23' S: see Figure 1.1) between June 1994 and January 1995, recording the harvest of "fish ≥ 1 kg" (n = 51), dugong (n = 8) and green turtles (n = 14). This thesis represents the first comprehensive survey of aquatic resource use in Northern Cape York Peninsula.

THESIS FLOW CHART

CHAPTER 1. INTRODUCTION

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CHAPTER 2. BACKGROUND INFORMATION

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CHAPTER 3. GENERAL METHODS

Chapter three explains the general approach that I adopted in the development of this study. I have provided this so that the reader will be aware how the collaborative approach to this study was generated. I also discuss the research limitations and opportunities to explain the scope of the information provided within this thesis.

In summary:

- Extensive steps were undertaken to encourage the involvement of community members in all elements of the project.
- Information about the beliefs and practices of the Indigenous fishers of Injinoo Community has been included in this thesis where it is integral to the description of the subsistence fishery.
- The appropriateness of information contained in this thesis was checked by representatives of the community.

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CHAPTER 4. INDIGENOUS SUBSISTENCE FISHING SURVEY

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CHAPTER 5. FIRST BLACK JEWFISH ASSESSMENT

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CHAPTER 6. SECOND BLACK JEWFISH ASSESSMENT

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CHAPTER 7. GENERAL DISCUSSION

CHAPTER 3. GENERAL METHODS

3.1 Components of this study

This study was initiated in response to the concerns held by the Traditional Owners of Northern Cape York Peninsula, regarding an apparent increase in fishing effort targeting local aggregations of black jewfish. The agency sponsoring this study, the Fisheries Research and Development Corporation, also provided funding to conduct a survey of the use of all aquatic resources utilised by the Indigenous fishers of Injinoo Aboriginal Community. This dual approach was adopted to help alleviate the deficit of information on the importance and scale of Indigenous subsistence fishing in Australia.

Sampling for both of these components was commenced in late 1998 and was completed in late 2000. The results of this work were immediately presented to the Injinoo Aboriginal Community Council and the Injinoo Land Trust. This presentation resulted in well-developed public expectations including the desire to implement a second assessment of the black jewfish stock. In response, additional sampling was commenced in mid 2002 and completed in late 2003. The results of this component of my work were presented to the Injinoo Land Trust in early 2004.

As such, this thesis has three components:-

1. A survey of the harvest of aquatic resources utilised by the Indigenous subsistence fishers of Injinoo Aboriginal Community (see Chapter 4).
2. An assessment of the harvest and biology of black jewfish utilised by the communities of Northern Cape York Peninsula (see Chapter 5).
3. A second assessment to review of the status of the black jewfish stock two years after the initial assessment (see Chapter 6).

3.2 Approach and research protocols

As far as possible community members were involved in the design and implementation of this study, as well as in the interpretation of its results. The act of working together on all aspects of the project greatly enhanced the community's understanding and trust, and hence their willingness to participate. At all stages this study adhered to the protocols established by Balkanu Cape York Development Corporation for conducting research in Indigenous environments (Balkanu Cape York Development Corporation 2005) These protocols were designed to allow individual communities to participate in scientific research in a manner deemed culturally appropriate by the Indigenous community.

Prior to the commencement of sampling, I made a substantial commitment in time meeting the community residents and promoting a two-way discussion of the needs of the project. From feedback generated at later stages this initial consultation was deemed critical to the success of the study. Although unproductive in terms of formal results, this period was essential to: (1) identify the issues of concern to ensure the relevance of the research, and (2) ensure the transmission of salient objectives so that the direction of the study was clear to all.

Injinoo Aboriginal Community, like many other Australian Indigenous communities, is the focus of numerous studies each year. Researchers in almost all these studies 'fly-in and fly-out', with the community often gaining little understanding of the study and its findings. This project benefited greatly from my decision to reside within the community (eighteen months in total) for the initial sampling period. By residing within the community I was able to build a strong personal and working relationship with the residents. With time this improved our mutual understanding of each others' needs.

The continued involvement of local fishers proved integral to the success of this study. Not only did they provide the critical information on the spatial and temporal scale of the fishery, they also supported this project by making available their catch for examination and sampling. Further, with appropriate training, many community members assisted in the sampling process. While limited employment opportunities were provided within the project, most of their contribution was voluntary.

From the outset of this project, it was clear that the Indigenous fishers in the region were not familiar with some of the methods and tools commonly used in western science. For example, while recreational and commercial fishers across Australia are generally familiar with fish tags, the Indigenous people of the Northern Cape York Peninsula had never been exposed to such tools. This lack raised the importance of community awareness programs implemented to increase the public's understanding of the project and its methods.

Initiatives undertaken to raise the profile of the project within the community included:

- An art drawing competition organised to create awareness of the project with the younger members of the community.
- The introduction of the study's objectives and methods in a public meeting held in the Injinoo Community Hall.
- The promotion of the project in local press media articles.
- Updates on the progress of the project in interviews broadcast on the local community radio service.
- The use of posters displayed throughout the region.

To maintain the high level of community ownership of the project, I consulted with the community at all stages and presented the results in a transparent manner as soon as they became final. At regular intervals, I reported the progress of my studies to the Community Council's Clerk, who also represented the interests of the community by serving on the project's steering committee (see 'Contribution of Others' in the opening pages of this thesis). The steering committee comprised elected representatives of each of the stakeholder groups who expressed interest in the fishery. The committee guided the progress and direction of the study, and served to ensure the transmission of the results to all stakeholder groups.

3.3 Research limitations and opportunities

This quantitative study of aquatic resource use was not designed to provide information on the maritime culture of the Indigenous community of Injinoo. Yet, to ignore evidence of the high cultural values associated with the fishery would underrate its importance to the Indigenous groups. Hence, I documented the cultural values that comprise inseparable components of the subsistence fishery. Throughout this thesis there are brief insights into the extensive maritime culture of the Indigenous people of Northern Cape York Peninsula.

During the eighteen months of 1999 and 2000 that I resided within the community of Injinoo, I was fortunate to be exposed to the beliefs and practices of the many cultures and traditions present. As prescribed by Hamilton and Walter (1999), I acquired cultural information with the same critical scrutiny that is applied by scientists to any other data set. Nonetheless, I acknowledge that ethnobiological knowledge is not a static entity but changes with the parent culture (Smith 1987). In such, the information presented within this thesis represents my perception of the traditional culture at the time of writing.

While residing within the community, I was regularly invited by Indigenous subsistence fishers from Injinoo to participate as an observer in many fishing, hunting and gathering expeditions which exploited local aquatic resources. These activities, some of which extended overnight, were conducted over a variety of locations, seasons and conditions, and involved a range of harvest equipment and capture methods. Observations made during these occasions form the basis of my description of the methods and tools presented in Chapter 4.

During the course of this study, I was entrusted with much information on the methods and locations of subsistence activities, and the cultural beliefs and practices of the Indigenous people of Injinoo. Every effort has been made to maintain the confidentiality of sensitive information. Cultural information has not been included without prior consent of the informant. Draft publications of this thesis were made available to the Injinoo Land Trust before the final publication and distribution. Endorsement for the publication of this version of this thesis was provided by the Chair of the Injinoo Land Trust, Mr Robbie Sallee.

THESIS FLOW CHART

CHAPTER 1. INTRODUCTION

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CHAPTER 2. BACKGROUND INFORMATION

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CHAPTER 3. GENERAL METHODS

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CHAPTER 4. INDIGENOUS SUBSISTENCE FISHING SURVEY

Chapter four commences with an explanation of the importance of rectifying the deficit of datasets on Indigenous subsistence fishing in Australia. I then state the aim of this component of my thesis, and explain the specific steps that I undertook in conducting this survey at Injinoo Community. This chapter also presents and discusses the survey results.

In summary:

- The survey provided a comprehensive dataset on the Indigenous subsistence fishery of Injinoo, and revealed the great diversity and scale of the fishery.
- The need for further information on the resources utilised by Indigenous subsistence fishers was highlighted in the examination of the fishery.
- The urgent need to reduce the high level of turtle nest predation by feral pigs was evidenced by the difficulty in harvesting turtle eggs.

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CHAPTER 5. FIRST BLACK JEWFISH ASSESSMENT

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CHAPTER 6. SECOND BLACK JEWFISH ASSESSMENT

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CHAPTER 7. GENERAL DISCUSSION

CHAPTER 4. INDIGENOUS SUBSISTENCE FISHING SURVEY

4.1 Introduction

Australian fisheries have a history of being managed, researched and monitored in cooperation with non-Indigenous commercial and recreational fishing groups. This process has, until recently, neglected the cultural and socio-economic values that are intrinsic to Indigenous Australians. The people of Injinoo possess a strong connection with the sea, and fishing is an important aspect of their culture. However, they feel that their knowledge and interests are not being clearly heard when decisions are made about their resources.

This situation led to the development of Indigenous Subsistence Fishing Survey Kit. The survey kit was developed by Balkanu Cape York Development Corporation, Queensland Department of Primary Industries and Fisheries, and the Queensland Environment Protection Agency. It was adopted in this study as it allows Indigenous groups to collect their own fishing data in a manner deemed acceptable by the community. The survey is unique in that it starts by asking the community what it is they want to achieve and how the survey should be undertaken.

This survey was initiated to overcome the lack of data on Indigenous subsistence fishing in Australia. Prior to this study, the Queensland Department of Primary Industries and Fisheries had no reliable data on the type or quantity of aquatic resources harvested by Indigenous fishers for traditional or cultural use (Tropical Fin Fish Management Advisory Committee, 1998). The importance of rectifying the situation is most evident in the *Fisheries (Gulf of Carpentaria Inshore Fin Fish) Management Plan 1999*. The Plan states that:

> 'The provision of a fishery that satisfies the traditional and customary fishing needs of Aborigines and Torres Strait Islanders is to be reviewed if surveys of participation in traditional or customary fishing that are accepted by the Authority show a significant decline in catches or participation'.

4.2 Aim

The aim of this component of my thesis was to conduct a qualitative survey of the utilisation of aquatic resources by the Indigenous subsistence fishers of Injinoo Aboriginal Community.

4.3 Methods

The present survey was based on the format suggested in the Indigenous Subsistence Fishing Survey Kit. The survey kit was developed to guide monitoring surveys undertaken in Indigenous communities. Recognising the diverse needs of individual communities, the survey kit states that the methods suggested are provided as a guide only. However, following the format as close as possible is advantageous, as this approach allows future studies which also adopt the survey kit to be directly compared.

The deviations that I made from the suggested format of the Indigenous Subsistence Fishing Survey Kit were:

- The data sheets of the interview style survey, door to door survey, and monitoring surveys were customised to the needs of Injinoo Aboriginal Community. The needs of the community were identified in the steps prior to the development of each survey.
- The decision to conduct either creel (esky) or access point monitoring surveys (Stage 10) was made after the door to door survey (Stage 9) was completed, not before as suggested in the survey kit. In this manner, the door to door survey complemented and confirmed the data profiled in the community survey assessment (Stage 6).
- Opportunities for the community to provide feed back at the completion of the surveys were provided so that the success of the project could be gauged for the benefit of future studies.

The survey methodology I adopted is outlined in the flow diagram below (see Table 4.1), and is explained in detail in the pages immediately following.

Table 4.1: Stages in the development and implementation of the Indigenous Subsistence Fishing Survey conducted at Injinoo Aboriginal Community.

1. Identification of community needs	1994
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2. Induction	Nov. 1998
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3. Community consultation	Nov. 1998+
↓	
Updates and feedback	Nov. 1998+
↓	
4. Community background survey	Dec. 1998+
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5. Interview style survey	Dec. 1998
↓	
6. Community survey assessment	Dec. 1998
↓	
Update and feedback	Dec. 1998+
↓	
7. Project team selection	Jan. 1999
↓	
8. Project team training	Jan. 1999
↓	
9. Door to door survey	Jan. 1999
↓	
10. Survey preparation	Jan. 1999
↓	
Update and feedback	Jan. 1999+
↓	
11. Monitoring surveys	Jan. 1999 – Aug. 2000
↓	
Update and feedback	Aug. 2000+
↓	
12. Data access	Aug 2000+
↓	
13. Findings presented to community	Nov 2000
↓	
Update and feedback	Nov 2000+

4.3.1 Identification of community needs (Stage 1)

Community concern for the sustainability of the harvest of black jewfish and other stocks in the local subsistence fishery were first raised publicly in 1994. These concerns were voiced by representatives of Injinoo Aboriginal Community during meetings with the Great Barrier Reef Marine Park Authority. Following the raised awareness of the concerns of the Indigenous fishers of Injinoo, the Indigenous Subsistence Fishing Survey Kit was identified by Balkanu Cape York Development Corporation as an appropriate tool for profiling the subsistence fishery of Injinoo Aboriginal Community. The Fisheries Research and Development Corporation granted funding in mid 1998.

4.3.2 Induction (Stage 2)

In late 1998, I was invited by Balkanu Cape York Development Corporation to implement and coordinate the survey of the subsistence fishery at Injinoo Aboriginal Community. The survey was conducted at the same time as an assessment of the harvest and biology of black jewfish (see Chapter 5). Prior to departing for Injinoo, I resided in Cairns (16° 55 S, 145° 46' E) for a period of three weeks in order to organise logistics and liaise with the agencies that developed the Indigenous Subsistence Fishing Survey Kit (Queensland Environment Protection Authority, Queensland Department of Primary Industries and Fisheries, and Balkanu Cape York Development Corporation). During this period, I also consulted several Injinoo Aboriginal Community members and representatives that resided in Cairns.

4.3.3 Community consultation (Stage 3)

Prior to the commencement of the initial surveys, I invested a period of two weeks at Injinoo meeting the community residents and introducing the goals of the study. Although seemingly unproductive in terms of annotated returns, feedback generated at a later stage proved that this period was essential to gaining the understanding and trust of community members. To ensure the continuing support for the study, at all stages in the project's development I consulted the Community Council's Clerk (Mr

Robbie Salee). The Clerk was also appointed to the project steering committee to represent the interests of the community.

4.3.4 Community background survey (Stage 4)

The community background survey provided a description of the environment in which the present survey was conducted. The community background survey was conducted in December 1998 and collected information about the community's fishing activities and peoples' views about fishing. The survey also collected information about the community's fishing area, local fishing issues, fishing history, and the legislative regimen governing Indigenous subsistence fishing. I collected this information through: (1) interviews with representative community fishers and hunters, and (2) a review of all available literature relating to the region. This information was utilised in the planning of future surveys (i.e., the interview style survey, door to door survey, and monitoring surveys).

4.3.5 Interview style survey (Stage 5)

The interview style survey provided the means for the community to design where, when and how they preferred to be surveyed. I conducted the interview style survey in December 1998. Each household in the community was visited and volunteer representatives of the household were interviewed. Representatives were chosen by the residents, but were required to possess a clear knowledge of the subsistence fishing activities conducted by members of the household. Representatives of 44 households contributed to the interview style survey, representing 92% of the 48 households at Injinoo. Most of interviewees were male (64% vs. 36% female), a consequence of the random selection of the households.

4.3.6 Community survey assessment (Stage 6)

The information gained from the community background survey (Stage 4) and the interview style survey (Stage 5) was collated to form a summary termed the 'community survey assessment'. The results of the community survey assessment are presented in Chapter 4.4.1. The review of all available literature, conducted as part of the community background survey, has been presented in Chapter 2 to provide a context for this thesis.

4.3.7 Project team selection (Stage 7)

The community survey assessment (Stage 6) revealed that the people of Injinoo strongly preferred members of the local community to monitor their use of aquatic resources. This result had been anticipated in the project budget and funds were made available by the Fisheries Research and Development Corporation to employ to two survey facilitators per day for seventy survey days. Subsequently these positions were advertised within Injinoo Aboriginal Community. The ability to identify local marine and freshwater species, and the ability to work with a minimum of supervision, were essential prerequisites for these positions. Those people that expressed an interest in the positions were invited to attend a formal meeting in which the applicants were informed in detail of the tasks required of the survey facilitators (Stages 8-11). All applicants were employed on a rotating roster. Persons employed as survey facilitators are listed in the ‘Contribution of Others’ located in the opening pages of this thesis.

4.3.8 Project team training (Stage 8)

I trained the survey facilitators in all aspects of the project to ensure that the future stages were undertaken in an appropriate and efficient manner. The facilitators were trained to conduct the door to door survey (Stage 9) and the monitoring surveys (Stage 11) in accordance with the protocols proposed in the Indigenous Subsistence Fishing Survey Kit. The survey facilitators were each provided with a copy of the survey kit for their own reference, and were encouraged to provide suggestions to improve each stage of the project's development. I was present at Injinoo for most of the survey days and randomly accompanied team members to check and confirm that the results where a true representation of the local fishery.

4.3.9 Door to door survey (Stage 9)

The door to door survey provided information on when, where, and how the Indigenous people of the community conducted subsistence activities utilising aquatic resources. The survey facilitators conducted the door to door survey in January 1999. The survey facilitators visited each household in the community and interviewed volunteer representatives. Over 90% of households in the community were interviewed. I was also able to gain a greater understanding of the community's subsistence activities by participating as an invited observer in over 30 fishing, hunting or gathering trips. These trips targeted a wide variety of species, used a range of methods, and were conducted during a variety of seasonal and weather conditions.

4.3.10 Survey preparation (Stage 10)

The community background survey (Stage 4) and door to door survey (Stage 9) were conducted to provide the baseline information necessary to design the most appropriate method (in terms of efficiency and community acceptance) of conducting the monitoring surveys. The Indigenous Subsistence Fishing Survey Kit recommends that either creel (esky) surveys or access point surveys should be adopted to monitor marine and freshwater resource use. In creel surveys, the facilitators interview fishers along a pre-planned route travelled at various times within a particular survey day. In access point surveys, the facilitators interview fishers at pre-determined access sites throughout the survey day. With the assistance of the survey facilitators, I determined that creel (esky) surveys were the most suitable means of monitoring subsistence fishing at Injinoo Aboriginal Community. Access point surveys were deemed less suitable because: (1) there were at least six access points within the survey area, and (2) a high volume of fishing activity was conducted during the night.

4.3.11 Monitoring surveys (Stage 11)

Monitoring surveys commenced in January 1999 and continued every month through to August 2000. Each month, between three and five days were randomly chosen for surveying. Catch details were collected on a total of 70 days (set by the capacity of the project budget). On the days of the survey, two survey facilitators conducted a minimum of three runs per day along a pre-selected route that incorporated the water access points identified in the background survey (see Figure 4.1). Popular shore-based fishing spots between the access sites were also examined en route. The runs of the route were conducted early morning, again at midday, and finally close to dusk.

At each site, survey facilitators interviewed all of the groups of fishers encountered. They recorded the type, quantity and length of the aquatic resources harvested, together with details of the fishing trips such as the number of people involved, the location and time of effort.

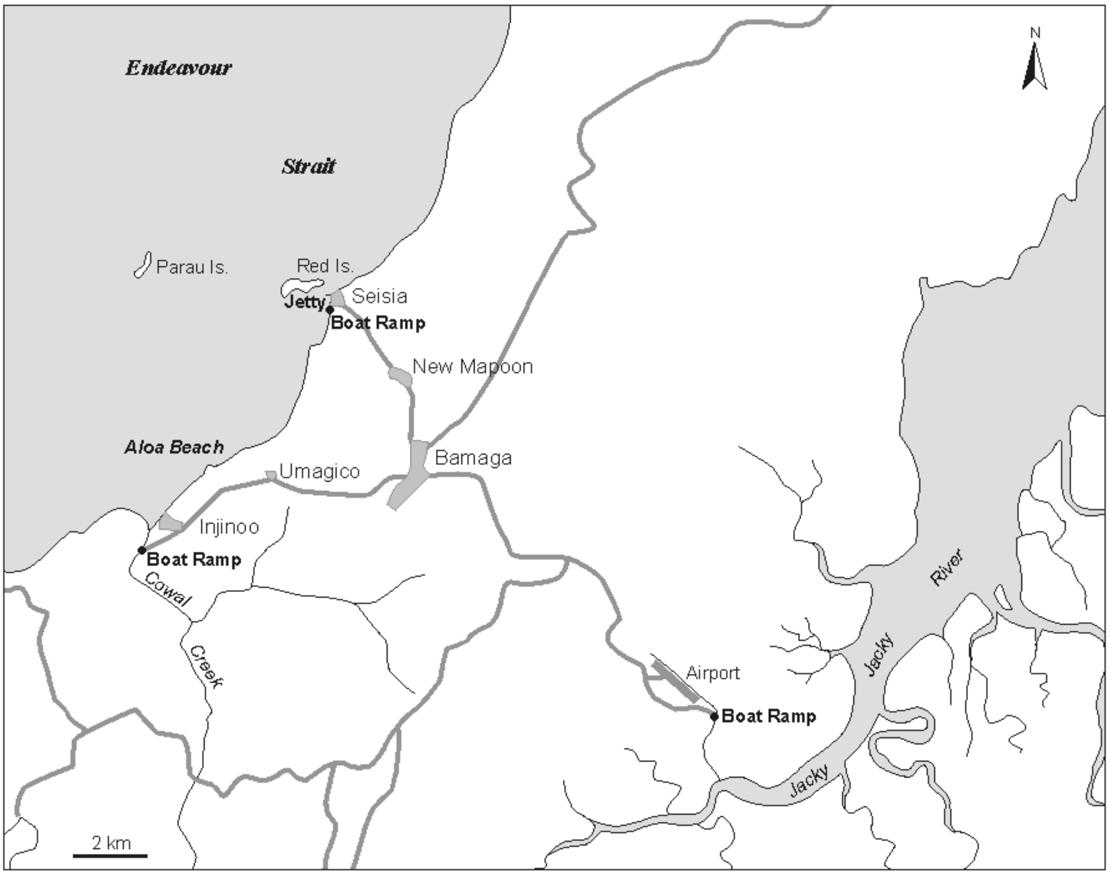

Figure 4.1: Map of the survey route using during the monitoring surveys.

As the fishers may not have completed fishing at the time the survey facilitators visited the site, the catch data initially recorded may not have accurately represented the day's total catch. Hence, at each site, the facilitators recorded the names of fishers who had not yet finished fishing for the day. Fishers out in vessels were identified by the cars or trailers at the boat ramp; the small population of the community (~350 people) made this possible. In the intervals between travelling the route, the facilitators visited the homes of these fishers, and whenever possible, the fishers were interviewed and the catch was examined.

4.3.12 Data access (Stage 12)

The data obtained through the monitoring surveys was entered into a database developed by the agencies that designed the Indigenous Subsistence Fishing Survey Kit. The database stores quantitative information on the community use of aquatic resources for subsistence purposes. According to the project agreement between Balkanu Cape York Development Corporation, Queensland Department of Primary Industries and Fisheries and the Fisheries Research and Development Corporation, this information is fully controlled by the Injinoo Aboriginal Community. Permission to present the data contained in this thesis was provided by the Chair of the Injinoo Land Trust, Mr Robbie Sallee.

4.4 Results

4.4.1 Community survey assessment

There are individuals residing at Injinoo who identify themselves as the Traditional Owners of estates that extend beyond the coast of Northern Cape York Peninsula. Many of these people expressed a strong desire to maintain their obligations to protect their customary sea estates, and to ensure the sustainable use of their resources. Injinoo is a multi-cultural community composed of many people from Aboriginal and Torres Strait Islander nations, and a non-Indigenous minority (generally <3% of the population). The people of Injinoo speak many languages, the most universal of which is Creole. The commonly used names of exploited species are listed in Appendix 1.

While some Indigenous fishers believe that aquatic resources are inexhaustible, others expressed the belief that some of the harvested species, for example black jewfish, had become relatively scarce. There was also some concern for the sustainability of the harvest of some species perceived to be vulnerable to overexploitation, for example, dugong. Mythology explaining the reduction in the availability of some species, such as the dugong, was widely accepted. Traditional beliefs and customs of the Indigenous people of Injinoo were commonly practised, and respect for Elders was strong. There was widespread importance placed on providing the children of the community and future generations with the opportunity to use their country in a productive manner.

The results of the interview style survey (see Appendix 2) demonstrated overwhelming support for the commencement of this study, with 98% of households interviewed (n = 44) approving of the project. The survey indicated that the household representatives thought it would be of most benefit to the community if the harvest of all aquatic resources used by the community were monitored (i.e. fish, sharks, rays, marine mammals, aquatic reptiles, crustaceans and molluscs).

The interview style survey (see Appendix 3) also revealed that the subsistence fishers of Injinoo held a clear preference for the monitoring of catches to be undertaken by an Indigenous person (81%). Fifty-nine percent of the interviewees suggested this person should be any Indigenous resident from Injinoo, 14% wanted any person of their own clan; and 9% specified that any community ranger would suffice. All interviewees were asked whether they preferred males or females to conduct the surveys. In response, 89% stated they had no preference for the gender of the survey facilitators. The five interviewees that held a preference were all females, and each of these women stated that they preferred males to conduct the surveys.

The background survey revealed that at least six access points were utilised by the subsistence fishers of Injinoo. The access points identified were Jacky Jacky boat ramp, Seisia boat ramp, Injinoo boat-ramp and two dirt ramps along Cowal Creek (see Figure 4.1). When asked in the interview style survey where they would prefer the monitoring surveys to be conducted, community members indicated their preference for roadside monitoring stations (43%), compared with monitoring at the fishing site (30%) or at the person's home (27%). No specific cultural protocols were identified as relevant to conducting the monitoring surveys at the roadside, fishing locations or at the fishers' homes.

4.4.2 Door to door survey

The vast majority of Indigenous people at Injinoo Aboriginal Community regularly harvested marine or freshwater resources for subsistence purposes. Ninety-five percent of household representatives participating in the door to door survey (n = 44) stated that at least one member of the family had been involved in subsistence activities within the last twelve months that had harvested aquatic resources. Most participated in such activities on a weekly (1-2 times/week), or daily (3-7 times/week) basis (see Figure 4.2). The survey also revealed all gathering and fishing trips lasted less than 24 hours.

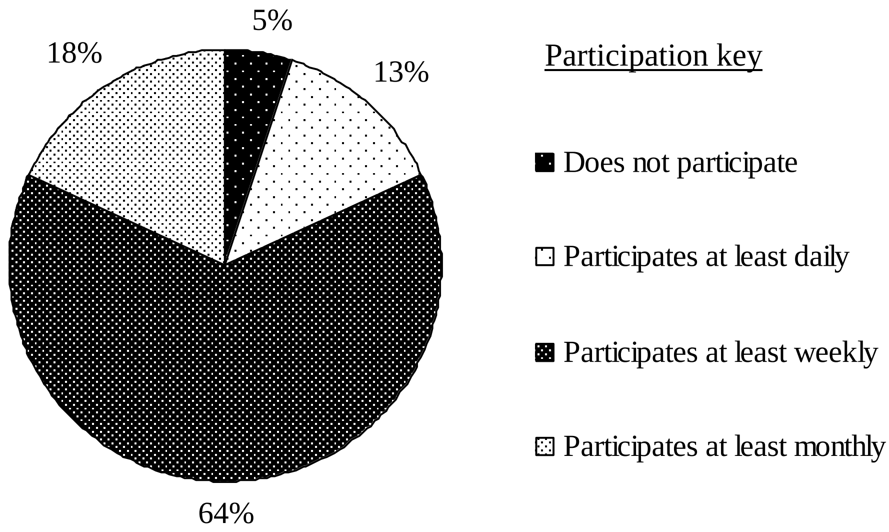

Figure 4.2: The rate of which households at Injinoo Aboriginal Community participated in the subsistence fishery (n = 44 households).

Only 5% of the interviewees that stated members of their household conducted subsistence harvesting activities alone, the majority choose to participate in a group of between three to five people (see Figure 4.3). Most of the catch harvested by the Indigenous fishers at Injinoo was shared among the fisher's family (see Figure 4.4). Most fishers typically divided their catch with their extended family (58%) and immediate family (27%). Many fishers (13%) shared their catch with the community beyond family lines.

A range of equipment was used by the subsistence fishers, with the most widely adopted being the handline (see Figure 4.5). Gathering activities were the next most common, followed by fish spearing and netting. No subsistence fishers regularly utilised fishing rods or cast/bait nets. Boat ownership was high within the community, with 61% of households stating they owned a seaworthy vessel (4.1 to 6 m vessels powered by 30 to 100 hp outboards). This was only marginally less than car ownership (69%).

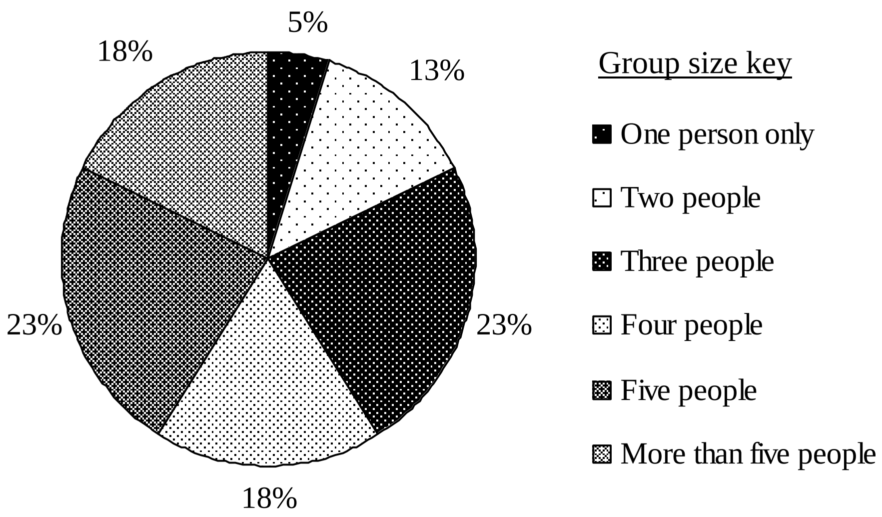

Figure 4.3: The size of groups conducting subsistence harvesting activities from Injinoo Aboriginal Community (n = 44 households).

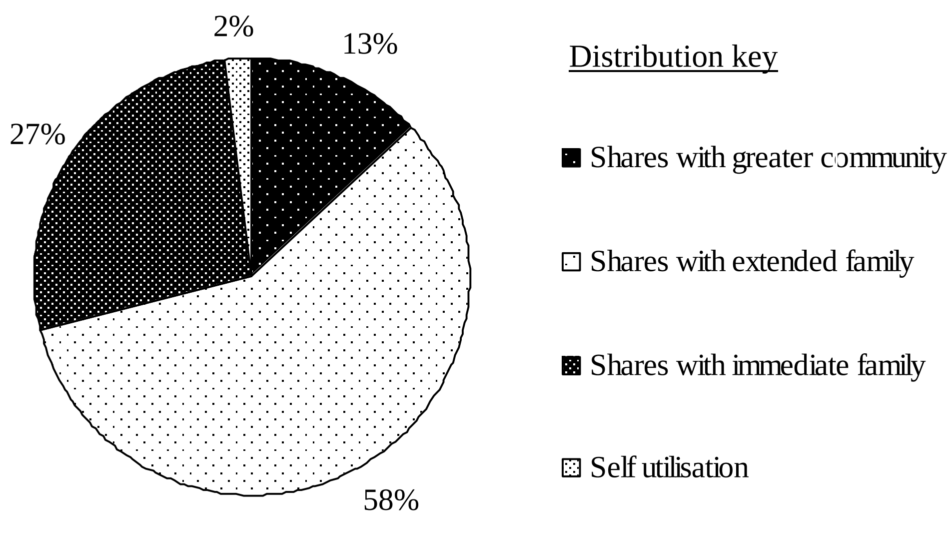

Figure 4.4: The extent to which the Indigenous fishers of Injinoo Aboriginal Community distribute the aquatic resources that they have harvested (n = 44 households).

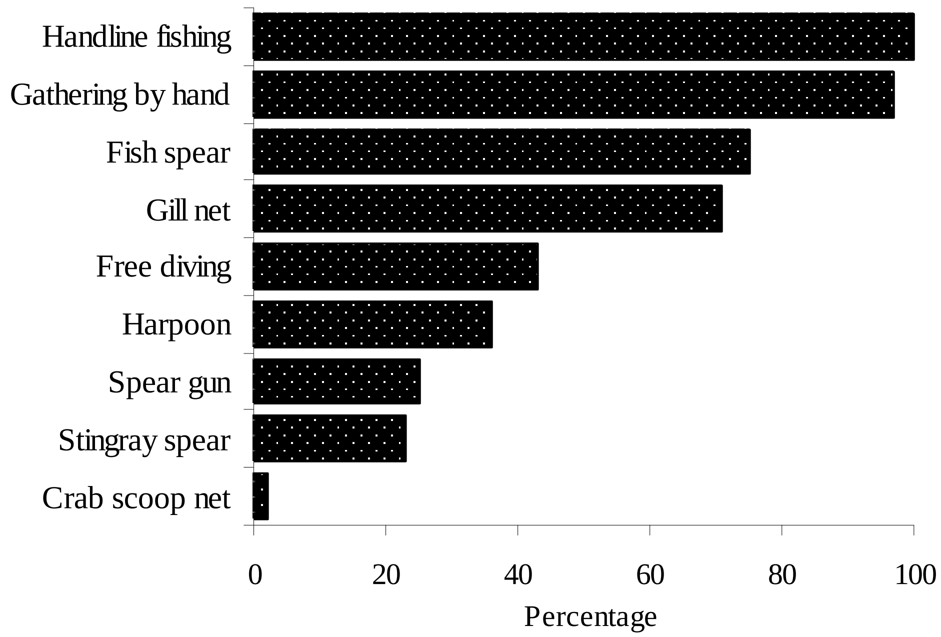

Figure 4.5: The percentage of people who utilise the different types of subsistence harvesting tools identified in the background survey (n = 44 households).

During the door to door survey, the household representatives were asked the question 'do you fish for subsistence proposes'. One hundred percent of the interviewees responded yes, but when asked 'do you fish for fun', 91% said no. In July 2000, this question was re-examined in a specific questionnaire. This new survey asked fishers to rate the importance of 'catching a fish' and 'having fun' on scales of one to ten (one being of little importance, ten being of great importance). Interviewees (n = 40) represented a random cross-section of the greater Northern Cape York Peninsula community.

The response to these questions revealed a major difference in the way Indigenous people and non-Indigenous people in Northern Cape York Peninsula value fishing activities. Indigenous fishers (n = 20) attached a great importance of 'catching a fish' (all interviews rated this 10 out the scale of 10), while non-Indigenous fishers (n = 20) provided a mean score of only 3.5 (range: 0 to 6). Conversely, Indigenous people attached little importance to having fun, providing a mean score of only 1.6 (range: 0 to 5) while non-Indigenous fishers scored a much higher mean of 8.4 (range: 6 to 10).

4.4.3 Monitoring surveys

4.4.3.1 Fishing location

The monitoring surveys revealed the general area in which the Indigenous fishers of Injinoo conducted subsistence harvesting activities (see Figure 4.6). The greatest concentration of effort occurred in the area west of between Muttee Head and Number Two River (44% of all effort), followed closely by the area between Muttee Head and Peak Point (36%).

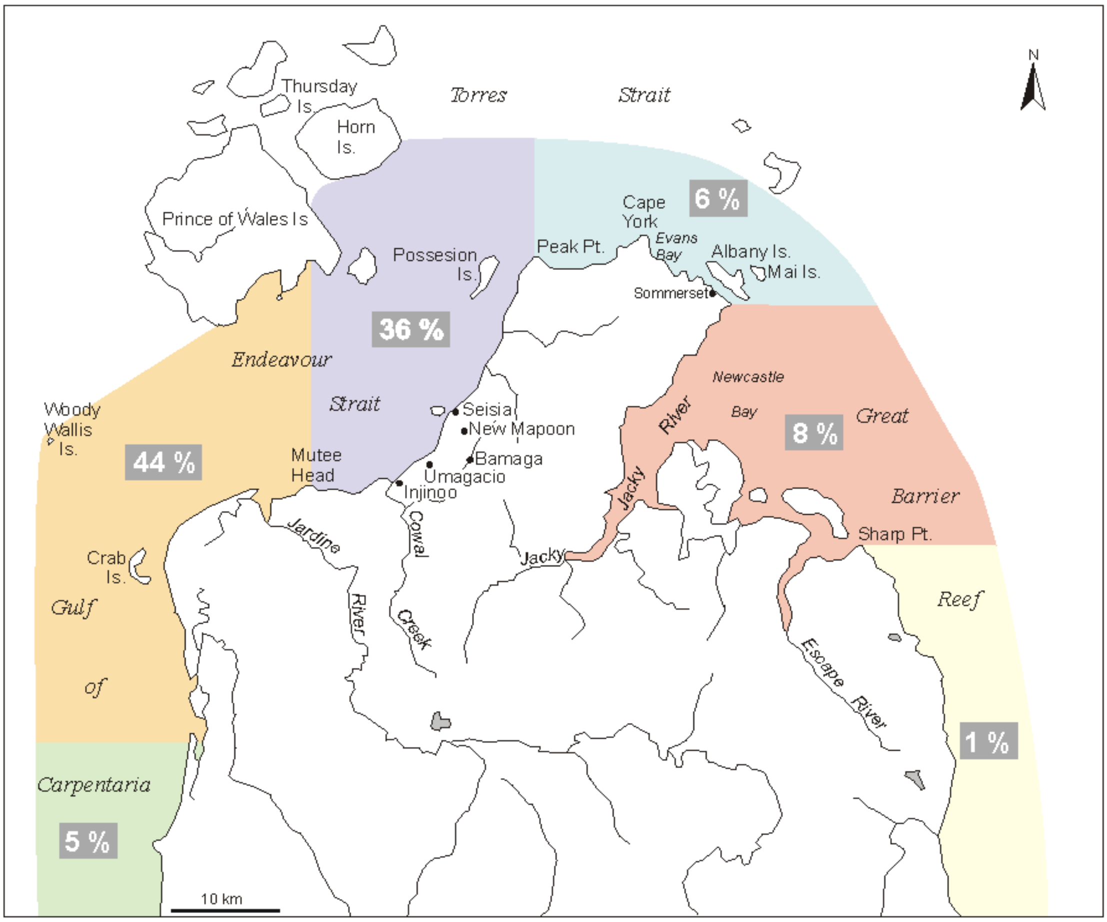

Figure 4.6: Map of Northern Cape York Peninsula displaying the distribution of fishing, hunting and gathering activities recorded in the monitoring surveys (n = 70 survey days).

4.4.3.2 Allocation of effort

Three categories of harvesting methods were recorded: fishing, hunting and gathering) to capture a variety of gears (see Table 4.2).

Table 4.2: Description of the categories and types of subsistence harvesting activities observed in the monitoring surveys (n = 70 survey days).

Activity	Defining attribute
Fishing	**Targeting of fish and sharks**
Handline	Use of a handline to hook fish and shark
Net	Use of a net to entangle fish, shark and crabs
Troll	Use of trolling equipment to hook pelagic fish
Spear	Use of a spear to capture fish or benthic animals
Hunting	**Targeting of elusive animals**
Dugong	Use of a wap to capture dugong
Turtles	Use of a wap to capture turtles
Stingrays	Use of a spear to capture stingrays
Gathering	**Targeting of stationary or slowing moving animals**
Crustaceans	The gathering of crustaceans by hand, scoop net or spear
Molluscs	The gathering of molluscs by hand
Turtle eggs	The gathering of turtle eggs by hand or with a stick (pat)

A total of 177 harvesting trips were recorded in the monitoring surveys (see Table 4.3). Handline fishing was the most frequent recorded activity, accounting for 62% of all trips. This was followed by netting, which accounted for 13% of all trips. Dugong hunting (11% of trips) and turtle hunting (10% of trips) followed, with the most common gathering activity being those that targeted crustaceans (8%). The harvesting activities involved a mean of four people per trip (see Table 4.3). The most labour intensive harvesting activity was netting with a mean group size of five people. Spearing fishing was the only activity to record a mean group size of one, but only one spearing trip was recorded in the monitoring surveys.

Table 4.3: The number of trips and the size of the groups of fishers recorded in the monitoring surveys (n = 70 survey days).

Activity	Total of recorded trips	Percentage of recorded trips	Range of group sizes recorded	Mean of group sizes recorded
Fishing	**110**	**62**	**1 to 10+**	**4**
Handline	80	45	1 to 10+	4
Net	23	13	4 to 10+	5
Troll	6	3	3 to 6	4
Spear	1	1	1	1
Hunting	**39**	**22**	**2 to 4**	**3**
Dugong	19	11	3 to 4	3
Turtles	18	10	2 to 4	3
Stingrays	2	1	4 to 4	4
Gathering	**28**	**16**	**1 to 6**	**4**
Crustaceans	14	8	1 to 5	4
Molluscs	7	4	3 to 6	4
Turtle eggs	7	4	3 to 6	3
Total	**177**	**100**	**1 to 10+**	**4**

The monitoring surveys recorded a total of 491 hours of effort (includes travelling to the harvesting grounds and searching) (see Table 4.4). The recorded hours were dominated by handline fishing (57% of all hours), dugong hunting (15%), turtle hunting (9%) and netting (9%). The duration of harvesting trips ranged between 0.5 hours to 9 hours, with a mean of only two hours (see Table 4.4). Handline fishing and dugong hunting had the longest mean duration (4 hours each), while turtle egg collecting (0.5 h) and mollusc gathering (0.5 h) were the briefest of all activities.

Table 4.4: The amount of effort (hours) recorded in the monitoring surveys (n = 70 survey days).

Activity	**Total hours recorded in 70 days**	**Percentage of recorded hours**	**Range of hours recorded**	**Mean hours recorded per trip**
Fishing	**333**	**68**	**0.5 to 8**	**2**
Handline	280	57	0.5 to 8	4
Net	46	9	0.5 to 6	2
Troll	6	1	1	1
Spear	1	1	1	1
Hunting	**123**	**25**	**1 to 9**	**3**
Dugong	76	15	3 to 9	4
Turtles	45	9	2 to 4	3
Stingrays	2	1	1	1
Gathering	**35**	**8**	**0.5 to 2**	**1**
Crustaceans	28	6	1 to 2	2
Molluscs	4	1	0.5	0.5
Turtle eggs	4	1	0.5 to 1	0.5
Total	**491**	**100**	**0.5 to 9**	**2**

Adult male fishers participated in each type of harvesting activity, while females and children participated in only some of the activities (see Table 4.5). Males dominated the vessel based activities such as trolling and dugong hunting. The only vessel based activities in which females and children participated were handline fishing, netting and crustacean gathering. Females and children did not participate in dugong, turtle or stingray hunting activities during the survey days.

Table 4.5: The sex and age groups of participants recorded in the monitoring surveys (n = 70 survey days).

Activity	Sex of participants	Age groups of participants	Vessel or shore based activity
Fishing			
Handline	Male and female	Adult and children	Vessel and shore
Net	Male and female	Adult and children	Vessel and shore
Troll	Male	Adult	Vessel
Spear	Male	Adult	Vessel and shore
Hunting			
Dugong	Male	Adult	Vessel
Turtles	Male	Adult	Vessel
Stingrays	Male	Adult	Vessel
Gathering			
Crustaceans	Male and female	Adult and children	Vessel and shore
Molluscs	Male and female	Adult and children	Shore
Turtle eggs	Male and female	Adult and children	Shore

4.4.3.3 Fishing methods

Fish

Line fishing was the most frequently identified subsistence harvesting method for targeting fish. Injinoo's Indigenous fishers had not adopted rod and reels; all line fishing was conducted using handlines. The Indigenous fishers typically rigged 20 to 100 lb monofilament lines with a hook on a short (~5 cm) leader set 30 to 40 cm from a terminal sinker. Lines of higher breaking strain were adopted when targeting large fish (e.g., black jewfish) or when lure fishing. The only lures observed were silver spoon lures that were used for trolling.

Fish were also harvested with fish spears made with three to six metal prongs (~15 cm) extending from a long, narrow bamboo shaft (see Figure 4.7). Fish were speared while the fisher waded in shallow water, or alternatively, as the fisher stood at the bow of a vessel moving slowly over a reef area. Many of the fishers of Injinoo were skilled in the use of fish spears, though this method of fishing was seldom used. The use of two types of nets was more common: set nets and drag nets.

Figure 4.7: Spear utilised by Injinoo's Indigenous subsistence fishers to harvest fish.

Monofilaments set nets of small mesh sizes (typically 3 to 7 cm stretched mesh) were frequently adopted, representing 9.3% of all effort recorded in the monitoring surveys. Generally, nets were set in shallow coastal waters and within tidal reaches of tributaries. The fishers positioned the nets according to the direction of the tide or water flow. The duration of time the nets were set was highly variable, depending largely on the success rate of the location. Typically, the fishers checked the nets every 15 to 30 minutes and retrieved any fish caught in the net. Nets were sometimes left unattended for longer periods to allow the fishers to participate in other activities.

The subsistence fishers also dragged nets in waters adjacent to sandy beaches or inshore sand bars. Drag nets were worked from a dinghy or from the shore, and were manoeuvred to sweep over the deepest water allowable. These nets were used only in areas free of substrate fauna, rocks etc, that may catch or damage the net. Therefore, I speculate damage to the substrate was limited. The process of drag netting typically involved four or more people moving along the ends of the net in a boisterous manner in order to scare the fish into the entrapment area. Drags typically covered less than

100 m of shoreline, and ended on the beach or in the shallows where the nets could be cleared.

Almost all of each harvested fish was used, with the meat, head, frame and eggs being utilised on most occasions.

Sharks and stingrays

Sharks retained by the Indigenous subsistence fishers were all caught as incidental catch while line fishing for fish. In contrast, stingrays were specifically targeted, and were hunted from vessels slowly manoeuvring along shallow coastal waters or tributaries. The stingrays were all caught using stingray spears which were made with a single ~50 cm prong (see Figure 4.8). The three or five pronged fish spears (see Figure 4.7) were rarely used to catch stingrays.

Figure 4.8: Spear utilised by Injinoo's Indigenous subsistence fishers to harvest stingray.

Marine mammals

Dugongs were harvested using a harpoon (wap) made with a hardwood shaft and a bamboo extension (see Figure 4.9). The hardwood end of the wap was loaded with a detachable serrated metal prong (kuiur), or more commonly, a prong made of three metal nails bound at the base (tata). These were secured to a synthetic haul line generally longer than 30 m. The wap was also attached to the haul line, but in order to aid the quick recovery of the wap from the water, it was attached in manner that allowed it to run freely along the line. The prongs used in harvesting dugongs were longer than those used in hunting turtles so that the metal would penetrate deep into the blubber beneath the dugong’s skin, and thereby retain a strong hold.

Figure 4.9: Wap (centre) and detachable tata (left) utilised by Injinoo's Indigenous subsistence fishers to harvest dugongs and turtles.

The location and method of hunting dugongs varied with the prevailing conditions. At times, when the moon was dark and the sea was calm, dugongs were hunted at night from a powered vessel by traversing large areas in a noisy manner with the intention of frightening the animals into a quick retreat. In doing so, the large moving animals left a glowing trail of phosphorescence which was easily followed at high speeds. The lead-hunter standing at the bow always directed the chase. When a dugong broke the surface to breathe, the wap was struck at the animal’s dorsal section so that the tata, attached to a length of rope, detached itself from the wap.

The vertically floating wap was swiftly recovered and the dugong quickly pursued. When the vessel was able to get close enough, a second tata was lodged into the dugong to secure the catch. Once the animal began to tire, the line was hauled in and the vessel brought alongside the animal. It was only when the dugong had become exhausted that the hunters could attempt to place a rope with a sliding loop knot around the tail. Before the animal was lifted into the boat, it was held upside down so that it could not breathe and hence drowned. Alternatively, the dugong was towed behind the vessel until it had drowned.

On occasions when the sea was calm and all other conditions were considered right, dugongs were hunted at first light. Here the dugong was tracked by following floating seagrass debris or ripples in the water as the animals moved or surfaced to breathe. In this kind of hunt, stealth was vital to success, for even the splash of a wave on the side of vessel was said to scare dugongs away. Hence, small (~2 to 3 m) wooden rowboats were used, requiring great skill and patience to move close enough to lodge the tata into the animal's back. At that point, the chase of the dugong was taken up by a waiting powered boat, which quickly followed the end of the line to which a large float was attached.

The successful hunting of dugongs requires many skills (such as great balance and strength), and necessitates an intricate understanding of the animals' interactions with the environment. Successful hunters were able to interpret the conditions and predict the animals' movements. Of the community of ~350 people at Injinoo, only five people regularly led dugong hunts. Others may, and occasionally did attempt to hunt dugongs, but only males participated in hunting trips (see Chapter 4.4.3.2).

Reflecting the great cultural importance of the dugong to the Indigenous people of Northern Cape York Peninsula, dugong meat was very highly regarded and was considered requisite fare for important community events. Captured dugongs were always butchered by the next morning, an event that typically attracted a large gathering of people. The dugong meat was always distributed around the community, and almost all of each animal was used, including the meat, brain, oil, skeleton, and fins. The meat from the underside of the dugong, where the skin is paler in colour, was the prized cut.

Aquatic reptiles

Green turtles (*Chelonia mydas*) were caught by the subsistence fishers of Injinoo using the same harpoon (wap) used to hunt dugongs (see Figure 4.9). The hardwood end was loaded with a detachable prong (tata) made of three sharpened metal lengths bound at the base. The tata used for harvesting turtles were slightly shorter than those used to catch dugongs. Hence, the prong was designed to penetrate only the carapace and not the underlying flesh, and so retain a greater hold on the impaled animal.

Like dugong hunting, the prevailing conditions determined the time, location and method of hunting turtles. Most commonly, turtles were hunted from powered vessels during periods of calm water, both by day and by night (with the aid of a spotlight). The lead-hunter typically rode at the bow of the vessel and directed the hunt at all stages. The hunters commonly targeted mating turtles near Horn Island (see Figure 1.1) and Crab Island (10° 58' S, 142° 06' E: see Figure 1.1). When a turtle was located, the loaded end of the wap was jabbed at the carapace so that the tata, attached to a length of rope, detached itself from the wap.

The bamboo extension ensured the wap floated vertically in the water, benefiting its quick recovery if let go. Tension was maintained on the haul line, and the vessel immediately pursued the turtle (directed by the lead-hunter) to assist hauling in the line. Once the turtle neared the surface for a breath, one of the hunters would dive into the water and placed a large (~30 to 40 cm) homemade hook into the turtle between the carapace and the fore flipper. The hook aids in holding the animal alongside the vessel. Once secured alongside, a rope slip-knot was then placed around the two fore flippers and the turtle was lifted into the vessel.

Once ashore, the turtle was placed on its back in the shade where it remained until the hunters were ready to process the animal. Although seven days was the longest period I observed turtles remaining on their backs, I was advised that turtles could survive weeks in this position when kept wet. Where the spear tip had pierced the carapace, the hole was commonly plugged with a section of cloth or bark. Almost the entire butchered animal was utilised, including the blood, meat, and part of the intestines. Even the carapaces were used when cooking in traditional ground ovens (kup muri).

Eggs (kakur) of green turtles, hawksbill turtles (*Eretmochely imbricata*) and flatback turtles (*Natator depressus*) were harvested from the sand dunes of the mainland and island beaches. Typically, the tracks of nesting adults were spotted from aboard a dinghy travelling parallel to the shoreline. The exact location of the nest was located by poking a sharpened tree branch (pat) into the sand and feeling its compaction. Alternatively, the tip of the pat was checked for the dampness of broken eggs. The freshness of the eggs was determined from the feel of the shell. Only nests within three days of laying were utilised and every egg from the nest was harvested. The eggs were not cold-stored unless they had been boiled.

Long-necked freshwater tortoises (Family Chelidae) were harvested opportunistically by the hunters of Injinoo. Occasionally, these freshwater turtles were picked up when spotted crossing a road. They survive well in holding ponds and were often retained for a period of weeks in order to fatten up the animal. Saltwater crocodiles (*Crocodylus porosus*) were not hunted despite their ready availability. One live crocodile (~2 m) was imported to Injinoo from outside of the region; only the meat was used.

Crustaceans and molluscs

Mud crabs (*Scylla serrata*) and sand crabs (*Portunus pelagicus*) were typically taken by spear (see Figures 4.7 and 4.8) or scooped up in fish landing nets. Most activity targeting crabs occurred during low tides along the mangrove lined tributaries of the west coast. Injinoo subsistence fishers did not use crab pots at the time of the monitoring surveys, although crabs were sometimes caught as incidental catch in nets. Spear gun divers working along the fringing reefs collected crayfish (*Panulirus* spp.) during the day. Crayfish were also harvested at night by spearing from a dinghy rigged with lights set up to illuminate the water (which attracts the crayfish to the surface). Hookah dives were not conducted by the Indigenous fishers of Injinoo to collect crayfish for subsistence purposes.

Bivalves were collected from the intertidal zone of sandy beaches and along the rocky headlands. Oysters (*Pinctada* spp.) were typically eaten immediately, and cockels (*Anadara* spp.) boiled and consumed fresh. Clams (*Tridacna* spp.) were identified during the background survey as an exploited species, although no specimens were recorded in monitoring surveys. Clam shells observed in the community area indicated that specimens 30-40 cm were typically targeted.

A4.4.3.4 Catch composition

A diverse range of marine and freshwater resources were harvested by the Indigenous subsistence fishers of Injinoo Aboriginal Community between January 1999 and August 2000 (see Table 4.6). Survey facilitators recorded the harvest of 75 marine and freshwater taxa which they identified to species, genus or family. In the following pages, I list and discuss the harvested taxa. The Injinoo creole names of the harvested taxa are listed in Appendix 1.

Table 4.6: Composition of harvest recorded in the monitoring surveys (n = 70 survey days).

Activity	Number of specimens	Number of taxa
Fishing	**1629 (approx)**	**59**
Handline	1052	47
Net	621 (approx.)	22
Troll	7	3
Spear	2	2
Hunting	**36**	**4**
Dugongs	14	1
Turtles	19	1
Stingrays	3	2
Gathering	**261 (approx)**	**8**
Crustaceans	129	3
Molluscs	120 (approx.)	2
Turtle eggs	12 (nests)	3
Total	**1979 (approx.)**	**75**

Fish

The fish species recorded in the monitoring surveys are listed in Table 4.7. The five most frequently harvested fish were:

1. Mullet (Family Mugilidae).
2. Sweetlip (*Lethrinus* spp.).
3. Stripey (*Lutjanus carponotatus*).
4. Snappers (*Lutjanus* spp.), and
5. Black jewfish.

Mullets were harvested primarily by hauling nets, the remainder of these five fish species were harvested primarily by line fishing.

Table 4.7: Details of the fish recorded in the monitoring surveys (n = 70 survey days).

Scientific name	**Common name**	**Mean length (cm TL)**	**Number of individuals recorded**
Acanthopagrus berda	Pikey bream	31	3
Alectes indicus	Diamond trevally	25	1
Arius armiger	Cat fish	29	8
Atherinomorus ogilbyi	Hardyhead	9	50
Caesio cuning	Red-bellied fusilier	21	5
Carangoides, Caranx, Gnathondon spp.	Trevally	48	61
Cephalopholis boenack	Brown-banded cod	19	13
Chirocentrus dorab	Wolf herring	75	1
Choerodon albigena	Blue tuskfish	24	41
Choerodon schoenleinii	Blue-spot tuskfish	23	16
Choerodon spp.	Tuskfish	26	89
Cymbacephalus and *Platycephalus* spp.	Flathead	34	4
Decapterus spp.	Scad	31	3
Diagramma pictum	Blackall	47	10
Eleutheronema etradactylum	Blue threadfin	42	12
Elops hawaiensis	Giant herring	44	4
Epinephelus fasciatus	Black-tipped cod	25	3
Epinephelus quoyanus	Long-finned cod	29	8
Family Hemiramphidae	Garfish	25	52
Family Mugilidae	Mullet	37	228

Hemiramphus far	Black-barred garfish	41	18
Herklotsichthys spp.	Herring	10	30
Lates calcarifer	Barramundi	64	12
Lethrinus spp.	Sweetlip	23	218
Lutjanus argentimaculatus	Mangrove jack	27	21
Lutjanus carponotatus	Stripey	19	134
Lutjanus russelli	Moses perch	30	14
Lutjanus sebae	Red emperor	34	27
Lutjanus spp.	Snappers	30	131
Lutjanus vitta	Striped sea-perch	22	16
Megalops cyprinoides	Tarpon	14	1
Monodactylus argenteus	Butter-bream	14	26
Neoniphon sammara	Blood-spot squirrel-fish	15	1
Platax novaemaculatus	Short-finned batfish	33	41
Plectorhynchus flavomaculatus	Gold-spot blubber lips	19	1
Plectropomus and *Variola* spp	Coral trout	40	38
Plectropomus maculatus	Bar-cheeked coral trout	36	31
Polynemus sheridani	King threadfin	65	14
Pomacanthus sexstriatus	Six-banded angelfish	30	2
Pomadasys spp.	Grunter	24	8
Protonibea diacanthus	Black jewfish	57	126
Rachycentron canadus	Cobia	76	1
Rhabdosargus sarba	Tarwhine	30	1
Sargocentron rubrum	Red squirrel fish	22	2
Scarus spp.	Parrot fish	28	43
Scleropages jardini	Saratoga	46	2
Scolopsis mongramma	Barred-face spinecheek	31	6
Scomberoides commersonianus	Queenfish	54	41
Scomberomorus commerson	Spanish mackerel	97	4
Scomberomorus munroi	Spotted mackerel	47	1
Selenotoca multifasciata	Stripped butterfish	16	1
Siganus doliatus	Barred spinefoot	18	3
Siganus lineatus	Golden-lined spinefoot	22	31
Siganus rivulatus	Spotted spinefoot	20	2
Sillago spp.	Whiting	28	1
Sphyraena barracuda	Barracuda	86	3
Terapon and *Pelates* spp.	Banded trumpter	16	9
Toxotes chatareus	Archerfish	14	1
Trachinotus blochi	Snub-nosed dart	32	3
Tylosurus acus melanotus	Longtom	80	1

Only hazardous species such as pike eels (*Muraenesox cinereus*), and less desired species such as catfish (*Arius* spp.), were released. Of those fish species taken for food, only specimens smaller than ~10 cm were released. Small fish (~10 to 25 cm) were colloquially known as 'pan size' and were prized for their sweet flesh. Large fish such as barracuda (*Sphyraena barracuda*), which are commonly released in other areas of Queensland for fear of ciguatera, were also retained. Few fishers at Injinoo were aware of ciguatera. Among the highly regarded large fish were cobia (*Rachycentron canadus*) and mackerel (*Scomberomorus* spp.).

Sharks and stingrays

Two shark species, the silver shark (*Carcharhinus* amblyrhynchos) and black-tip reef shark (*Carcharhinus melanopterus*), were recorded in the monitoring surveys (see Table 4.8). Not all of the Indigenous fishers of Injinoo harvested sharks, and those that did retained only the smaller specimens. All of the sharks harvested were less than one metre in total length. Two species of stingrays, the cowtail ray (*Pastinachus sephen*) and the mangrove ray (*Himantura granulata*) were harvested. Several other species, such as the lagoon ray (*Taeniura lymna*) and shovelnosed ray (*Aptychotrema rostrata*), were known to be favoured by the Indigenous subsistence fishers, but were not attained on the survey days.

Table 4.8: Details of the sharks and stingrays recorded in the monitoring surveys (n = 70 survey days).

Scientific name	**Common name**	**Mean length (cm TL)**	**Number of individuals recorded**
Carcharhinus amblyrhynchos	Silver shark	72	3
Carcharhinus melanopterus	Black-tip reef shark	81	1
Himantura granulata	Mangrove ray	101	1
Pastinachus sephen	Cowtail ray	90	2

Marine mammals

Catches of dugongs were highly clustered, with 14 animals harvested by eight vessels on three days. On one occasion, seven dugongs were caught in one day by five vessels. Ten of the dugongs caught were adult females, two were adult males, and two were calves of undetermined sex. Female dugongs were more highly sought than males because they contained more body fat. The Indigenous hunters of Injinoo Aboriginal Community explained that female dugong could be spotted by the manner in which they move through the water, and that pregnant females could be spotted by their size and shape.

While pregnant females were said to be avoided, the calves of lactating females were harvested where the mother had just been taken. The Indigenous hunters informed me that a calf will stay close to its mother, even when the mother has been caught. Dolphins were frequently spotted in the waters adjacent to Northern Cape York Peninsula, but were not targeted by the Indigenous fishers, nor were they caught incidentally in any netting activity that I observed.

Table 4.9: Details of the marine mammals recorded in the monitoring surveys (n = 70 survey days).

Scientific name	**Common name**	**Mean length (cm TL)**	**Number of individuals recorded**
Dugong dugon	Dugong	220	14

Aquatic reptiles

Large green turtles were the only marine turtles harvested. Nineteen turtles were harvested by 13 vessels on 11 days. All of the specimens retained were female. The female green turtles (ipika waru) are more highly sought after than the males (garka waru) and are considered the prized turtles (mina waru) for their higher fat content and better taste. The Indigenous hunters were able to differentiate between the sexes;

female turtles may be spotted from a vessel by their 'shorter tail and rounder carapace'.

In recent years, hawksbill turtles had also been harvested at Injinoo, but no catches were recorded during this study. It was common knowledge among the Indigenous subsistence fishers of Injinoo that hawksbills turtles possess a 'poison sac from eating corals'. Despite some hunters in the community possessing the ability to butcher hawksbill turtles safely, the hunters did not target these animals as the meat was not as highly regarded as that of the green turtles. Similarly, flatback turtles were frequently encountered by hunters but were not harvested because they were considered poor eating.

Eggs (kakur) of green turtles, hawksbill turtles and flatback turtles were harvested. The harvesting of nests was based on need rather than opportunity, and as such, many nesting sites were left untouched. Long-necked freshwater tortoises were harvested opportunistically by the hunters of Injinoo. Crocodiles were not harvested locally despite their ready availability.

Table 4.10: Details of the aquatic reptiles recorded in the monitoring surveys (n = 70 survey days).

Scientific name	**Common name**	**Mean length (cm)**	**Number of individuals recorded**
Chelonia mydas	Green turtle	131 CCL	19
Family Chelidae	Long necked tortoise	160 CCL	1
Natator depressus, Eretmochelys imbricata, and *Chelonia mydas*	Turtle eggs	N/A	12 nests

Crustaceans and molluscs

The most commonly harvested crustaceans were mud crabs and sand crabs (see Table 4.11). All crabs caught were retained regardless of sex and size. Likewise, all crayfish were retained by the subsistence fishers. Crayfish were also collected for commercial purposes by some Injinoo residents; these animals were not recorded as they were not collected as part of the subsistence harvest. The blacklip oyster (*Pinctada margaretifera*) was the most commonly harvested mollusc. Trochus (*Trochus niloticus*) were harvested only for commercial proposes during the study period and hence are not included in this study of the subsistence fishery.

Table 4.11: Details of the crustaceans and molluscs recorded in the monitoring surveys (n = 70 survey days).

Scientific name	**Common name**	**Mean size**	**Number of individuals recorded**
Anadara sp.	Mud cockle	4 cm TL	3
Panulirus spp.	Crayfish	12 cm Tail	23
Pinctada margaretifera	Black lip oyster	9 cm TL	95
Portunus pelagicus	Sand crab	12 cm CW	5
Scylla serrata	Mud crab	13 cm CW	101

4.4.3.5 Harvest rates of marine and freshwater resources

A high proportion of trips to exploit most target groups were successful (see Table 4.12). All trips targeting molluscs, crustaceans, and stingrays were successful in attaining a harvest, as were all trips targeting fish by hand spear or drag/set net. Catches proved most elusive when trolling for pelagic fish (43% successful) or hunting for dugongs (42%). Hunting trips targeting turtles were much more successful (72%) than those targeting dugongs. Success in harvesting turtle eggs (71%) was reduced because of the extensive feral pig predation of nests along the mainland coast.

The time expended by the individual fishers in successfully harvesting the target species was variable among the different fishing, hunting and gathering methods (see Table 4.12). Dugong hunting required the greatest investment of time to attain a catch (16.6 h). This investment greatly surpassed hunting activities targeting turtles (7.1 h) and stingrays (2.5 h). Catches of fish and shark occurred at intervals averaging 1.3 h when using a handline, and 0.4 h when netting.

Table 4.12: Details of the success rate of fishing, hunting and gathering trips recorded in the monitoring surveys (n = 70 survey days).

Activity	**Number of recorded trips**	**Trips that resulted in a harvest**	**Mean amount of effort per harvest***
Fishing			
Handline	80	94%	1 hr. 20 mins.
Net	23	100%	22 mins.
Troll	6	43%	3 hrs. 20 mins.
Spear	1	100%	30 mins.
Hunting			
Dugongs	19	42%	16 hrs. 40 mins.
Turtles	18	72%	7 hrs. 10 mins.
Stingrays	2	100%	2 hrs. 30 mins.
Gathering			
Crustaceans	14	100%	50 mins.
Molluscs	7	100%	3 hrs. 15 mins.
Turtle eggs	7	71%	55 mins.

* The mean time between harvests is based on the individual CPUE (see Table 4.3).

Some of the activities harvesting aquatic resources required the combined efforts of all participants in the trip (e.g., netting, stingray, turtle and dugong hunting), or were conducted as a group to improve the rate at which the resource may be harvested (e.g., turtle eggs and crustaceans). In the remaining activities, although the fishers typically went out in groups, the fisher harvested the resource individually. Hence, to provide the best indication of the true CPUE, I have provided both the overall CPUE (per boat) and individual CPUE (per individual) (see Table 4.13). Overall CPUE was derived from all trips recorded in the monitoring surveys. Individual CPUE was derived from the overall CPUE divided by the mean number of participants per activity (see Chapter 4.4.3.2).

Table 4.13: Overall and individual CPUE revealed by the monitoring surveys (n = 70 survey days).

Activity	No. of recorded trips	Overall CPUE (CPUE per vessel)	Individual CPUE (CPUE per fisher)
Fishing			
Handline	80	3 fish/boat hr^{-1}	0.75 fish/person hr^{-1}
Net	23	13.5 fish/boat hr^{-1}	2.7 fish/person hr^{-1}
Troll	6	1.2 fish/boat hr^{-1}	0.3 fish/person hr^{-1}
Spear	1	2 fish/boat hr^{-1}	2 fish/person hr^{-1}
Hunting			
Dugongs	19	0.2 dugong/boat hr^{-1}	0.06 dugong/person hr^{-1}
Turtles	18	0.42 turtle/boat hr^{-1}	0.14 turtle/person hr^{-1}
Stingrays	2	1.5 stingray/boat hr^{-1}	0.4 stingray/person hr^{-1}
Gathering			
Crustaceans	14	4.6 crustaceans/boat hr^{-1}	1.2 crustaceans/person hr^{-1}
Molluscs	7	34.3 molluscs/boat hr^{-1}	11.4 molluscs/person hr^{-1}
Turtle eggs	7	3.4 nests/boat hr^{-1}	1.1 nest/person hr^{-1}

Harvest rates were highly variable among the different fishing, hunting and gathering methods. Although the most labour intensive of all activities, netting also resulted in the greatest return to the individual fisher (2.7 fish/person hr^{-1}), and greatly surpassed handline fishing (0.75 fish/person hr^{-1}). Spearing fish appeared to be relatively productive (2.0 fish/person hr^{-1}), however this figure is based on only one trip record so it should be regarded with caution. In comparison, the occasional spearing trips targeting stingrays resulted in a less productive individual CPUE of 0.4 stingray/person hr^{-1}.

It is unlikely that each of th persons aboard the vessels hunting stingrays were manning a spear at the same time, so the overall CPUE (1.5 stingray/boat hr^{-1}) appears a more appropriate measure of the harvest rate. Fishers also typically combined their effort in the exploitation of crustaceans and turtle eggs. The overall CPUE for these activities were 4.6 crustaceans/boat hr^{-1} and 3.4 nests/boat hr^{-1} respectively. Likewise, both turtle and dugong hunting required the combined effort of all persons aboard the vessel. The catch rate for turtle hunting (0.42 turtle/boat hr^{-1}) was greater than that for dugongs (0.2 dugong/boat hr^{-1}).

4.4.3.6 Seasonal trends in the catch

Seasonal changes in environmental conditions influenced fishing, hunting and gathering activities. Subsistence harvesting activities appeared to be restricted during the wet season (generally December through to April) when frequent storms and most of the precipitation occur. Only 36% of all effort recorded in the monitoring surveys occurred during the two wet seasons studied. Conditions are more conducive to fishing effort during the dry season, though the characteristic strong south-east winds may have contributed to the concentration of fishing effort on the north-west (leeward) coast (see Chapter 4.4.3.1).

Fishers exploited opportunities whenever conditions allowed. For example, crayfish were targeted once the visibility in coastal waters improved with the decrease in the wet season river discharge. The fishers also took advantage of opportunities presented by changes in the local abundance of species. For example, pelagic species were targeted during the mid-year period when their numbers increased following the arrival of large schools of baitfish.

Increases in fishing effort and catch rates were often facilitated by targeting species that congregate to breed, feed, or migrate. Many species were targeted when aggregating (e.g., black jewfish, batfish) or moving in schools (e.g., mullet, salmon). The Indigenous people of Injinoo prized the flesh of animals containing high levels of fat, and hence many species were targeted when known to be 'fat' (e.g., sweetlip in mid-year, stingrays late in the year).

I observed effort targeting certain species, such as dugongs, turtles, and turtle eggs, often increased when community feasts were scheduled. Dugong and turtle meat were highly sought after when major events were being held, and often multiple catches were required. The number and size of community events appeared to influence the annual harvest of these animals, however I did not record the dates of community events, and hence this correlation cannot be checked. I also observed that hunting effort often appeared to increase in the days following the capture of an elusive animal such as a dugong or turtle. As there were few back-to-back survey days, I was unable to confirm this observation.

Table 4.14: Seasonal variation in the harvest of the Indigenous subsistence fishers from Injinoo Aboriginal Community between January 1999 and August 2000.

The shading indicates the months the taxa where harvested.

Resource	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Fish	■	■	■	■	■	■	■	■	■	■	■	■
Shark						■		■		■		
Stingray										■		
Dugong				■					■		■	■
Turtle (adult)		■			■			■	■	■	■	■
Turtle (egg)	■			■		■	■	■		■		■
Crustaceans						■	■	■	■			
Molluscs		■			■		■	■	■	■	■	

Although intra-annual trends were evident in the exploitation of major taxa (see Table 4.14), there were insufficient data to define the commencement and end of these periods, or to demonstrate any inter-annual differences. Although monitoring surveys were conducted over the full year of 1999 and over most of 2000, it proved difficult to interpret the duration of seasons of increased catches, as the harvest of several resources was highly clustered. For example, 50% of the catch of dugong occurred on a single day. As I was unable to establish the commencement and end of these seasons accurately, I did not extrapolate the data to form estimates of the annual catch.

4.5 Discussion

4.5.1 Characteristics of Injinoo's Indigenous subsistence fishery

This thesis documents the sustained importance of subsistence fishing, hunting and gathering to the Indigenous people of Injinoo Aboriginal Community. Despite the profound lifestyle changes over the last 140 years (see Chapter 2), the act of utilising aquatic resources for subsistence proposes remained an important component in the lives and culture of these people. Harvesting aquatic resources not only fulfilled subsistence needs, but also contributed to the preservation of important cultural practices such as meeting kinship obligations and maintaining connections to country.

As discussed below, the surveys revealed that the Indigenous subsistence fishery of Injinoo was unique in many ways, and was shaped by the culture and beliefs of the local resource users and custodians, as well as the environment and the species it hosts. This chapter commences with a discussion of some of these characteristics that make this fishery unique. By examining the motives, needs, and activities of the Indigenous subsistence fishers, the distinction between this fishing sector and others becomes evident. Understanding these characteristics will assist natural resources managers to make decisions that are relevant and acceptable to the community.

4.5.1.1 Use of natural resources.

The Indigenous subsistence fishery of Injinoo Aboriginal Community incorporated an extensive area of coastline, and numerous offshore islands and reefs (see Chapter

4.4.3.1). A diverse spectrum of habitats was represented in the areas where fishing effort was recorded. These included open waters (e.g., lure fishing), offshore reefs (e.g., line fishing), inshore waters (e.g., netting), tributaries (e.g., spearing), the intertidal zone (e.g., bivalve gathering), and above the tidal zone (e.g., turtle egg collecting).

The diversity of habitats allowed an even greater diversity of species to be harvested. Monitoring surveys conducted in 1999-2000 identified the harvest of 75 marine and freshwater taxa identified to the level of species, genus or family. The number of harvested taxa is close to that reported by Smith (1987), who recorded the people of Hope Vale Aboriginal Community utilise 80 taxa for subsistence purposes. The National Indigenous Fishing Survey identified the harvest of only 59 taxa, and its study area spanned across northern Australia (Cairns to Broome but excluding the Torres Strait) (Coleman et al. 2003). Forty-eight of these taxa were harvested by Indigenous people residing in Queensland (Coleman et al. 2003).

The number of harvested aquatic taxa recorded at Injinoo, Hope Vale (Smith 1987) and across northern Australia (Coleman et al. 2003), exceeds the totals provided by Collins et al. (1996) for terrestrial taxa harvested by Australia's Aboriginal groups. They list 48 mammals, 37 birds, 13 reptiles, seven insects and two amphibians. These totals do not come close to the 75 different taxa in the Indigenous subsistence fishery of Injinoo. The difference highlights the wealth of natural resources in the waters of Cape York Peninsula.

Despite the challenge of this diversity, the subsistence fishers at Injinoo appeared to have mastered a sound understanding of the local environment and the optimum conditions for the harvest of targeted species. They considered that their sound understanding of the animals, the environment, and the ways in which the two interact, was essential to successful fishing and hunting, particularly for elusive animals such as dugongs and turtles. They did not rely on fish finders or any other modern electronic aids which are common in recreational and commercial fisheries across Australia.

The door to door survey conducted in 1999 (see Chapter 4.4.2) revealed that 95% of households at Injinoo Aboriginal Community frequently harvested marine or freshwater resources for subsistence purposes. Most households participated in the fishery on a weekly basis, with line fishing and netting being the most common activities. Only a small number of people within the community regularly lead hunting trips for the more elusive dugong and turtle. This reflected the high degree of skill required to successfully hunt these species.

Injinoo's subsistence fishers retained for consumption virtually all specimens caught irrespective of size (see Chapter 4.4.3.4). Only species that were potentially hazardous and considered to be of poor taste were released (e.g., shark, catfish). The subsistence fishers at Injinoo made extensive use of their catch, producing very little waste (see Chapter 4.4.3.3). In addition to the meat of the animal, the head, frame, intestines, blood, oil, eggs and fat were often utilised.

4.5.1.2 Tools, methods and roles.

The methods and equipment adopted by the subsistence fishers of Injinoo are a blend of traditional and modern (see Chapter 4.4.3.3). Some of the methods and tools observed appear to be similar to those described in historical accounts from the region. For example, Haddon's (1912 and 1934) descriptions of turtle egg collecting and dugong hunting are similar in many ways to that observed during the study period (including the use of unpowered vessels).

In some activities conducted by the subsistence fishers, hunters and gathers, the intentions have stayed the same, but the technology has been modernised. For example, whereas Kennet (1867-68: in Moore 1979), Roth (1901) and Hale and Tindale (1933-1934) all observed Indigenous fishers using fishing line and hooks made from natural products, commercially manufactured monofilament lines and metal hooks are now the norm. This change is hardly surprising given the greater durability and ease offered by the new products.

It has been well documented that the Indigenous subsistence fisheries of Cape York were quick to adopt modern materials with the arrival of Europeans in the region. For example, Roth (1901) recorded the use of metal in tatas, spear tips, and hooks. Several authors have already discussed the process of change in regards to the tools adopted by Indigenous subsistence fishers (e.g., Altman 1982, 1987; Ellana et al. 1988; Young et al. 1991; Ponte 1996).

I noted that some traditional methods were no longer used at the time of the monitoring surveys, e.g., the use of remoras in turtle hunting (Moore 1979), or turtle lookouts (Moore 1979). At the same time, some modern influences have opened new opportunities (e.g., dive masks enable diving for crayfish), or increased the efficiency of the fishery (e.g., vessels of greater range and carrying capacity). Yet, there are many tools and methods characteristic of the recreational and commercial fishing sectors that have not been adopted by the subsistence fishers of Injinoo.

Despite their basic understanding of modern fishing aids (such as sounders, fishing rods and lures), the ownership and use of such items among the subsistence fishers were rare. The use of basic fishing equipment, such as handlines, nets and spears, appeared to suffice. This may appear to be a function of the subsistence fishers' lower exposure to such items, as well as the high purchase and maintenance costs associated with modern fishing aids. However, among the fishers of Injinoo Aboriginal Community, there was a widespread belief that such items were simply not necessary.

Although sounders and global positioning system units (GPS) were seldom used by the fishers of Injinoo, their knowledge of the local underwater topography was exact. The Indigenous fishers of Injinoo maintained skills that were formerly used by non-Indigenous commercial and recreational fishers before the widespread adoption of electronic aids. These skills include depth sounding using weighted lines and fixing of positions from landmark features. On countless occasions, I witnessed the pin-point accuracy at which these fishers could position their vessel over deepwater holes or bommies.

Monitoring of the Indigenous subsistence fishery at Injinoo highlighted the characteristic differences between the roles of male and female fishers (see Chapter 4.4.3.2). For example, dugong and turtle hunting were exclusively male activities. Male participants dominated vessel-based activities, while shore-based activities were dominated by female participants. The division of roles has already been noted in several Indigenous communities of northern Australia (e.g., Thomson 1934, Walker 1972, Smith 1987, Roberts et al. 1996).

4.5.1.3 Motivation of fishers

All Indigenous persons surveyed at Injinoo Aboriginal Community stated that their primary reason for fishing, hunting and gathering was for the provision of food items (see Chapter 4.4.2). In Northern Cape York Peninsula, attaining a catch was of much greater importance to Indigenous people than it was to the non-Indigenous fishers. In contrast, non-Indigenous people attached a high importance of having fun while fishing, while Indigenous people placed a low importance on the recreational values.

Aquatic resources harvested by the Indigenous subsistence fishers of Injinoo were widely distributed within the community, with the fishers providing for their immediate and extended families, as well as for community ceremonial needs. Turtles and dugongs were considered essential components of community feasts, and were invariably provided by a small, select group of fishers renowned for their hunting ability. Others contributed to community needs by gathering natural resources such as turtle eggs or molluscs.

Utilising natural resources was considered essential for holding community feasts; not only to provide favoured food items such as turtles or dugongs, but also to overcome the prohibitive cost associated with hosting large numbers of people (typically between 200 to 500). Although frozen and cryovac meats were available from several stores in Northern Cape York Peninsula, the prices were higher and the quality was less than in metropolitan areas. Altman and Talyor (1989) recognise this, suggesting that in remote Indigenous communities, the high prices in community stores coupled with unstable incomes, compel residents to complement their diet with subsistence production.

Asafu-Adjaye (1994) calculated the value of subsistence food production in Northern Cape York Peninsula based on a market replacement model. The value of subsistence production was estimated from the difference in the hypothetical cost of purchasing of all food items and the recorded average spending made on food purchases by local residents. Asafu-Adjaye (1994) valued subsistence production in the region at $2,804 per household per annum. With 48 houses in Injinoo, this equates near to $135,000 per annum for the community (in 1994 dollars). However, this method does not include natural resources utilised in community feasts.

Roberts et al. (1996) highlighted the importance of natural resources in community feasts. They estimated that 17% of subsistence activities in the Northern Cape York Peninsula community of New Mapoon (10° 52' E, 142° 23' S: see Figure 1.1) harvested natural resources for ceremonial purposes. If an additional 17% of subsistence production is added to the figure provided by Asafu-Adjaye (1994), then the overall value of subsistence production in Injinoo Aboriginal Community is near to $157,500 per annum (in 1994 dollars). If this figure is adjusted by 2.6% per annum to allow for the mean annual rate of inflation over the last decade (Reserve Bank Australia, 2005), the value of subsistence production at Injinoo in 2005 exceeds $200,000 (or $80 per household per week).

4.5.1.4 Social and cultural benefits

It is reasonable to suggest that Injinoo Aboriginal Community gained great nutritional benefit from its subsistence fishery given that the Community of 48 houses harvested almost 2,000 aquatic taxa in only 70 survey days. Asafu-Adjaye (1994) estimate that subsistence production in Northern Cape York Peninsula provides about 80% of protein intake in the local communities. The high nutritional importance of subsistence activities in Indigenous communities in Australia has already been documented in several studies (e.g., Meehan 1982, Whalley 1990).

Cultural issues were deeply intertwined with the act of subsistence fishing, hunting and gathering in Northern Cape York Peninsula. The people of Injinoo held in high regard the role of subsistence activities in maintaining traditional practices and linkages with land and sea estates. For example, the Injinoo Community Plan (Kleinhardt-FGI 1999) aims to 'generate greater respect for traditional values, Elders and community unity' and to 'improve environmental management of community and traditional lands' by 'encouraging community members to participate in joint hunting and gathering expeditions onto traditional lands'.

Maritime aspects were deeply rooted in the customary traditions and beliefs of Injinoo's Indigenous groups. There were legends that explained the behaviour of animals, e.g., it was believed dugongs moved to the Torres Strait Islands when a dugong's backbone was taken to the Islands (the late Daniel Ropeyarn, Anggamuthi Elder, Injinoo Aboriginal Community, *pers comm*. 1998). There were also legends that explained the behaviour of the environment, e.g., it was believed that unfavourable winds blow when a starfish was returned to the seabed on its back (Gordon Solomon, Deputy Chair, Injinoo Aboriginal Community, *pers comm.* 2000). There were even totemic marine animals among the Aboriginal groups of Injinoo Aboriginal Community. For example, the dugong is the totem animal of the Anggamuthi (Mary Eusli, Councillor, Injinoo Aboriginal Community, *pers comm*. 2000).

Fisher (1984) argues that the economic exploitation of the land to support material needs, and its spiritual maintenance are not separate aspects of Indigenous peoples' relation to country, but rather each of these needs underwrites the other. To delineate and value each of the cultural issues would be notoriously difficult, if not impossible. Ponte (1996) suggested that the significance of subsistence production varies among Australia's Indigenous communities depending on the groups concerned and the circumstances surrounding their decision to hunt. There are undoubtedly many reasons why Indigenous people in Australia fish, hunt and gather; at Injinoo Aboriginal Community these include nutritional, economic, social and cultural influences.

4.5.2 Comparison with the other Australian Indigenous fishing studies

Roberts et al. (1994, 1996) report on monitoring surveys conducted in the neighbouring community of New Mapoon (10° 52' E, 142° 23' S: see Figure 1.1). The surveys were conducted between June 1994 and January 1995 (the number of survey days is not published). The study recorded the harvest of eight dugong, 14 green turtles, 15 crayfish, and 51 fish. From the brief descriptions of the fishing and hunting methods observed at New Mapoon, the techniques appear similar to those that

I observed at Injinoo. Unfortunately, the information provided by Roberts et al. (1994, 1996) is preliminary data only, and few comparisons can be made as the published data are scant.

To the south of Northern Cape York Peninsula, Smith (1987) conducted a comprehensive ethnobiological study of Indigenous subsistence fishing at Hope Vale and Lockhart River Aboriginal Communities. He found a similar level of diversity in the subsistence harvest, confirming 80 taxa were harvested for food (compared to the 75 taxa identified in the present study). The fishing, hunting and gathering tools and techniques described by Smith (1987) closely resemble those that I observed at Injinoo. Notable differences were limited to: (1) 'spear-throwers' (Milbiirr) were not used at Injinoo, and (2) females never participated in the dugong hunting trips conducted from Injinoo.

To the north of Cape York, Harris et al. (1994) conducted what remains the most comprehensive set of monitoring surveys to focus on Indigenous subsistence fishing in Australia. Spanning all regions of the Torres Strait Protect Zone (14 communities on 13 islands), the surveys were conducted on 271 days between June 1991 and May 1993. Unlike the present study, the surveys conducted in the Torres Strait also recorded commercial fishing effort, and so special consideration is required in the comparison of figures. In some instances it is possible to separate the two totals, although in others it is not.

Harris et al. (1994) report that 6% of people in the Torres Strait fish daily, while the present study found that 13% of households at Injinoo Aboriginal Community fish at least daily (see Chapter 4.4.2). The figure for the Torres Strait includes fishers participating for either subsistence or commercial purposes, while the figure for Injinoo relates to subsistence activities only. Similar to the present study, Harris et al. (1994) observed that males dominated vessel based activities, while woman and children mainly fished from the shore. They also reported that the most labour intensive activity was netting, though they reported a mean size of four people for this activity rather than the mean of five that I recorded for Northern Cape York Peninsula.

Harris et al. (1994) report that the most common activities recorded across the Torres Strait were handline fishing and then crustacean gathering (versus handline fishing followed by net fishing at Injinoo). The importance of crustacean gathering highlights the significance of the commercial component in the Torres Strait survey. At the time of the Torres Strait surveys, the Indigenous residents of the region harvested 123 tonnes of crayfish annually, and retained only 9% of this catch for subsistence purposes (Harris et al. 1994).

Johannes and MacFarlane (1991) claim that the Indigenous peoples of the Torres Strait region consume among the greatest amounts of seafood in the world. The seafood consumption rates provided for Mabuiag (450 grams per person per day), Boigu (238) and Yorke (191-214), greatly exceed figures for the rest of Australia (22), the United States (19), and Japan (102). Harris et al. (1994) support this notion, providing a figure of 342 grams per person per day for the whole of the Torres Strait Protected Zone. Given the strong cultural ties and high level of interaction between the Indigenous people of Northern Cape York Peninsula and the Torres Strait, it is feasible that if a similar dietary study were to be conducted at Injinoo, it would also reveal a high level of seafood consumption.

A survey of Indigenous subsistence fishing across northern Australia was conducted between April 2000 and November 2001 (Coleman et al. 2003). The survey involved over 900 households in 46 communities spread from Cairns (16° 55 S, 145° 46' E) to Broome (17° 57 S, 122° 13' E). Catch and effort data were collected over twelve month periods, with households interviewed six times per year and asked to recall information from the past seven days. Coleman et al. (2003) extrapolated recorded catches to produce annual harvest estimates (applying an inflation factor of 75 to the harvest recorded in Queensland). No allowance was made for seasonal changes in effort or the availability of species, and therefore the harvest estimates is likely to be inaccurate for some species. The precision of the extrapolated figures is open to speculation as standard errors are not provided.

Coleman et al. (2003) found that 92% of Indigenous people over the age of five had participated in fishing activities during the twelve month survey period. This is similar to the findings of the present study, in which 95% of households indicated they participated in the subsistence fishery. Coleman et al. (2003) calculated that Indigenous fishers in Queensland participated in subsistence harvesting activities on 11.4 days per year on average. In comparison, I found 77% of Indigenous households participated either daily or weekly, and a further 18% of Indigenous households participated on a monthly basis.

In Table 4.15, I present a summary of the groupings of taxa most harvested by Indigenous fishers at Injinoo, the Torres Strait (Harris et al. 1995) and across northern Australia (Coleman et al. 2003). The figures presented for the Torres Strait include only the subsistence harvest. The numbers of aquatic animals harvested at Injinoo and Torres Strait communities are reasonably similar. The figures produced from the National Indigenous Fishing Survey were much greater. In Table 4.16, I present the ten most harvest taxa as recorded in the present study, Harris et al. (1995), and Coleman et al. (2003). As should be expected for surveys conducted in different areas, the lists vary considerably.

Table 4.15: The rate of harvest by Indigenous subsistence fishers at Injinoo (present study), the Torres Strait (Harris et al. 1995) and across northern Australia (Coleman et al. 2003). The figures are presented as number of organisms harvested per day per community.

Injinoo Indigenous Subsistence Fishing Survey	**Torres Strait Indigenous Fishing Survey (Harris et al. 1995)**	**National Indigenous Fishing Survey (Coleman et al. 2003)**
Fish (23 fish per day)	Fish (24 fish per day per community surveyed)	Molluscs (70 molluscs per day per community surveyed)
Crustaceans (1.8)	Bivalves (13)	Fish (54)
Molluscs (1.7)	Crustaceans (1.8)	Crustaceans (50)
Turtles (0.3)	Dugongs (0.8)	Turtles (1.6)
Dugongs (0.2)	Turtles (0.5)	Dugongs (1)

Table 4.16: The ten taxa most harvested by Indigenous fishers at Injinoo (present study), the Torres Strait (Harris et al. 1995) and across northern Australia (Coleman et al. 2003).

	Injinoo Indigenous Subsistence Fishing Survey	**Torres Strait Indigenous Fishing Survey (Harris et al. 1995)**	**National Indigenous Fishing Survey (Coleman et al. 2003)**
1	Mullet	Crayfish	Mussels
2	Sweetlip	Tuskfish/Wrasse	Cherabin
3	Stripey	Green turtles	Mullet
4	Snappers	Sardine/Herring	Prawns
5	Black jewfish	Trevally	Oysters
6	Mud crab	Emperor	Catfish
7	Oyster	Groupers/Rockcod	Perch/Snappers
8	Tuskfish	Blackfish	Pippi
9	Trevally	Coral trout	Bream
10	Garfish	Dugong	Barramundi

4.5.3 Comparison with the recreational fishing studies

Queensland has developed Australia's most comprehensive data collection system to monitor the recreational fishing sector. Telephone surveys have been conducted in 1997, 1999, and 2002 (Roy Morgan Research 1999). Volunteers identified during these surveys have been asked to maintain a diary of their fishing activities in 1997 (Higgs 1999) and 1998 (Higgs 2001). Queensland also participated in the National Recreational Fishing Survey which was conducted between May 2000 and April 2001. The national survey also asked volunteers to maintain a diary of their effort. Like the National Indigenous Fishing Survey conducted at the same, no allowance was made for seasonal variations in effort or catch.

A striking difference between the two fishing sectors is the frequency at which they participate in activities that utilise aquatic resources. Ninety-five percent of households at Injinoo had at least one member who had participated in subsistence harvesting activities at least once a year. In comparison, only 33% of Queensland households had at least one member (15 years or older) who went fishing, crabbing, or prawning at least once a year (Roy Morgan Research 1999). Highlighting the contrast further, 77% of households at Injinoo participated in subsistence-based activities at least once a week, while only 7% of households in Queensland participated in recreational-based activities on a weekly basis (Roy Morgan Research 1999).

Given the participation rates stated above, it is not surprising that boat ownership at Injinoo greatly exceeded the equivalent state and national figures. Sixty-one percent of households at Injinoo owned a seaworthy vessel, while only 11% of all Queensland households own a boat used for recreational fishing (Roy Morgan Research 1999). By comparison, the National Recreational Fishing Survey indicates that 7% of all Australian households own a boat that is used for recreational fishing (Lyle et al. 2003).

The National Recreational Fishing Survey also recorded the frequency of each type of harvesting activity identified (see Table 4.18). Unfortunately, this information is not recorded in the recreational fishing surveys overseen by the Queensland Department of Primary Industries and Fisheries. The national survey found line fishing was the most frequent activity conducted by recreational fishers, accounting for 85% of all effort (versus 45% at Injinoo). Trapping was the second most frequent activity conducted by recreational fishers. This activity was not recorded at Injinoo during the survey period. Instead of using traps to harvest crustaceans, the Indigenous subsistence fishers used scoop nets and spears.

Only sweetlip, trevally (*Carangoides, Caranx, Gnathondon* spp.) and snappers were among the ten most harvested taxa for both the Indigenous fishers of Injinoo and the recreational fishers of Queensland. Mullet is the only species to appear in both the Injinoo survey and the national survey. Some of the difference between the lists may be explained by the greater geographic range of the recreational fishing surveys. What is similar is that each list is composed of fish that may be described as ‘bread and butter species’; these are species that are relatively abundant and reasonably accessible to fishers. It is important to note here that Table 4.18 lists only the harvested species. Diary surveys (Roy Morgan Research 1999) and the National Recreational Fishing Survey (Lyle et al. 2003) reveals that recreational fishers release large numbers of fish; releasing over 1/3 of fish from almost 40 taxa.

Table 4.17: The five most frequent harvesting activities conducted by Indigenous fishers at Injinoo (present study), and recreational fishers across Australia (Lyle et al. 2003).

Injinoo Indigenous Subsistence Fishing Survey	**National Recreational Fishing Survey (Lyle et al. 2003)**
Handline fishing 45%	Handline fishing 85%
Net fishing 13%	Traps 7%
Dugong hunting 11%	General gathering 4%
Turtle hunting 10%	Net fishing 3%
Crustacean gathering 8%	Spear fishing 1%

Table 4.18: The ten species most harvested by Indigenous fishers at Injinoo (present study) and recreational fishers across Queensland (Higgs 2001) and Australia (Lyle et al. 2003).

	Injinoo Indigenous Subsistence Fishing Survey	**Queensland Recreational Fishing Survey (Higgs 2001)**	**National Recreational Fishing Survey (Lyle et al. 2003)**
1	Mullet	Whiting	Yabbies
2	Sweetlip	Bream	Prawns
3	Stripey	Freshwater crayfish	Whiting
4	Snappers	Crabs	Flathead
5	Black jewfish	Trevally	Freshwater crayfish
6	Mud crab	Snappers (tropical)	Australian herring
7	Oyster	Sweetlip	Bream
8	Tuskfish	Flathead	Sand crab
9	Trevally	Tailor	King George Whiting
10	Garfish	Cod species	Mullet

4.5.4 The sustainability of the fishery

The background survey conducted in early 1998 identified that some Aboriginal and Torres Strait Islander people residing at Injinoo viewed aquatic resources as inexhaustible (see Chapter 4.4.1). Several persons explained to me that ‘what is taken out of the sea is replaced’; a belief held with the view that the harvest of living resources is integral to the renewal of life. Typically, declines in the local abundance of aquatic resources were explained by legends or myths. For example, the decline in the abundance of dugong along the coast of Northern Cape York Peninsula was explained by the belief that the animals migrated to the Torres Strait after a backbone of a locally caught dugong was moved to one of the Islands (the late Daniel Ropeyarn, Anggamuthi Elder, Injinoo Aboriginal Community, *pers comm*. 1998).

Similar accounts of the lack of knowledge of stock vulnerability have been recorded in the adjacent Torres Strait Islands by Johannes and MacFarlane (1991). These authors concluded that it was not surprising that awareness of the vulnerability of aquatic resources is limited among the Indigenous people, as the depletion of local stocks is not part of their experiences. Davies et al. (2000) argue against the view of Johannes and MacFarlane (1991), claiming that awareness among Indigenous people of the limited nature of wildlife resources is evidenced in the regulation of resource use, increase ceremonies, and the general abhorrence of waste.

During the course of this study, awareness of the vulnerability of the aquatic stocks appeared to develop rapidly at Injinoo Aboriginal Community. This may have been facilitated in part by documentation of the declining size of the black jewfish harvested from the annual inshore aggregations near the Community (see Chapters 5 and 6). Concern for the sustainability of subsistence activities also appeared to stem also from an awareness of the declines in stock health experienced in nearby areas. For example, many people were aware of the reported decline in dugong numbers in southern Queensland. The CPUE of dugongs in shark nets set for bather protection between latitudes 16.5º S and 28º S may have declined by about 97% between 1962 and 1999 (Marsh et al. 2005).

The data gained through the present monitoring survey will allow Injinoo Aboriginal Community to monitor the state of its subsistence fishery by repeating the survey in the near future. The results of this survey provide the baseline against which the Community may detect any change in effort or catch. However, monitoring surveys alone do not provide the comprehensive set of information required to establish the impact on harvested species. To achieve such, catch data obtained through the monitoring surveys must be complemented by an understanding of the factors that influence the productivity of the exploited stocks (e.g., recruitment, mortality, and genetic population structure).

In multi-species fisheries as diverse as the subsistence fishery of Northern Cape York Peninsula, the biological information required as input to stock assessments is typically lacking for all but the most universally exploited species. Dugong and turtles are the only species harvested by Indigenous people that have regularly attracted attention from researchers. There is sufficient information available on these animals to warrant a desktop examination of current exploitation practices, however, even for these species there are still significant gaps in our knowledge that preclude any accurate assessment of the sustainability of Injinoo's subsistence fishery. Further research should be commenced with the aim of generating a list of species that may serve as indicators of the state of the subsistence fishery (see Chapter 7).

4.5.4.1 Dugongs

Distributed throughout the coastal waters of the tropical and sub-tropical Indo-west Pacific, the dugong is considered rare over much of its range (Marsh et al. 2002). However, the Torres Strait and the northern Great Barrier Reef support the largest known population of dugong in the world (Marsh et al. 2004). In their review of the molecular investigations of dugong population structure conducted by Tikel (1998) and McDonald (unpublished), Marsh et al. (2002) conclude that the Torres Strait region is an important area in which overlap occurs between the two maternal lineages found along Australia's coast.

The abundance of dugongs in the Torres Strait has been estimated from aerial surveys detailed by Marsh and Sinclair (1989). The surveys have been conducted in a similar manner during November and/or December in 1987, 1991, 1996 and 2001. The resulting population estimates vary from 13,319 to 27,881. The fluctuations cannot be accounted for by either the effects of harvest or intrinsic population growth alone, and are likely to be a product of dugongs moving in and out of the region, most likely in response to seagrass dieback (Marsh et al. 2004). Recorded harvests in the Torres Strait Protected Zone range up to 1226$\pm$204 dugongs per year (for details see Bertram and Bertram 1973, Neitschmann 1985, Hudson 1986, Johannes and MacFarlane 1991, Kwan 2002).

Marsh et al. (1997) evaluated the sustainability of the harvest of dugongs using population estimates from aerial surveys conducted in 1987 and 1991, and surveys of catches harvested by Indigenous fishers in the region between 1991 and 1993. The mean estimate of the annual catch in the Torres Strait for 1991-1993 was approximately 5% of the mean estimate of the population size in 1991. Hence, Marsh et al. (1997) concluded that this is too close to the maximum rate of increase of the dugong population to be sustainable if the estimate of dugong numbers is close to the absolute number. Earlier, Marsh (1995) had estimated that the maximum rate of population growth under the most opportunistic conditions (calving interval of 3 years, and a pre-reproductive period of 10 years) is likely to be about 5% per year.

Since Marsh et al. (1997) published their findings, further aerial surveys were conducted in 1996 and 2001, and new biological information has allowed the empirically-derived estimates of dugong life-history parameters for the Torres Strait to be refined (e.g. Boyd et al. 1999, Kwan 2002). Marsh et al. (2004) incorporated the latest information in their evaluation of the dugong fishery and also found dugongs in the Torres Strait are being harvested in an unsustainable manner. By employing the ‘potential biological removal method’ (Wade 1998), Marsh et al. (2004) conclude that based on the 2001 population estimate the sustainable harvest for the entire Torres Strait region (including that harvested by communities in Northern Cape York Peninsula) is 80 to 90 dugongs (this figure does not allow for occasional stochastic events that impact on dugong numbers).

In a separate, independent study, Heinsohn et al. (2004) conducted ‘population viability analyses’ using the computer program VORTEX and published estimates of population sizes and hunting rates. They also conclude that the Indigenous dugong fishery in the Torres Strait (incorporating the communities of Northern Cape York Peninsula) is unsustainable, and predict that if the rate of harvest in the Torres Strait remains unchanged, the number of dugongs in the region will fall below 10% of the level in 1996 within 42 and 123 years. Heinsohn et al. (2004) suggest the communities of Torres Strait and Northern Cape York Peninsula should harvest no more than 100 dugongs per annum (this figure allows for occasional stochastic events).

Unfortunately it is currently not possible to evaluate independently the impact of Injinoo’s harvest of dugong. This is because: (1) the large-scale movements of individual dugong mean assessments must be completed on at least regional scale, and (2) catch data from the neighbouring communities is presently unavailable (Dr. Helene Marsh, Researcher, James Cook University, Townsville, *pers comm.* 2004). In order to better assess the sustainability of dugong hunting, a monitoring program should be implemented immediately to record the details of harvested dugong by each of the Communities in Northern Cape York Peninsula (see Chapter 7).

4.5.4.2 Turtles

Six of the world's seven sea turtle species inhabit the waters of Northern Cape York Peninsula. Three of these species, the flatback turtle, the hawksbill turtle and the green turtle were frequently observed in the study area, but only the last of these was harvested by the Indigenous fishers of Injinoo. It appears the ready availability of the green turtle in the waters adjacent to Northern Cape York Peninsula forfeits the needs to utilise these other species. Flatback turtles are said to be less agreeable in taste, and the hawksbill turtle requires careful butchering to avoid spoiling the meat. The Indigenous residents of the Injinoo Aboriginal Community also harvested the eggs of green, hawksbill and flatback turtles (*pers obs*).

The monitoring surveys conducted during this study revealed catches of green turtles peaked in September (see Chapter 4.4.3.6), the time when these animals congregate in inshore waters to mate. The increased availability of turtles during the mating season only partly explains the peak in catches. The increased harvest also reflects the fact that mating turtles store large amounts of body fat in the lead up to nesting (Kwan 1991), and Indigenous fishers in the region have long have long held a preference for turtles with a high fat content. Exemplifying this, Barbara Thompson, a shipwreck survivor who lived with the Kaurareg people on the nearby Prince of Wales Island (10° 41’ S, 142° 11’ E: see Figure 1.1) between 1844 and 1849, stated that green females were favoured as the male contains little fat and has no eggs (Moore 1979).

Limpus (1993) observed mating aggregations on the Great Barrier Reef, reporting that while males appears to display a fidelity to a particular mating area, there appeared to be a constantly changing group of females at the aggregation site. Therefore, one may conclude that the act of targeting female green turtles for their preferred taste and fat content may inadvertently enhance the sustainability of targeting aggregations by not targeting the resident male population. However, Kennett et al. (1997) argues that the bias toward females in Indigenous fisheries is a cause for concern. They suggest that targeting the females, versus harvesting a random sample of turtles, greatly impacts on the reproductive capacity of the turtle population.

Chaloupka (2003) has developed a stochastic simulation model to predict the impact of potential anthropogenic impacts on the green turtle population inhabiting the southern Great Barrier Reef. The model clearly demonstrates that the harvest of turtles has the potential to significantly impact on population numbers. The model provides, for example, that a harvest rate of 15% of sub-adults per annum will reduce the abundance of turtles by over 95% within 100 years. Unfortunately, our ability to utilise this model to evaluate the sustainability of current harvesting practices is restricted by the lack of regional scale estimates of the numbers of turtles harvested in Australia. Similar to dugongs, the evaluation of the impact of harvesting turtles must occur on broad scale due to the large movements turtles are known to undertake. To allow the sustainability of turtle hunting to be established, new monitoring programs should be implemented as a matter of priority (see Chapter 7).

4.5.4.3 Turtle eggs

The monitoring surveys recorded the harvest of 12 turtle nests during the 70 survey days. Based on my observations during the study period, this level of harvest appeared to be insignificant compared to the number of nests predated by feral pigs (*Sus scrofa*). Exemplifying this, on one egg collecting trip in which I participated as an observer, every nest (>15) over a distance greater that 500 meters had been raided by pigs. Along the mainland beaches, feral pigs have been observing raiding nests almost immediately after the turtles had returned to sea (Doyle Sebasio, Community Police Officer, Injinoo Aboriginal Community, *pers comm.* 2000).

The stochastic simulation model developed by Chaloupka (2003) allows the impact of harvesting eggs to be predicted. The model is based on environmental and demographic information for the green turtle population inhabiting the southern Great Barrier Reef. The model predicts that when 75% of all nests are harvested over a 100 year period, the mean number of mature green turtles in the region will decrease by 50% within 40-50 years, and more than 90% within 90-100 years.

Predation of turtle nests by feral pigs is well recognised in Australia as a major threatening process. The Recovery Plan for Marine Turtles in Australia (Environment Australia, 2003) acknowledges that feral pigs are responsible for high levels of nest predation on beaches used by flatback turtles on Cape York Peninsula. To manage this situation, the Plan prescribes that the Queensland Environment Protection Agency should act to minimise pig predation of flatback turtle nests on Cape York. It also stipulates a measure of success, being "more than 70% of nests produce hatchlings".

A variety of measures are available to control pig populations, including shooting, baiting, trapping and exclusion fencing. The eradication or culling of the wild pig population would present a great challenge due to the remoteness of the areas concerned, and the capacity of pigs to rapidly re-populate areas. Feral sows average seven piglets per litter when conditions are favourable, and with a gestation period of 113 days, they are capable of producing two litters per year (Caley 1999). Therefore, any control programs must be sustained over the long-term.

While many of Injinoo's residents may not wish to see the total eradication of feral pigs (as they form an important component of terrestrial hunting yields), if no action is taken to protect the mainland and island beaches from pig predation, turtle populations will be greatly reduced. Clearly, replenishment of stocks cannot occur if the young do not survive. Research should be implemented immediately to identify the extent of feral pig predation and describe its impact on recruitment (see Chapter 7). In the interim, feral pig populations should be eradicated on islands where there is no subsistence harvest and control programs would be likely to produce lasting results. Steps should also be taken to gain long-term funding to implement control programs on the mainland in consultation with the community.

THESIS FLOW CHART

CHAPTER 1. INTRODUCTION

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CHAPTER 2. BACKGROUND INFORMATION

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CHAPTER 3. GENERAL METHODS

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CHAPTER 4. INDIGENOUS SUBSISTENCE FISHING SURVEY

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CHAPTER 5. BLACK JEWFISH ASSESSMENT: 1999-2000

Chapter five commences by defining the need for an assessment focusing on black jewfish. After examining the identification of this species, I focus on the harvest and the biology of the species.

In summary:

- I demonstrated black jewfish can be distinguished from other jewfish.
- I provided a record of the fishery since its inception, and provided a comprehensive dataset on fish harvested in 1999 and 2000.
- I detailed aspects of the fishes' reproduction strategy, diet, movement patterns, and genetic population structure.
- The results documented the progressive truncation of the black jewfish stock, and warranted urgent concern for the state of the fishery.

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CHAPTER 6. SECOND BLACK JEWFISH ASSESSMENT

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CHAPTER 7. GENERAL DISCUSSION

CHAPTER 5. BLACK JEWFISH ASSESSMENT: 1999-2000

5.1 Introduction

This assessment was initiated in response to concerns raised by the Traditional Owners of Northern Cape York Peninsula regarding the potential impact of the perceived increase in fishing effort targeting aggregations of black jewfish. These aggregation events represent a significant increase in the density of black jewfish compared to normal. The annual aggregations of black jewfish that form off Muttee Head (10° 54' S, 142° 13' E: see Figure 1.1) have been line fished by Indigenous subsistence fishers for over fifty years (see Chapter 5.3.1). However, there is an extensive body of evidence derived from fish stocks around the world that indicate aggregation fishing can rapidly undermine fishery production.

Intensive fishing of aggregations has been shown to have negative effects on the proportion of reproductively active fish and subsequent fishery yields (Olsen and LaPlace 1978, Shapiro 1987, Colin 1992, Sadovy 1994, Zellar 1998, Johannes et al. 1999). Sustained fishing pressure has been attributed to the disappearance of the annual aggregations of several tropical fish species (Olsen and LaPlace 1978, Carter 1989, Colin 1992, Beets and Friedlander 1992, Coleman et al. 1996, Aguilar-Perera and Aguilar-Davila 1996).

The practice of aggregating is one of the most widespread behavioural mechanisms used by marine species to reduce natural predation (Die and Ellis 1999). Yet it is this behaviour that often promotes increased fishing effort and higher catches, as concentrations of fish are both easier to detect and more efficient to harvest (Turnbull and Samoilys 1997). Consequently, a large percentage of the recreational and commercial catch of fish in Queensland is obtained through the targeting of aggregations formed for migration, feeding or spawning (Beumer et al. 1997).

Anecdotal evidence suggests that intensive fishing has already severely impacted several annual aggregations of black jewfish along the east coast of Queensland (Bowtell 1994, Bowtell 1998). Exemplifying the vulnerability of this species to overfishing, the once flourishing commercial fishery along the north-west coast of India has become ‘non-existent’ (James 1992). The Traditional Owners of Northern Cape York Peninsula voiced their concerns to avoid the same outcomes occurring in their own waters.

Despite the susceptibility of black jewfish to overfishing, there remained a dearth of information on the species and the demands made upon those stocks by the various fishery sectors. In particular, the biological purpose and importance of these aggregations had yet to be demonstrated. The aim of my assessment was to alleviate the deficit of information on this species by focusing on the biology and harvest of black jewfish in the waters of Northern Cape York Peninsula. This assessment was conducted at the same time as the Indigenous Subsistence Fishing Survey (see Chapter 4).

For the purpose of this project, a General Fisheries Permit (number PRM00814A) was issued by the Queensland Department of Primary Industries and Fisheries. This permit authorised me to be in possession of black jewfish exceeding the size limits and bag limits prescribed by Queensland fisheries legislation.

5.2 Species identification

In Australia, the colloquial term ‘jewfish’ refers to a grouping of several tropical and temperate marine teleosts. The origins of the name is uncertain, but may be derived from ‘jewelfish’, which was until recently commonly used to describe this group of fish. The name jewelfish was derived from their pearly otoliths (Pollard 1980). Jewfish are also still widely known as ‘drums’ or ‘croakers’. These names are based on the amplified croaking sound this group of fish produce with the aid of their pharyngeal plates (Connaughton and Talyor 1995). The common name ‘black jewfish’ reflects the tendency of the scales of the fish to darken upon death (Grant 1999). The species is also known in Australia as northern mulloway, spotted croaker, and blotched jewfish, although these names are no longer commonly used.

The original description of the nominal taxon was provided by Lacepede (1802), who designated the name *Lutjanus diacanthus* to the holotypic specimen. The species was first re-classified as *Protonibea diacanthus* by Trewavas (1971). Prior to Trewavas (1971) and the subsequent taxonomic revision of the sciaenid fishes of the Indo-West-Pacific presented by Trewavas (1977), the classification of the species was inconsistent. Trewavas (1977) recognised 20 separate scientific names for the species; the most recent uses of which are: *Pseudosciaena diacanthus* (Dhawan 1971), *Johnius maculatus* (Ahmad 1971), *Nibea diacanthus* (Taniguchi 1970), *Sciaena diacanthus* (Taylor 1964), and *Johnius diacanthus* (Munro 1955). Suvatti (1981) acknowledged an additional species name, *Johnius coibor*, to those listed by Trewavas (1977).

Trewavas (1977) positions black jewfish in the tribe Nibeini, among five other monotypic genera (*Austronibea, Aspericorvina, Dendrophysa, Daysciaena and Paranibea*), and a sixth genus, *Nibea*, comprising six species. Two additional species that inhabit the Gulf of Carpentaria and northern Australia waters, *Nibea squamos* and *Nibea microgenys,* have since been described by Sasaki (1992) and added to the tribe Nibeini. Garrett (1997) suggests that prior to the identification of these two species, both may have been recorded in Queensland commercial catch logs under the umbrella of 'black jewfish'. These two species were not observed during the present study.

Sciaenids possess several characteristic diagnostic features including their comparatively large membranous labrinth and saccular otoliths, their distinctive acustico-lateralis system, and their unique swim (air) bladder that has up to 53 pairs of diverticula (Trewavas 1977). Trewavas (1977) has provided a simplistic systematic key that allows for the confident identification of fish representing the Tribe Nibeini. According to the keys, Sciaenidae are distinctive in that: (1) the swim bladder ('carrot' shaped) has several pairs of branched, arborescent (branching) appendages along its length, and (2) the anterior pair of mental pores is close together behind symphysis or open by a single pore.

The key to the generic separation of the Tribe Nibeini (Trewavas 1977) allows for the rapid identification of the black jewfish. These fish are distinguished from other species of the Tribe in that the first appendage of the swim bladder is not cephalic. This contrasts with the other species of Nibeini which have a part or whole of the anterior appendage entering the head and branching under the occipital and otic regions of the skull (Trewavas 1977). The two species of sciaenids assigned to the Tribe Nibeini by Sasaki (1992) possess small, uniform teeth on the lower jaw. Although similar dentition may be observed among other Nibeini (Sasaki 1992), this contrasts with the enlarged teeth in the lower jaw of black jewfish (Trewavas 1977).

I identified the specimens harvested from the Northern Cape York Peninsula aggregation sites as black jewfish using the systematic keys of Trewavas (1977). Identification of the species was confirmed by following the diagnostic features provided within the 'Species Identification Field Guide for Fishery Purposes' developed by the Food and Agriculture Organisation of the United Nations (De Bruin et al. 1994): 22-24 soft rays, 7-8 gill rakers on the lower limb of the first arch, and 16-20 pairs of appendages on the swim bladder.

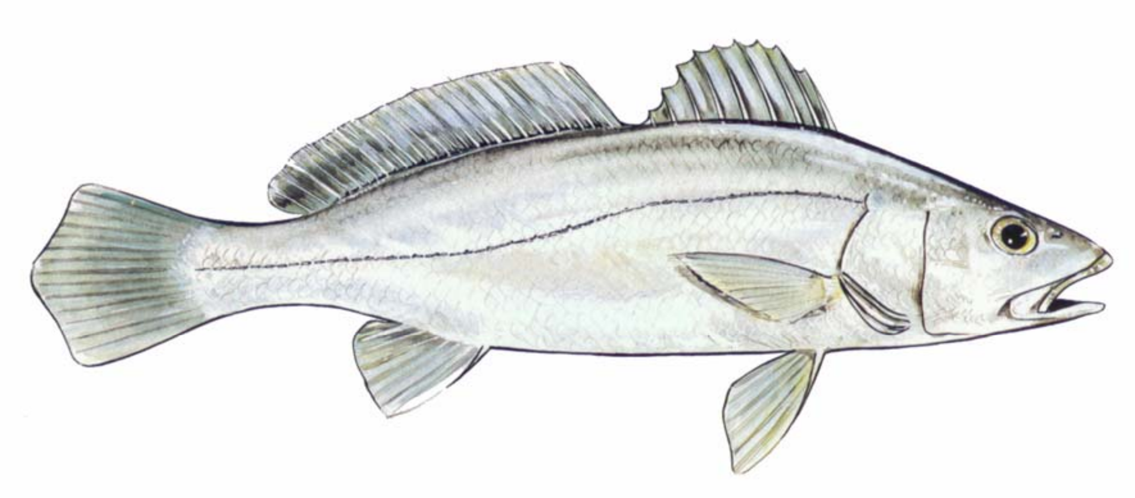

Figure 5.1: Illustration of a black jewfish, *Protonibea dicanthus.*

Source: Department of Primary Industries, Fisheries and Mines, Northern Territory Government.

Five specimens (size range 61 to 64 cm TL) collected from the Muttee Head (10° 54' S, 142° 13' E: see Figure 1.1) and Peak Point (10° 43' S, 142° 25' E: see Figure 1.1) aggregations in July 1999 were examined (and preserved) by taxonomist Dr Jeff Johnson of the Ichthyology Department at the Queensland Museum. He confirmed that these fish were black jewfish. A single specimen (size 18 cm TL) of slightly differing external appearance was also examined by Dr Johnson. This specimen, collected from Big Creek in the Escape River (10° 58’ S, 142° 39’ E: see Figure 1.1) tributary in December 1999, was confirmed to be a silver jewfish (*Johniops volgeri*). This exercise demonstrated that I was able to distinguish between similar species of jewfish.

5.3 Profile of the harvest of black jewfish

5.3.1 Historical catch data

5.3.1.1 Introduction

Achieving responsible and sustainable stewardship of fish stocks requires an understanding of the dynamics of the resource in relation to each of the pressures placed upon it (Garrett 1997). In recent years the aggregations of black jewfish that form annually off Muttee Head (10° 54' S, 142° 13' E: see Figure 1.1) appear to have been subjected to increasing levels of fishing pressure (Bligh 1994, Bligh 1995, Bowtell 1995, Bligh 1996, Ford 1999, Mondora 2000). Black jewfish are currently utilised in the region by local Indigenous subsistence fishers, local and transient recreational fishers, and by tourist anglers from all over Australia and the world. However, the fishery databases available to resource managers governing Queensland waters are presently limited to recreational and commercial harvests.

The management and monitoring of fish stocks utilised by Indigenous subsistence fishers is a relatively new concept to many natural resource management agencies in Australia, and as a consequence, there is a deficit of catch data on Indigenous fisheries. It is in such circumstances, when access to data is otherwise not available, that oral history proves an invaluable tool in establishing a retrospective analysis of resource use. Developing a historical record involves recognition that stock assessment does not consist of the assignment of static predictions about optimal efforts and sustainable yields, but concerns the assignment of time trajectories of fish and fishermen in response to management and other changes (Hilborn and Walters 1992).

5.3.1.2 Aim

The aim of this component of my thesis was to collate available information on historical catches of black jewfish in Northern Cape York Peninsula, and identify any trends in the fishery that may have occurred over time.

5.3.1.3 Methods

Oral and recorded accounts were received from Elders and Traditional Owners, as well as from long-term Indigenous and non-Indigenous residents of Northern Cape York Peninsula. Oral accounts were obtained in both formal and informal interviews, and recorded accounts in the form of photographs and fishers' diaries. Every effort was made to ensure that the documented information accurately reflected the informants' knowledge, and only oral and written accounts confirmed by more than one source were adopted. The names of the people who provided the original information have been referenced within the text of the results.

5.3.1.4 Results

The fishery based on black jewfish originated when the deep-water jetty at Muttee Head (10° 54' S, 142° 13' E: see Figure 1.1) became accessible to Indigenous subsistence fishers with the end of the Second World War. Injinoo Elders, Muen 'Shorty' Lifu (Gudang Elder), Gordon Pablo (Wuthathi Elder), and the late Daniel Ropeyarn (Anggamuthi Elder) attributed the first catch of black jewfish at the jetty to the late Patrick Ropeyarn. Each of these Elders independently recalled that year to be 1946, and each stated that this was the first time black jewfish were caught by the Traditional Owners of the area.

The traditional language word for black jewfish is 'Unyunguthi' in the Yadhaykenu dialect of the Injinoo Ikya (Harper 1996), or 'Ambu' in the Wuthathi language (Gordon Pablo, Wuthathi Elder, Injinoo Aboriginal Community, *pers comm*. 1999). In the Creole language of the region, currently the most commonly spoken language at Injinoo, the species is called 'jewpis'. The place name Muttee Head ('Ukumva' in Injinoo Ikya) may have been derived from the European perception of the spelling of the latter part of the clan name Anggamuthi (Gary Wright, Charter Boat Operator, Seisia Islander Community, *pers comm.* 2000).

From the period when black jewfish were first caught in the late 1940s through to the 1960s, people regularly walked from the community at Cowal Creek (10° 55' S, 142° 22' E: see Figure 1.1) to Muttee Head (10° 54' S, 142° 13' E: see Figure 1.1) in order to fish from the jetty (Shorty Lifu, Gudang Elder, Injinoo Aboriginal Community, *pers comm.* 1999). The fish, kept fresh by burying in the sand, were carried back to be cut up at the Community and eaten immediately (Gordon Pablo, Wuthathi Elder, Injinoo Aboriginal Community, *pers comm.* 1999). Even those people who travelled to Muttee Head by canoe or rowboat took few fish, as they had to be eaten fresh because of the lack of refrigerators and freezers in the Community (Gordon Pablo, Wuthathi Elder, Injinoo Aboriginal Community, *pers comm.* 1999).

Over the same period, four additional Indigenous communities were established within Northern Cape York Peninsula. The first of these, the Torres Strait Islander community of Bamaga (10° 53' S, 142° 23' E: see Figure 1.1), was initially settled at Muttee Head. The establishment of the four additional communities, coupled with the gradual return of non-Indigenous residents following their evacuation during World War Two, greatly increased the number of people residing in the region. At the time of this study, the population of Injinoo was close to 350 people, while the greater population of the Northern Cape York Peninsula totalled of approximately 2600 people.

From the 1960s, fishing effort targeting black jewfish became predominantly vessel based following the loss of the jetty at Muttee Head to a fire. The pylons are now the only evidence of the wharves built by the Allied forces to allow Liberty class supply ships to take on freshwater for the war effort in Papua New Guinea (Bligh 1994). For many years following the fire, the artificial reef created by the sunken remains of the jetty continued to attract large numbers of jewfish. Deepwater harbours and artificial reefs in northern Australian waters are well known habitats for black jewfish (Ross and Duffy 1995, Grant 1999).

From the late 1980s people began to target black jewfish in the deepwater holes in the area off the rocky headland at Muttee Head (~150 m from pylons). In time, this area became renowned as the best site to catch jewfish, and is said to be the location that the majority of black jewfish have been harvested in recent years (Tex Nona, Builder, Injinoo Aboriginal Community, *pers comm.* 1999). Some local residents believe the deepwater holes at Muttee Head were created by Defence Force personnel exploding surplus ammunition at the end of the Second World War.

With the progressive introduction of outboard-powered dinghies in the region, new areas producing good jewfish catches were discovered, first near Pajinka (10° 41’ S, 142° 31’ E: see Figure 1.1) and then in the Escape River (10° 58’ S, 142° 39’ E: see Figure 1.1), and most recently near Peak Point (10° 43’ S, 142° 25’ E: see Figure 1.1) (David Epworth, Project Officer, Balkanu Cape York Development Corporation, Cairns, *pers comm.* 1999). Deep holes are characteristic of each of these sites. The rapidly growing number of households which own powered vessels has served to increase access to these fishing locations, and perhaps reflects the improving economic situation within the communities (Ron Harvey, Accounts Manager, Injinoo Aboriginal Community Council, *pers comm.* 2000).

Ownership of vessels has increased dramatically in the last decade. In 1990, there were five powered dinghies at Injinoo (Danny Salee, Community Police Officer, Injinoo Aboriginal Community, *pers comm.* 2000), by 1995 there were twelve vessels on the community fishing vessel register, and in August 2000, the number had increased to 42 vessels. At the same time there were 48 houses in the Community of Injinoo. The community fishing vessel register also displays a trend over time towards larger vessels and outboard motors. Whereas the first powered dinghies which began to replace the sail and rowboats of the 1960s were small one-cylinder engine models (Gordon Pablo, Wuthathi Elder, Injinoo Aboriginal Community, *pers comm.* 2000), the latest purchases include 100 hp models.

While catches of black jewfish have occurred at a growing number of locations in the region, Muttee Head with its predictable mid-year aggregation remained the site where most of the total annual catch was taken in the region (Doyle Sebasio, Community Police Officer, Injinoo Aboriginal Community, *pers comm.* 2000). Typically, the aggregation of the fish at Muttee Head extended from late April through to early August (Shorty Lifu, Gudang Elder, Injinoo Aboriginal Community, *pers comm.* 1999). Anzac Day was well known at Injinoo as the start of season for black jewfish (Gordon Solomon, Deputy Chair, Injinoo Aboriginal Community, *pers comm.* 2000).

When conditions were suitable during the aggregation period, it was common to see in excess of twenty vessels fishing Muttee Head per night (Jackson Sailor, Quarantine

Officer, Australian Quarantine and Inspection Service, Bamaga Islander Community, *pers comm.* 2000). The dinghies were often tied side-by-side in order to fish the trenches and holes (Robbie Salee, Clerk, Injinoo Aboriginal Community, *pers comm.* 1999). Catches were frequently well in excess of fifty black jewfish per boat per night (Dale Salee, Councillor, Injinoo Aboriginal Community, *pers comm.* 2000). Exemplifying the ease with which black jewfish can be caught, specimens have reportedly been landed using metal bolts instead of hooks (the late Daniel Ropeyarn, Anggamuthi Elder, Injinoo Aboriginal Community, *pers comm.* 1999).

Black jewfish with ripe ovaries were previously caught during the period of the annual aggregations (Tex Nona, Builder, Injinoo Aboriginal Community, *pers comm.* 2000). The Indigenous subsistence fishers of Northern Cape York Peninsula eat the eggs of many marine species, including jewfish, and have a good knowledge of the breeding season of the species they utilise (Gordon Pablo, Wuthathi Elder, Injinoo Aboriginal Community, *pers comm.* 2000). Black jewfish close to their maximum size (150-180 cm TL) were said to be commonly caught in the last few decades (Shorty Lifu, Gudang Elder, Injinoo Aboriginal Community, *pers comm.* 2000). These fish greatly exceeding the observed length at first maturity (92 cm TL) in female black jewfish inhabiting North Queensland waters (McPherson 1997).

In 1994, two black jewfish caught at Muttee Head barely fitted inside the commercial freezer at the Injinoo Service Station, suggesting these specimens were over 150 cm TL (Joel Nona, Community Police Officer, Injinoo Aboriginal Community, *pers comm.* 1999). This was the last reported catch of specimens of this size. The largest black jewfish were said to be found at Muttee Head during the later stages of the aggregation around July and August (Erris Eseli, Councillor, Injinoo Aboriginal Community, *pers comm.* 2000). Juveniles (<30 cm) were reportedly caught within the Jardine River (10° 57’ S, 142° 11’ E: see Figure 1.1) and Jacky Jacky/Escape Rivers (10° 56’ S, 142° 30’ E: see Figure 1.1) (Tex Nona, Builder, Injinoo Aboriginal Community, *pers comm.* 1999).

As a testament to the large size of the black jewfish caught in years past, it was said that thick wire cable found in the area of the old military base at Muttee Head was used to land the jewfish while fishing the old jetty (the late Daniel Ropeyarn, Anggamuthi Elder, Injinoo Aboriginal Community, *pers comm.* 1999). In the early to mid-1990s, the use of clothes-line wire or whipper-snipper line was commonly used to catch black jewfish (Pedro Steven, Mayor of Torres Shire, Thursday Island, *pers comm.* 2000). Presently, 100 lb line is most commonly used by the Indigenous fishers. This decrease in line size may reflect a decrease in the maximum size of the black jewfish.

Private diary records held by community members which I viewed revealed that the duration of the aggregation has progressively reduced in recent years. Further, the number of fish in the aggregations formed annually at Muttee Head, as evidenced by sounder readings, has dramatically diminished over the last decade. Sounder readings display a lower density of fish and the area the schools of fish cover appears much reduced (Gary Wright, Charter Boat Operator, Seisia Islander Community, *pers comm.* 2000). Up until as recently as about 1995, the mass of fish around the pylons was so large that the jewfish were clearly visible from a boat (Gary Wright, Charter Boat Operator, Seisia Islander Community, *pers comm.* 2000).

5.3.1.5 Discussion

The historical accounts of black jewfish catches in Northern Cape York Peninsula provide a record of the species' exploitation in local coastal waters since the inception of the fishery. The collated accounts of the exploitation of black jewfish at Muttee Head span over a fifty year period, and present anecdotal evidence of a gradual reduction in the size of the fish caught during the aggregation period. It appears that the fishery was previously based on sexually mature fish, whereas catch records collected in 1999 and 2000 demonstrate the fishery is now based almost exclusively on juvenile fish (see Chapter 5.3.2.). These data support the notion of a significant change in the black jewfish resource.

The number of fish caught per boat appears to have remained relatively steady during the annual mid-year fishery at Muttee Head. Catches in 1999 and 2000 still commonly exceeded 50 black jewfish per night (see 2.2.3). The persistence of these large catches despite the apparent decline in other measurable characteristics of the aggregation was not surprising. Samoilys and Gribble (1997) have suggested that in situations where the exploited species aggregates, catch per unit of effort (CPUE) can remain relatively steady until the last school of fish is removed.

Private diary records revealed the period over which large schools of black jewfish may be encountered at Muttee Head has became much reduced over the years. Consequently, both the catch and effort at Muttee Head have become increasingly concentrated in time. This trend was believed to be responsible for the shift in the effort during 1999 to Peak Point (10° 43' S, 142° 25' E: see Figure 1.1), a site apparently never before exposed to intensive fishing effort (see Chapter 5.3.2).

The changing circumstances of the Northern Cape York Peninsula fishery appear similar to accounts of the black jewfish catches along the Capricorn and Central Coasts of Queensland (Bowtell 1995, 1998). Bowtell's (1995) account published in the correspondence section of 'Fish and Boat', bears a striking resemblance to the Muttee Head scenario. The article reads:

> "In the late 70's and into the early 80's, an area known locally as "The Pinnacles" was discovered as being a congregation area for large black jewfish. Throughout this period, the area was very heavily fished.....Catches of fish were very high, with boats recording catch numbers in the forties and fifties.....As word got around, more and more people wanted in on the action. Until it got to a stage where the ocean resembled a floating city."

The article concludes by describing the present situation along the Capricorn and Central Coasts. The article's dim reminder of the risks of overfishing reads:

> "Today the fish still show up, but only in very small numbers and their time of stay is very short. The recruitment of stocks inshore along the coast is minor whereas once it was common to catch small black jew in the coastal creeks and rivers, now it is a rarity."

5.3.2 Contemporary catch data

5.3.2.1 Introduction

Populations of fish that are subject to sustained fishing pressure may exhibit many changes such as shifts in total numbers or biomass, size-frequency distributions, age-structure, and spatial distributions (Haddon 2001). Fisheries science has naturally adopted analytical descriptions of these processes in an attempt to understand how exploited populations respond to different harvest strategies (Haddon 2001). Traditionally, stock assessments have relied upon statistics gathered directly from fishing operations, but unfortunately the pursuit of fish usually results in a highly un-random and non-representative sampling pattern (Hilborn and Walters 1992).

In recognition of the dangers of fishery dependent approaches, many agencies have invested in fishery independent sampling programs. These programs are generally very expensive to implement and result in a lesser number of samples (Hilborn and Walters 1992). Hence, Hilborn and Walters (1992) attest to value of establishing some type of cooperative data-gathering system where fishers assist agencies with the gathering of information. Dayton (1998) takes this notion one step further, suggesting the manifestation of the precautionary principal in modern fisheries management has shifted the burden of proof to those who claim it is safe to keep fishing.

5.3.2.2 Aim

The aim of this component of the assessment was to describe the utilisation of black jewfish in Northern Cape York Peninsula, characterising the local fishery in terms of catch and effort. I also aimed to profile the black jewfish aggregation events in terms of their formation and dispersal as revealed by the catch data.

5.3.2.3 Methods

Data on the harvest of black jewfish by fishers residing in Northern Cape York Peninsula was collected from the 1st of January 1999 to the 31st of December 2000. Catch details collected in the Indigenous Subsistence Fishing Survey (see Chapter 4) were used in this component of my thesis, and supplemented with additional information provided local residents.

The local residents of Northern Cape York Peninsula assisted me greatly by providing details of observed catches, and providing access to their own catches so that I may confirm the number caught and sample a portion of the fish. Details of black jewfish catches were obtained from Indigenous subsistence fishers, recreational fishers and charter boat operators from the communities of Injinoo, Bamaga (10° 53’ S, 142° 23’ E: see Figure 1.1), New Mapoon (10° 52’ E, 142° 23’ S: see Figure 1.1), Umagico (10° 53’ S, 142° 21’ E: see Figure 1.1), and Seisia (10° 51’ S, 142° 22’ E: see Figure 1.1).

As often as possible, I offered fishers who provided me with details of their catch, or allowed me access their catch, a gift of hooks or sinkers. I did this to ensure their continuing assistance, and to encourage them to provide me with regular access to their catch. I visited fishers either on the water or at their homes to confirm the details of reported catches, and to sample the fish.

Fishing trip details (number of fishers involved, the place and time of catch), fishing effort (hours spent fishing), and specimen details (number of fish caught, total length and weight of individual specimens) were recorded. The length and weight of the fish were rounded down to the last full unit, for example, a fish 65.4 cm in length was recorded as 65 cm. The age of the fish was estimated from length/age keys established by Bibby and McPherson (1997) for black jewfish in Queensland waters.

5.3.2.4 Results

Between 1st of January 1999 and the 31st of December 2000, I recorded the harvest of 4031 black jewfish (see Figure 5.2 and 5.3). Close to 15% of this catch (n = 580) was measured (41-103 cm TL) and weighed (0.7-10.5 kg). The extrapolated total weight of the recorded black jewfish catches in the coastal waters and tributaries of the region was 3.91 t in 1999 and 4.46 t in 2000. CPUE was highly variable in 1999 and 2000, ranging between 2.8 kg boat h^{-1} to 224.5 kg boat h^{-1}.

Catches of black jewfish in 1999 and 2000 occurred in patches at a range of locations. Black jewfish were caught during January 1999 off Seisia (10° 51' S, 142° 22' E: see Figure 1.1), followed by catches off Muttee Head (10° 54' S, 142° 13' E: see Figure 1.1) in March through to May 1999. Catches of the fish occurred at Peak Point (10° 43' S, 142° 26' E: see Figure 1.1) during April and May 1999. The last catches in 1999 were off Horn Island (10° 36' S, 142° 17' E°: see Figure 1.1) in June. In January 2000, the species was again caught off Seisia, as well as at Muttee Head and the Jardine River mouth (10° 57' S, 142° 11' E: see Figure 1.1). In May 2000, black jewfish were obtained off Seisia, followed by catches in June and July 2000 off Muttee Head and Peak Point. The last catches of black jewfish in 2000 occurred off Seisia in September.

In 1999, the number of black jewfish harvested at Muttee Head peaked during the period of the 21st to 31st of May (catches between 10-74 black jewfish per boat/day, mean 36). In 2000, catches at Muttee Head peaked between the 13th and 18th of July (13-111 black jewfish per boat/day, mean 50). In 1999, 88% of the total catch of black jewfish occurred from April through to August, the period in which historical accounts (see Chapter 5.3.1) suggest that the species aggregates in the area. In 2000, 89% of the total catch of black jewfish occurred between May and September.

During April to August, the period in which black jewfish have historically aggregated off Muttee Head, comparably high catches were obtained in 1999 at Peak Point (10° 43' S, 142° 25' E: see Figure 1.1), a site never before exposed to intensive fishing effort. Catches of black jewfish at Peak Point peaked during 1999 in the period 27th of April to 28th of May (13-58 black jewfish per boat/day, mean 31). In 2000, fishing effort at Peak Point was much reduced, most likely because of rough weather and inaccessibility. Hence in 2000, catches from Peak Point failed to form an appreciable component of the annual catch.

Differences in the mean size of black jewfish sampled during 1999 and 2000 were tested using a 2-sample *t*-test (Sokal and Rohlf 1995). The mean length of fish in 2000 [618.6 ± 2.2 mm (± s.e.)] was significantly (t=-33.6, d.f.=1474, P<0.001) less than in 1999 [739.6 ± 2.9 mm (± s.e.)]. The size difference can be clearly seen in Figures 5 and 6. In 1999, 79% of black jewfish obtained from Northern Cape York Peninsula had a total length of 70-79 cm. In 2000, 92% of the catch of black jewfish was represented by specimens 60-69 cm TL. In both years, the remainder of the catch was composed almost exclusively of smaller specimens.

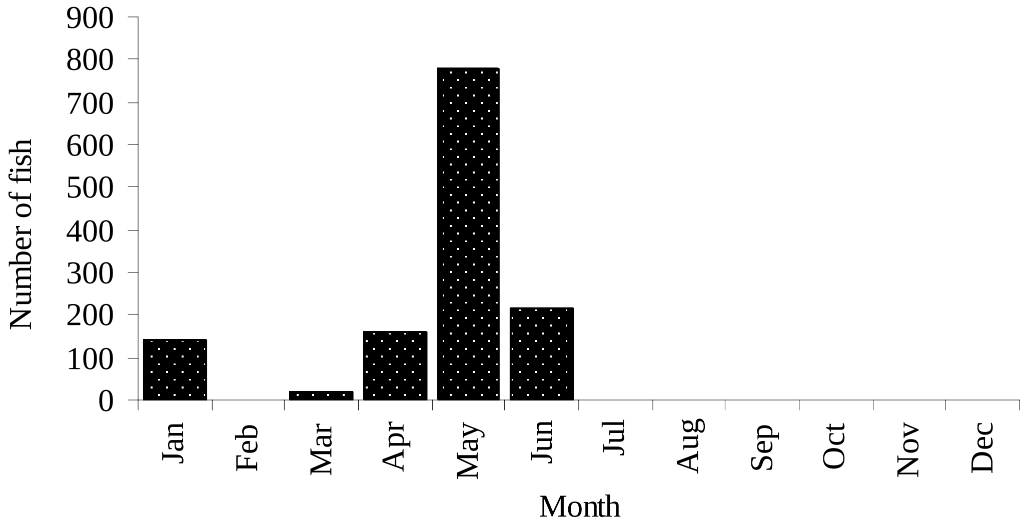

Figure 5.2: Number of black jewfish harvested each month of 1999 from the coastal waters and tributaries of the Northern Cape York Peninsula (n = 1376).

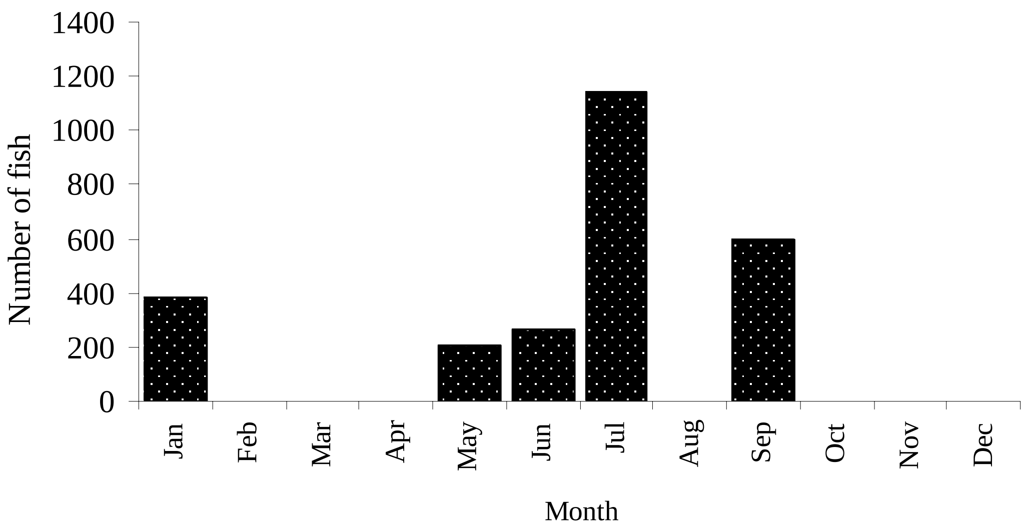

Figure 5.3: Number of black jewfish harvested each month of 2000 from the coastal waters and tributaries of Northern Cape York Peninsula (n = 2655).

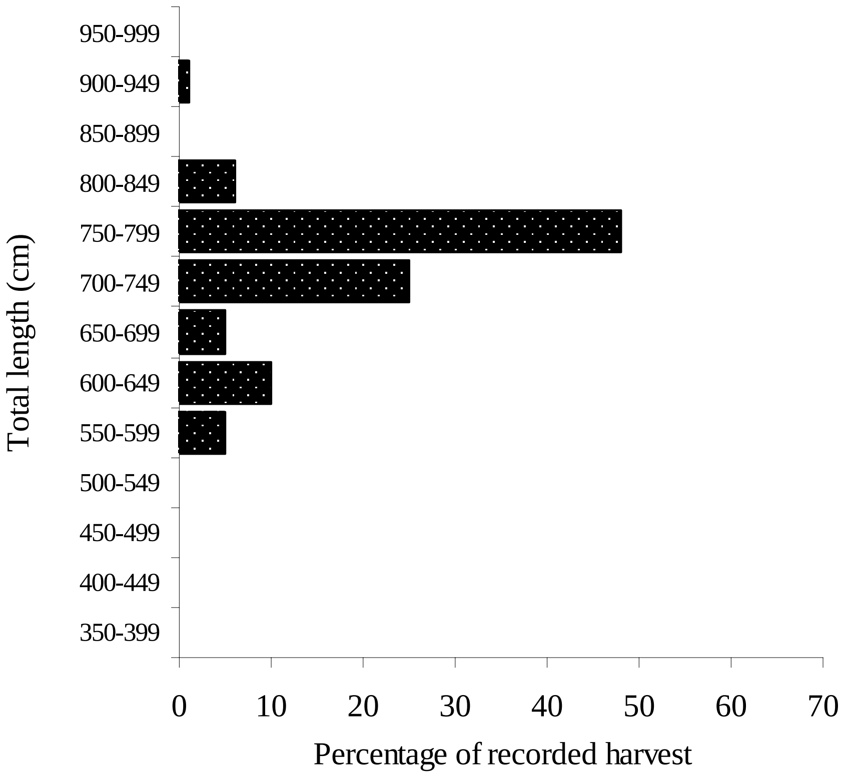

Figure 5.4: Length of black jewfish harvested and measured in 1999 (n = 330).

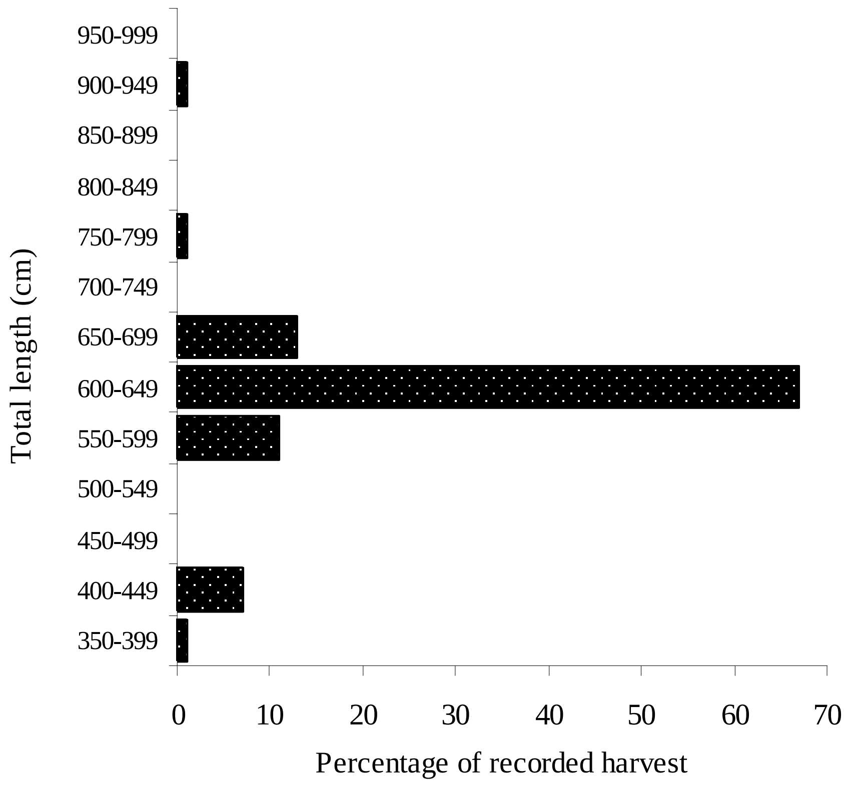

Figure 5.5: Length of black jewfish harvested and measured in 2000 (n = 250).

Based on length-age keys developed by Bibby and McPherson (1997), the fishery harvested one-year-old to five-year-old fish (see Figure 5.6). The predominate age class represented in catches from Muttee Head (10° 54’ S, 142° 13’ E: see Figure 1.1) during the aggregation period fell from three-year-old stock (~70-85 cm TL) in 1999 to two-year-old stock (~50-65 cm TL) in 2000. Catches at Peak Point (10° 43’ S, 142° 25’ E: see Figure 1.1) in 1999 had been composed exclusively of two-year-old stock, and catches at Crab Island (10° 58’ S, 142° 06’ E: see Figure 1.1) in 2000 were exclusively one-year-old stock (~35-45 cm TL). In 1999 and 2000 combined, black jewfish four-years of age or greater amounted to less than 1% of the total catch obtained from the waters of Northern Cape York Peninsula.

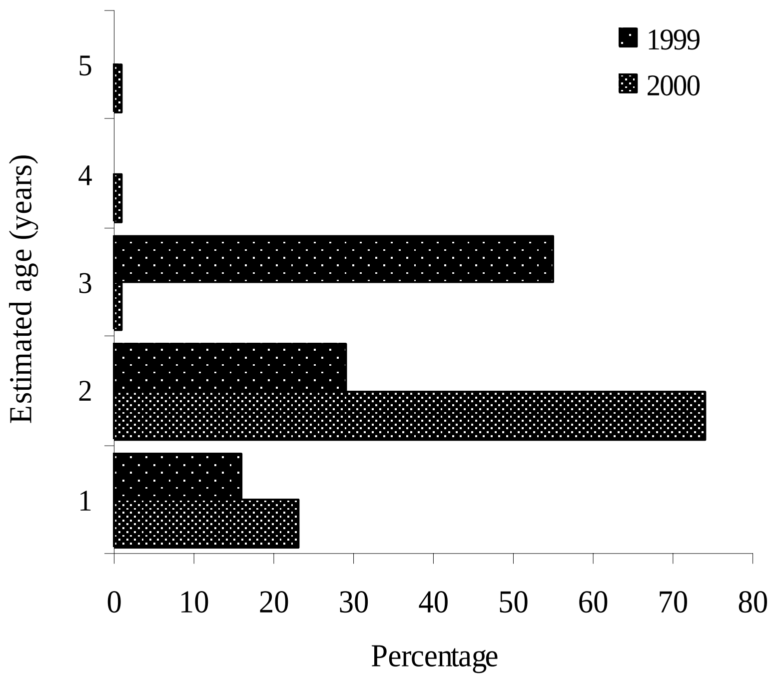

Figure 5.6: Estimated age of black jewfish harvested and measured in 1999 and 2000 (n = 580).

5.3.2.4 Discussion

In 1999 and 2000, catches of black jewfish were based almost exclusively on immature fish. Less than 1% of the stock harvested in the fishery was larger than 92 cm TL, the length that McPherson (1997) determined as the minimum size female black jewfish attain sexually maturity. The high representation of juveniles in the catch warrants concern for the state of the resource given that historical data indicate the fishery was previously based on adults (see Chapter 5.3.1).

Changes in the structure of the stock appear to have occurred rapidly. Historical records reveal specimens close to maximum size (>150 cm TL) were caught up until 1994 (see Chapter 5.3.1). In 1999, three-year-old fish (one-year class below which 50% of females become sexually mature) dominated catches. In 2000, the dominant size class was two-year-old stock (half the age of the breeding class). These data suggest a major reduction in the proportion of adults in the population occurred in only five years. There are many examples in the literature of similar losses led by larger individuals following heavy exploitation of aggregations (e.g., Rowling 1990; Beets and Friedlander 1992; Sadovy 2004; Wanless et al. 2004).

The consequences of the truncation of the natural size and age structure are yet to be realised for black jewfish, but may be expected to have a detrimental effect on stock's ability to renew itself. Turnbill and Samoilys (1997) provide evidence that estimates of the critical stock density which must be maintained for stock replenishment vary in tropical fish between 20% (Goodyear 1989) to 40% (Caddy and Mahon 1995) of the virgin spawning biomass. While the critical stock density for black jewfish has not been determined, my findings that less than 1% of the catch were of a mature size, challenges existing management measures if overfishing is to be avoided.

While it is uncertain what numbers of black jewfish participate in the annual aggregations, it is clear that these fish congregate in numbers that may be counted in thousands. For example, on 18 July 2000, 480 specimens were landed by handline within eighty minutes at Muttee Head, and in the five days prior, an additional 419 specimens had been caught at the site. Thomas and Kunju (1978) report on a large catch by a purse-seiner off Goa, north-west India, in which the total number of black jewfish captured was 2,309 individuals. The total weight of the catch was estimated at 30.4 tonnes (Thomas and Kunju 1981).

Local catches of black jewfish in 1999 and 2000 ranged up to 224.5 kg boat h^{-1}, with the most productive effort occurring during the aggregation period. Based on a mean of four people per boat, catches of black jewfish per line ranged from 0.7 kg line h^{-1} to

56.2 kg line h^{-1}. This catch rate is comparatively high for handline fishing in tropical waters. Dalzell et al. (1996) conducted a review of CPUE in tropical waters revealing handline fishing in water <60m deep yielded a mean catch rate of between 0.5 and 2.0 kg line h^{-1}. The greatest CPUE that Dalzell (1996) reported was 4.4 kg line h^{-1}.

Catch rates are often adopted in mainstream fisheries science as an index of stock size and changes in abundance. However, the persistence of high catches attainable from Muttee Head is unlikely to provide an accurate indication of the abundance of this species. It is recognised that where fishers concentrate their effort on aggregations of relatively high fish density, CPUE may remain steady until the last school is removed (Samoilys and Gribble 1997). Alternatively, CPUE effort can decline rapidly as a few local concentrations of fish are depleted, but with little change in the total stock size if only a small percentage of the fish participate in the aggregation events (Hilborn and Walters 1992).

The rapid rate in which aggregations of fish may decline is exemplified by the Nassau grouper (*Epinephelus striatus*) and red hind (*E. guttatus*) at St. Thomas in the U.S. Virgin Islands. The 1973-74 season brought a notable change in catches and hence in the following year a study was initiated to assess the need for management action. However, by 1975-76 the grouper fishery had collapsed dramatically, with handline catches falling to only 2% of the previous year (Olsen and LaPlace 1979). The absence of any reports of the aggregations reforming, even after almost ten years of protection (Eklund et al. 2000) is cause for concern

In 1999, I recorded a shift in the majority of the fishers' effort to targeting juvenile fish at Peak Point (10° 43' S, 142° 25' E: see Figure 1.1); a site never previously subjected to intensive fishing. Catches at Peak Point were composed exclusively of two-year-old stock. The shift in effort appeared to be a direct result of the delayed and limited temporal scale of the aggregation at Muttee Head in 1999. The exposure of the fishing site to the strong south-easterly winds characteristic of the dry season (generally May through to September), may have may have contributed to its previous light use and its light use again in 2000.

Establishing trends in the abundance of black jewfish is difficult in the absence of long-term catch and effort data. However, it is evident that boat ownership in the region increased dramatically in the period prior to the recent changes in the stock. At Injinoo Aboriginal Community, for example, there were only five powered dinghies in 1990, but by 2000 the number of vessels had risen to 42 (see Chapter 5.3.1). Unfortunately there were insufficient catch data available to test for a correlation between increased boat use and catch. Due caution should always be applied in assigning changes in the characteristics of a fishery to human intervention as exploited stocks may also display fluctuations reflecting interannual variations in emigration, recruitment, growth etc (Jenning and Lock 1996).

In examining the aggregations of three serranid species, Johannes et al. (1999) observed considerable intra- and inter-annual variation in the size of the aggregations. They believed that this variation was independent of fishing pressure and management measures. It is possible that climatic or changing hydrological conditions may account for some of the observed variation in the formation and dispersal of the annual mid-year aggregations of black jewfish. For example, evidence from across the globe suggests that the aggregation of tropical fish may be temperature related (Sadovy 1996). Exemplifying this, off the north Queensland coast adjacent to Cairns (16° 55 S, 145° 46’ E), aggregations of coral trout form once waters temperature rises above 24°C following the Austral winter (Turnbull and Samoilys 1997).

In 1999 and 2000, catches of black jewfish from the aggregation sites peaked at the end of the Austral summer when the water temperature near Thursday Island (10° 33’ S, 142° 13’ E: see Figure 1.1) was between 24.3 and 27.8°C (Source: Ray Berkelmans, Australian Institute of Marine Science/Great Barrier Reef Marine Park Authority). Between April and August, the period in which the aggregations have historically formed in the region, historical monthly average water temperatures in the region averaged between 24.5 and 28.4°C (Source: Ray Berkelmans, Australian Institute of Marine Science/Great Barrier Reef Marine Park Authority, 2002). This temperature range is remarkably similar to the temperatures in which coral trout form spawning aggregations in north Queensland (24.2-28.5°C: Samoilys 1997b).

The temperature range in the period black jewfish are known to aggregate is not as broad as previous documented ranges for sciaenids. For example, Acha et al. (1999) found that whitemouth crocker (*Micropogonias furnieri*) aggregate in temperatures ranging between 16-26.8°C, while Saucier and Baltz (1993) have demonstrated spotted sea trout (*Cynoscion nebulosus*) and black drum (*Pogonias cromis*) form aggregations in waters temperatures ranging between 24.5-33.5°C and 15.0-24.0°C respectively. However, teleosts inhabiting tropical waters are expected to exhibit a narrow range reflecting the lower intra-annual variation in water temperature. Exemplifying this idea, spawning aggregations of Nassau grouper are confined to the temperature range of 25.0-26.0°C (Colin 1992, Tucker et al. 1993).

The tidal and lunar conditions most conducive to catching black jewfish had long been common knowledge among fishers, but have hereto remained undocumented. With currents in the region attaining speeds nearing ten knots, fishers displayed a logical predilection for allocating effort to the slack water periods that come with tide changes. The need to fish these periods was compounded by the fact that most fishing effort occurred during the spring tides that coincide with the full moon. Lunar periodicity in fish aggregations has been demonstrated for a large number of species, but appears to be limited to large pelagic fish that migrate to spawn (see Appendix 4).

5.4 Profile of the biology of black jewfish

5.4.1 Reproduction

5.4.1.1 Introduction

A significant characteristic of the life cycles of many sciaenids is the seasonal aggregation of adult fish for spawning (e.g., Griffiths 1996, Norbis and Verocai 2005). Mid-year aggregations of Australia's largest tropical sciaenid, the black jewfish, have been reported at a number of northern Australia locations extending from Central Queensland (Bowtell 1995) to northern Western Australia (Newman 1995). Annual aggregations of black jewfish have increasingly become the focus of line fishing effort in northern Australia, however, the biological purpose and importance of these aggregations had yet to be determined.

Aggregations of fish present especially vulnerable fishery targets (Turnbill and Samoilys 1997), often warranting special regulatory measures governing their exploitation (Johannes et al. 1999). Intensive fishing of spawning aggregations has had demonstrated negative effects on the proportion of reproductively active fish and consequent future fishery yields of many species (Olsen and LaPlace 1978, Shapiro 1987, Colin 1992, Sadovy 1994, Johannes et al. 1999). The largest member of the family Sciaenidae, *Totoaba macdonaldi*, is now considered critically endangered (IUCN 2004) as a consequence of commercial and recreational fishing activity targeting the annual inshore migration to inshore spawning sites (True et al. 1997).

A sound knowledge of the reproductive strategies employed by fish is vital to the development of management practices that ensure the protection of breeding stocks vulnerable to fishing pressure (Fowler et al. 1999). Understanding the reproductive traits of an exploited species is required to determine appropriate legal size restrictions, to provide protection of vulnerable breeding aggregations, and to aid in understanding the replenishment processes integral to the maintenance of local populations (McPherson 1997). Establishing the period and location of peak reproductive activity in northern Australia's black jewfish stocks is therefore a priority task for ensuring the sustainable use of this culturally and economically important species.

5.4.1.2 Aim

The aim of this component of my study was to identify the period and location at which peak reproductive activity of black jewfish occurs in the waters of Northern Cape York Peninsula. With this information, I aimed to examine the relevance of the fish's reproductive strategy in the formation of the annual aggregations.

5.4.1.3 Methods and materials

The gonads of female black jewfish were sampled from specimens caught by Indigenous subsistence fishers and recreational fishers. All fish were caught by handlines from depths ranging between 10 to 25 metres. I sampled subsets of these catches whenever opportunities presented. On each occassion, the largest females were sampled. Sampling the largest specimens was necessary due to the high proportion of juveniles in the catches of 1999 and 2000 (see Chapter 5.3.2). The fishers retained the fish and were reimbursed for their assistance whenever possible with a gift of hooks or sinkers. When specimens were not available from local fishers, I sampled fish caught during sampling trips conducted in the project's vessel. After these fish had been sampled and cleaned, they were donated to members of Injinoo Aboriginal Community.

Between January and June 1999, 122 specimens (size range 55-80 cm TL) were sampled from the aggregation sites at Muttee Head (10° 54' S, 142° 13' E: see Figure 1.1) and Peak Point (10° 43' S, 142° 25' E: see Figure 1.1). In January 2000, 37 specimens (70-75 cm TL) were sampled from catches collected at Muttee Head. Between May and July 2000, a further 97 specimens (60-92 cm TL) were sampled from catches collected from Muttee Head, and an aggregation sampled at Peak Point. During the same period, additional samples were collected near Crab Island (10° 58' S, 142° 06' E: see Figure 1.1) and within the Escape River (10° 58' S, 142° 39' E: see Figure 1.1). Aggregations of black jewfish have not been recorded at these two sites. A further 14 samples were obtained in August 2000, from an aggregation which forms annually off Cullen Point near the Mapoon Community (12° 01’ S, 141° 54’ E). In all, 270 specimens were sampled from catches made in the inshore waters and tributaries of the Cape York Peninsula.

Sampled fish were measured and weighed before the gonads were removed. Macroscopic observations on the gonads were recorded before they were fixed in 10% formaldehyde-acetic acid-calcium chloride fixative (FAACC). Sixty-four preserved gonads were chosen for histological examination. The gonads selected included each of the samples believed to be most developed based on the macroscopic observations. I also histologically examined representatives of the other macroscopic stages so that their details could be described.

These gonads were sectioned along the sagittal plane for histological analysis, dehydrated, and then embedded in paraplast. Sections were cut at 5μm and stained with Mayer’s haematoxylin and Young’s eosin. Nomenclature of the oogenesis stages was based on Rao (1963), West (1990), Samoilys and Roelof (2000) and Mackie and Lewis (2001), as well as observations made during the present study (see Table 5.1). The state of maturity was classified by the most advanced type of oocyte present, regardless of how numerous they were. The age of the fish was estimated from length/age keys developed by Bibby and McPherson (1997).

Diving at the fishing sites to observe the aggregating behaviour of the fish was not feasible due to the combination of high turbidity, strong currents, and the frequent presence of sharks at the site. During 2000, a local professional diver had made available a shark cage and underwater video camera in the event that ideal conditions were presented, however such conditions did not eventuate in the period the fish were aggregating in the area.

5.4.1.4 Results

No black jewfish specimens collected in 1999 displayed any evidence of sexual maturity and were deemed sexually inactive. All fish collected in 1999 were below 92 cm TL, the length of first maturity reported by McPherson (1997) for female black jewfish. The reproductive status of the females collected in 1999 was confirmed in 20 histological sections of ovaries from the largest of the black jewfish (75-80 cm TL) sampled in 1999. Most (80%) of these ovaries were at stage I, with the remainder at stage II.

Table 5.1: Observed stages in the ovaries of black jewfish sampled from Northern Cape York Peninsula.

Stage	Description
I. Juvenile	Macro: In developing virgins the ovary is flaccid and thread-like, extending to 1/2 body cavity, translucent to light pink. Micro: Previtellogenic oocytes of the chromatin nucleolus stage display a large, clear nucleus surrounded by a thin layer of basophilic (dark staining) cytoplasm. Few squamous follicle cells are visible.
II. Immature	Macro: Similar to stage 1 in external presence. Micro: The light nucleus of the perinucleolar stage oocyte increases is size and may show multiple peripheral nucleoli its periphery. The thick, homogenous cytoplasm stains dark purple in the early perinucleolus stage and fainter in the late stage. Generally the cytoplasm remains basophilic, though microvilli may be visible, giving the cytoplasm a slightly granular appearance.
III. Developing	Macro: Ovary long, thin and flaccid as in previous stage occupying about 2/3 body cavity. Light reddish-grey in colour. Micro: Yolk vesicles appear in the cytoplasm of the vitellogenic oocyte (appear empty with haematoxylin and eosin stain) which appears more granular. Yolk vesicles increase in size and number to form several peripheral rows and give rise to the cortical alveoli (yolk vesicle). The zona radiata (pink) forms between the follicle cell layer (darker in colour) and the oocyte. Toward the end of this stage the follicle thickens and forms a layer of distinctly nucleated cells (the granulosa).
IV. Mature	Macro: Ovary broad and swollen, filling 2/3 to 3/4 body cavity. Light yellow or reddish yellow in colour. Micro: The yolk granular oocyte shows early development of acidophilic (pinkish-red staining) yolk spheres (globules or granules) in outer regions of cytoplasm. As the oocyte increases in size, the yolk granules increase in number and size. The yolk granules may begin to coalesce in the late stage. The zona radiata is well developed.

From the specimens caught in 2000, a further 30 ovaries were examined histologically. Thirteen specimens, sampled between January and June 2000, had Stages I or II ovaries. Nine specimens (<69 cm TL), sampled between May and July had Stage III ovaries, while four specimens (ranging from 79 to 92 cm TL) sampled between May and July, were classed at stage IV and determined to be sexually mature. Four of the 14 specimens (79-80 cm TL) collected at Cullen Point in September 2000, were also observed to be at stage IV. The remainder of the examined fish from Cullen Point were determined to be a stage II.

In all of the female specimens examined in this study, none was determined to be ripe or spent.

5.4.1.5 Discussion

I observed a minimum size of first maturity (smallest mature fish) at 79 cm TL for female black jewfish, a significant departure from the minimum size of 92 cm TL reported by McPherson (1997). This result is interesting as the specimens sampled by McPherson (1997) where sampled from the adjacent waters of the Gulf of Carpentaria. The size range observed in the present study matches reports based on black jewfish sampled in Indian waters. Rao (1963) found 5% of fish were mature between 75-80 cm TL, increasing to 100% at 90-95 cm TL. McPherson (1997) observed 50% of the black jewfish he examined were mature at 97.8 cm TL.

Mature ovaries (stage IV) were observed in specimens sampled from aggregations formed at Muttee Head and Cullen Point in the period between May and September 2000. I was unable to collect samples in the period from October to January as no fish were available for sampling. Therefore, I cannot be certain there was not a second spawning season. However my findings are not unlike that reported by Rao (1963). In his study of the species' spawning season in north-west India, Rao (1963) concluded that a single, extended spawning season occurs from June to through to August.

I found no ripe gonads (containing hydrated oocytes, and may contain post-ovulatory follicles, atretic oocytes and brown bodies) or spent gonads (containing atretic vitellogenic oocytes, disorganised lamellae with brown bodies), so the timing and location of the spawning season in northern Australian waters remains unknown. Yet, the Indigenous people of the Injinoo do eat the eggs of many marine species and state that ripe eggs were readily available during previous jewfish aggregations (see Chapter 5.3.1).

Black jewfish displaying sexual development composed only a small percentage (12 fish out of 270 = 4.4%) of the catch I examined in a sampling program that was biased towards the largest individuals available. Catches of black jewfish were composed almost exclusively of specimens one to three years before maturity (see Chapter 5.3.2), allowing little opportunity to provide any evidence that the reproductive strategy of the species was directly related to the formation of the annual inshore aggregations.

It appears that fishing pressure has selectively removed the larger, older individual specimens from the population. Similar losses of larger specimens following heavy exploitation of aggregations have been observed in several species, e.g., gemfish (*Rexea solandri*) (Rowling 1990), coney (*Epinephelus fulvus*) (Beets and Friedlander 1992), red hind (Munro 1983, Bohnsak et al. 1986) and Nassau grouper (Sadovy 1999). The consequences of the truncation of the natural size and age structure are yet to be understood for black jewfish, but may be expected to have an adverse effect on the stock.

The loss of a significant proportion of the population, particular the more fecund individuals, jeopardises the resource’s capacity to sustain recruitment of future generations. It may also influence the seasonal migration pattern of the species. There exists some evidence that the location of aggregation sites, and the migration routes to them, is learnt from older individuals (Warner 1988, 1990; Rose 1993). For example, changes in the migratory behaviour of herring (*Clupea harengus*) and Atlantic cod (*Gadus morhua*) have been observed after adult stocks were depleted (Dragesund et al. 1980; Rose 1993; Rose 1993; Aziz 1996).

If the limited data presented within this thesis are representative of the status of the black jewfish resource in the region, then concern must be held for the future viability of the stock, particularly if the low abundance of reproductively active females observed is representative. Further monitoring of the situation is warranted, and controls on fishing are necessary if the black jewfish population structure determined in this study truly represents the situation in the wild. Due to the limited number of large, mature black jewfish in the waters of Northern Cape York Peninsula, I was unable to achieve my objective of establishing the relevance of the species' reproduction strategy to the formation of the annual aggregations. Therefore, I recommend that future reproductive studies be conducted at other aggregation sites which host larger black jewfish.

5.4.2 Diet

5.4.2.1 Introduction

The diets of many predatory fishes inhabiting tropical Australia's inshore waters have been described; however, the black jewfish has not been examined in Australia. Despite penaeid prawns composing a significant component of the species' diet in the waters of north-west India (Rao 1963), black jewfish has not been included in any of a series of studies which have examined the diet of prawn predators in northern Queensland waters (Blaber 1980; Robertson 1988; Salini et al. 1990, 1994, 1998; Brewer et al. 1995). Examination of diet is a necessary precursor to understanding the population dynamics and distribution of an exploited species (King 1995), and hence is the focus of this component in my study.

In September 1973, a large aggregation of black jewfish was harvested by a purse seiner off Goa, north-west India. The number of specimens caught was 2,309, with the total weight of the catch estimated at 30.24 tonnes. In about 95% of the specimens, the mouth contained traces of regurgitated food identified as Malabar sole (*Cynoglossus macrostomus*). Analysis of the stomach contents of 40 specimens revealed that the stomachs were half to three-quarters full, each containing between 8 and 22 sole. Reporting on this event, Thomas and Kunja (1981) suggested that the seasonal availability of food in the inshore waters governs the annual inshore migration of black jewfish.

5.4.2.2 Aim

The aim of this component of my study was to identify the items of food in the stomachs of black jewfish collected from the waters of Northern Cape York Peninsula. With this information, I aimed to examine the relevance of the fish's diet in the formation of the annual aggregations.

5.4.2.3 Methods

I examined the gut contents of 256 black jewfish sampled from the waters of Northern Cape York Peninsula. The specimens were obtained from local fishers, or sampling trips conducted in the project's vessel when specimens where otherwise unavailable. All fish sampled in 1999 were line fished at Muttee Head (10° 54' S, 142° 13' E: see Figure 1.1) and Peak Point (10° 43' S, 142° 25' E: see Figure 1.1) from depths of 10-25 m. In the following year, further sampling was conducted at Muttee Head, and expanded to locations within the Jacky Jacky/Escape Rivers (10° 56' S, 142° 30' E: see Figure 1.1), and off Crab Island (10° 58' S, 142° 06' E: see Figure 1.1). The fish were measured and weighed, and the stomach and mouth of each fish were inspected. Macroscopic observations of the gut contents (stomach fullness, content items) were recorded on site and food items were preserved in 80% ethanol. The taxonomic family to which the food items belong was identified using a variety of identification books and guides.

5.4.2.4 Results

The stomach contents of 256 black jewfish (42-82 cm TL) were examined in 1999 and 2000, and revealed a wide range of prey items including fish, prawns, crabs, and gastropods (see Table 5.2). The stomachs of the majority of specimens examined were empty (93%). It is likely that the stomach contents of many fish had been expelled through the mouth when the hooked specimens were raised to the surface. Decompression caused the expansion of gas in the swim bladder, which consequently filled the body cavity. Attempts to raise the fish slowly to the surface were hampered by the presence of sharks.

5.4.2.5 Discussion

The range of taxa represented in the food of black jewfish support the description of an 'opportunistic predator' attributed to the species by Rao (1963). Rao (1963) suggests that the opportunistic feeding behaviour is reflected in the variety of prey, which is composed primarily of fish and prawns, but also includes crabs, molluscs, and gastropods. I also observed that the food items included a variety of teleosts and invertebrates. Crustaceans were the most dominant taxon observed in this study, perhaps a result of slower digestion relative to less protected taxa. In all crustacean food items, which were predominantly sand crabs, the carapace was still intact.

Table 5.2: Items observed in the mouth or stomach of black jewfish sampled from the waters of Northern Cape York Peninsula (n = 256).

Key: *N* = Number of stomachs examined; *N*F = Number of stomachs with food; Mo = Mollusca; Cr = Crustacea; Pen = Penaeidae; Tel = Teleostei; U = Unidentified.

Month	***N***	***N*F**	**Mo**	**Cr**	**Pen**	**Tel**	**U**
January	43	3 (7%)		1		2	
April	12	1 (8%)		1			1
May	62	3 (5%)			1		2
June	49	4 (8%)		2		2	
July	54	3 (5%)	1	2			
September	36	4 (7%)		2		1	1
Total	256	18 (7%)	1	7	1	5	4

Teleosts also proved an important component of the diet of the black jewfish. Rao (1963) observed specimens >50 cm TL displayed a strong piscivorous tendency, with the percentage of prawns much higher in juveniles than in adults. Predatory fish commonly switch from invertebrate to teleost prey when they become adults (Kwei 1978, Blaber and Cyrus 1983, Dall et al. 1990). It is possible that this change in diet at around 50 cm TL may reflect the transition of the fish from nursery areas to open water habitats.

Suntag data reveals that virtually all tagged specimens less than one-year-old (<42 cm TL based on Bibby and McPherson 1997) were caught in estuarine areas and river (see Chapter 5.4.3). Sciaenids are commonly reported to utilise estuarine areas and rivers as nurseries during their first year (Levy et al. 1998, Adams and Tremain 2000, Waessle et al. 2003). I was unable to examine if the change in diet observed by Rao

(1963) reflects a change in habitat, as all of the samples I gained were sourced from open water sites.

That black jewfish develop into capable predators of other fish is well demonstrated. Both Jacob (1948) and Rao (1963) reported finding whole mackerel (*Rastrelliger kanagurta*) in the stomach of this species. The predatory ability of adult black jewfish is further demonstrated by accounts of Thomas and Kunju (1981), who observed black jewfish with as many as 22 Malabar sole in their stomachs. The opportunistic nature of their dietary habits is well demonstrated by Newman (1995), who describes black jewfish off Western Australia taking lures while whales (species not provided) were 'herding up 40lb fish like they were sardines'.

A large number of stomachs were found to be empty (93%) during the aggregation events at Muttee Head (10° 54' S, 142° 13' E: see Figure 1.1) and Peak Point (10° 43' S, 142° 25' E: see Figure 1.1), probably because the decompression of gas in the body cavity caused the food items to be expelled. The limited data that were gained in this study presented no evidence to support the notion that the annual mid-year migration of black jewfish was related to the increased availability of prey items in the inshore waters, as is suggested by Thomas and Kunja (1981). The occurrence and contents of stomach items observed between April and July were not different from that observed in January and September. However, my results must be interpreted with caution because of the low sample size of fish with food items in their stomachs.

5.4.3 Mark and recapture

5.4.3.1 Introduction

Fish of the family Sciaenidae are widely distributed in tropical and subtropical waters (Trewavas 1977, Sasiska 1996). Sciaenids commonly dominate epibenthic fish assemblages of near-shore waters of both regions (e.g., Blaber et al. 1990, Rhodes 1998, Plunket and La Peyre 2003), and often form the basis of commercial and recreational fisheries throughout the world (e.g., Gray and McDonnall 1993, Sadovy and Cheung 2003). Catches of black jewfish, one of the largest tropical sciaenids, form an important component of commercial, recreational, and subsistence fisheries in several countries, including Australia (Suvatti 1981, Apparao et al. 1992, DeBruin et al. 1994, Williams 1997).

Intra-annual changes in the abundance of black jewfish in inshore waters have been recorded (Rao 1965, Bhatt et al. 1967, Ansari et al. 1995) and may reflect a seasonal migration of the species. Indian research suggests black jewfish may undertake seasonal migrations related to the availability of food (Thomas and Kunja 1981), or based on the species' reproductive cycle (Dhawan 1971). These annual events may facilitate the harvest of this species in inshore waters of northern Australia (e.g., Bowtell 1995, 1998), yet the biological importance of the aggregations has remained unknown.

The effects that fishing an aggregation will have on a population of fish is influenced by several factors, including the number of sites used by the aggregations, catchment distances (i.e., how far individuals move to specific aggregation sites), aggregation fidelity (i.e., whether fish move between different aggregations), participation rates (i.e., proportion of the population participating in an aggregation event), residence times of individual fish at aggregation sites, and potential differences between the sexes in any of the above factors (Zellar 1998, Johannes et al. 1999).

The tagging and subsequent recapture of fish can provide data on both the species' movement patterns and stock boundaries. Tagging programs may also be used in the estimation of exploitation rates and population size, provided that potential sources of error are eliminated to avoid biases in the estimation of these parameters (Pierce and Tomocko 1993). Hence, tagging experiments need to incorporate some provision for the estimation of tag shedding and mortality so that the success of managing exploited species is not diminished by the miscalculation of these parameters (Timmons and Howell 1995).

In this chapter I explain and discuss: (1) a wild tagging program (in which wild black jewfish were 'double tagged' with two tags to examine tag loss), and (2) a captive tagging trial (in which black jewfish retained in tanks were tagged to examine tag loss and tag induced mortality).

5.4.3.2 Aim

The aim of the tag and release study was to reveal details of the movement patterns of individual black jewfish in the Northern Cape York Peninsula waters. I also aimed to identify the frequency of tag-induced mortality and tag loss.

5.4.3.3 Methods

Wild tagging program

I hoped to tag and release black jewfish in the waters of Northern Cape York Peninsula before, during, and after the historical aggregation period of late April to early August in both 1999 and 2000. However, black jewfish were tagged only in 1999 between January to June while the species was locally abundant. No further tagging was conducted in 2000 due to the brevity of the periods in which black jewfish were caught in sufficient numbers.

Fish for tagging were caught using a barbless hook on a 100 lb hand-line. The landed fish were inspected for tags or tag marks and placed onto padding freshly soaked in salt water. Excess gas in the swim bladder was released using a hypodermic needle and then the total length of the fish was measured to the last centimetre. The fish were tagged with PD series dart tags (Hallprint, South Australia). Each specimen was tagged twice, with the primary tag placed slightly above and forward of the secondary tag positioned on the alternate side. The external streamer of primary tags was coloured yellow and the secondary tag coloured orange.

The tags were applied with a sharpened stainless steel applicator, which was withdrawn when the barb of the tag lodged behind the pterygiophores. The tags were inserted at an angle of 45 degrees to the longitudinal axis of the fish, with the exposed section of the streamer facing to the posterior of the fish. The fish were held in the water current until resuscitated. Only fish judged to be in a viable condition were tagged and released. I ceased tagging when sharks became attracted to the hooked fish.

The polypropylene tubing of the tag was marked with unique numbers at both ends. Between these numbers, a contact phone number was printed along with a prompt that requested the fisher 'record length, place date and tag number'. A dedicated freecall phone line was set up at the Cairns office of Balkanu Cape York Development Corporation and run over the duration of the program. Alternatively, the fishers had the option of returning tags directly to me or the Injinoo Aboriginal Community Council. I resided at Injinoo throughout the period in which black jewfish were being captured in 1999 and 2000.

The freecall phone number and recorded message was established as the message service provided by the Suntag tagging program was deemed unsuitable to the conditions of the present study. The Suntag service, when unattended, asks for a telephone number. This approach was not suitable for a tagging program in Northern Cape York Peninsula as phone ownership in households was low (estimated to be less than 50% of households). I also deemed it necessary to have a recorded message that reminded the caller which details should be provided, because of the low exposure of the local people to fish tagging.

A random prize draw was established to encourage complete reporting of tags. Sunstate Airlines donated the major prize: a return flight for two passengers to travel from Thursday Island to Cairns (16° 55 S, 145° 46' E). The tagging program and the associated prize draw was advertised on the local community radio station, at a community meeting held at Injinoo, and in a two-page article published by in the regional Torres News newspaper. Posters about the tagging program were displayed at shops, community buildings, etc.

Captive tagging program

Members of the Gulf Barramundi Restocking Association collected ten black jewfish (size 35-40 cm TL) in March 1999, by line fishing at the mouth of the Norman River (17° 27’ S, 140° 49’ E). The double tagging trial was accommodated at the Gulf Barramundi Restocking Association Hatchery, Karumba, with the assistance of staff from the Queensland Department of Primary Industries and Fisheries. The black jewfish were quarantined (two weeks) prior to being placed in a 10-tonne capacity fibreglass tank. The tank was also occupied by grunter (*Pomadasys kaakan*). The tank was equipped with a recirculating estuary water supply and biological filter system. Each black jewfish was tagged with PD series dart tags (similar to above) with yellow tubing. The specimens were each tagged at three sites (front, middle, rear) along the 3rd scale row below the dorsal fin. The fish were tagged on both the left and right side of body. The experiment was conducted over a total of 330 days.

5.4.3.4 Results

In 1999, 114 black jewfish (size range 56-79 cm TL) were double tagged and released. The progress of the tagging program was balanced with the need to retain a proportion of the specimens being caught for examination of the gonad and gut contents. An additional six specimens were lost to sharks before being landed. A further two specimens were deemed unfit for release. Both these fish had taken the hook deep in the throat (an outcome which I generally avoided by quickly reacting following the bite).

Only three of the tagged fish (3 out of 114 fish = 2.7%) were recaptured (see Table 5.3). The greatest movement identified by the return of tag details from recaptured specimens was from a fish that showed a westerly movement of 30 km direct distance or 36 km along the coastline. This specimen was tagged when sampling an aggregation of black jewfish at Peak Point (10° 43’ S, 142° 25’ E: see Figure 1.1), and was recaptured 13 days later by subsistence fishers fishing a separate aggregation at

Muttee Head. A further two specimens, tagged five days later at Peak Point, were both recaptured two days later at the same aggregation site.

Table 5.3: Recapture details of tagged black jewfish.

Tag number	Date of tagging	Days out	Fish length	First location	Second location	Distance moved
058 Yellow 308 Orange	10 May 1999	13	65 cm	Peak Point	Muttee Head	30 km west
070 Yellow 320 Orange	15 May 1999	2	65 cm	Peak Point	Peak Point	0
079 Yellow 329 Orange	15 May 1999	2	65 cm	Peak Point	Peak Point	0

Both the primary and secondary tags remained in situ in the few wild fish tagged and recaptured in the program. The double tagging experiment at the Karumba Holding Facility revealed 100% retention of tags and 100% survival over an eleven month period. No tag losses occurred in each of the alternative tag sites tested. There was no mortality of the specimens attributable to the tagging of the fish.

5.4.3.5 Discussion

Information gained from the wild tagging program

The movement of a specimen from Peak Point (10° 43’ S, 142° 25’ E: see Figure 1.1) to Muttee Head (10° 54’ S, 142° 13’ E: see Figure 1.1) represents the greatest recorded movement of a black jewfish between two open water sites (30 km direct). More significant, is that the data represent the movement of an individual fish between two distinct aggregation sites. This result may be indicative of a wider behaviour in the population. If so, then given that line fishers target both the aggregations at Peak Point and Muttee Head, this behaviour would seem to increase the susceptibility of the fish to exploitation. Since only one instance was recorded, this interpretation must be treated with caution.

The remaining two tag returns were each made within two days of release at the same aggregation site of Peak Point. Neither revealed movement of the individuals away from the release site, but are significant in that the fish were tagged and recaptured during the same aggregation. This suggests the same fish remain at or return to the aggregation site for several days. Again, if this behaviour of black jewfish is normal this activity may also increase the susceptibility of black jewfish to capture during the aggregation period. Movement to and from the site several times during the presence of an aggregation has been demonstrated in other marine fish (e.g., Zellar 1998, Johannes et al. 1999).

The results of the analysis of the genetic population structure of the local black jewfish population (see Chapter 5.4.4) support the findings of the tagging program. No significant genetic variation was revealed between black jewfish sampled from the two sites of Muttee Head and Peak Point, suggesting that the two sites are utilised by the same genetic stock. In fact, the black jewfish sampled from the waters of Northern Cape York Peninsula were found to be homogenous with those sampled from the waters of the Northern Territory, which suggests aggregation sites along the northern Australia's coast are each linked to some degree.

Comparison of the wild and captive tagging programs

The suitability of the PD series dart tags (Hallprint, South Australia) adopted in the present pilot study was revealed by the high retention displayed during the captive experiment. All tags were retained over a period of up to 330 days, and there was no evidence of tag-induced mortality over that period. However, the high retention rate of tags in the captive program, coupled with the zero mortality, contrasts with the low rate of tag returns (2.6%) from the wild stock tagging program, despite the steps undertaken to encourage the reporting of catches.

Johannes et al. (1999) stated their tagging efforts in Palau were hampered by fishermen from outside the local community not wanting to admit to fishing at the sites associated with other communities. While I could not be sure that this situation did not exist in Northern Cape York Peninsula (many of Injinoo's residents are officially recognised as the Traditional Owners of much of the region), there was no evidence to suggest that fishers were withholding information. Support for the project from fishermen in neighbouring communities was strong, and informal discussions with fishers did not reveal any evidence of non-reporting of recaptured tagged black jewfish.

There was no evidence to suggest mortality in the double tagging of wild stocks was greater than in the captive program. The released fish all appeared to recover well, quickly dashing away from the surface. The act of puncturing the swim bladder with a hypodermic needle in order to overcome depressurisation has been shown to reduce direct mortality caused by bladder inflation, and indirect mortality of the stricken fish caused by predation and adverse environmental conditions at the surface (Bruesewitz et al. 1993, Keniry et al. 1996).

Experience with a large number of specimens indicated that the brief time out of water required to complete the tagging procedure (<1 minute) was not a critical factor in the rehabilitation of black jewfish, hence there was sufficient time to ensure firm anchoring of the tag. The importance of properly engaging the barb of the tag behind the pterygiophore has been demonstrated by Heller (1971). Heller (1971) revealed tag retention in brook trout (*Salvelinus fontinalis*) decreased from 98% down to 10% when the tag end was not engaged behind the vertebral spine

It is feasible that the tagged black jewfish migrated outside of the area where recapture was likely. In Northern Cape York Peninsula large areas of coastal and offshore waters are rarely fished (see Chapter 4.3.3.1). Certainly, several other sciaenids have demonstrated the ability to move considerable distances. Mercer (1984a) reported 10% of recaptures of red drum (*Sciaenops ocellatus*) revealed movements greater than 100 km. A tagged silver nob (*Argyrosomus inodorus*) was recaptured 240 km from the release site (Griffiths 1997), and a spotted seatrout (*Cynoscion nebulosus*) tagged specimen travelled over 500 km (Mercer 1984b). Low tag return rates have been obtained in other highly mobile species (e.g., Bartel 2000, Peterson et al. 2000).

Comparison with the Suntag data

Further information on the movement of individual black jewfish in Queensland waters is available through the National Fish Tagging Database administered by Suntag. Suntag is a joint program run by the Queensland Department of Primary Industries and Fisheries and the Australian National Sportfishing Association. The program also displays a below average recapture rate for black jewfish. As of March 1999, 370 black jewfish have been tagged and released in Queensland waters (size range 18-1530 cm TL), with 19 recaptures (producing a 5.1% return vs. state multiple-species average 8.6%) (see Table 5.4).

Table 5.4: Recaptures of black jewfish tagged by the Suntag Program.

Tag number	**Date of tagging**	**Days out**	**Fish length**	**First location**	**Second location**	**Distance moved**
F874405	6 Dec. 1987	1	380	Off Karumba	Same area	0
B002092	7 Dec. 1987	1	380	Off Karumba	Same area	0
S22731	31 Jan. 1988	2	200	Mary River	Data lacking	0
Z62841	14 Apr. 1993	14	390	Fitzroy River	Same area	0
Z54935	15 Sep. 1993	21	350	Fitzroy River	Same area	0
Z73376	8 Sep. 1993	116	350	Fitzroy River	Down river	15 km
K20503	28 Sep. 1995	7	290	Fitzroy River	Same area	0
K20504	5 Oct. 1995	19	300	Fitzroy River	Same area	0
K20205	14 Jul. 1995	8	315	Fitzroy River	Same area	0
K81108	1 Aug. 1998	131	420	Boundary Ck	Same area	0
J14899	25 Jun 1999	487	360	Bizant River	Marrett River	45 km east

J54787	16 Oct. 1999	14	350	Cawarral Creek	Same area	0
J03269	09 Oct. 2001	4	370	Fitzroy River	Same area	0
N63618	05 Jul. 2002	0	330	Waterpark Creek	Same area	0
N63618	05 Jul. 2002	2	330	Waterpark Creek	Same area	0
P61931	02 Jun. 2004	123	350	Burnett River	Same area	0
P92106	10 Mar 2005	3	255	Elbow Bank	Same area	0
P91130	1 Jun. 2005	100	270	Fitzroy River	Same area	0
R00916	10 Jun. 2005	9	310	Fitzroy Rr	Same area	0

In the Suntag program, the mark and recapture of black jewfish has occurred throughout the year, however only two tag returns have revealed significant movements over periods extending many months. One fish (Z73376) had moved 14 km from the release site during 116 days at liberty. Another fish (J14899) moved 45 km between rivers during 487 days at liberty. The remainder (one specimen excluded for insufficient data) were recaptured near to the same site where they were tagged, including three specimens at large for over 100 days. The data suggests that juvenile specimens tend to remain in restricted areas for periods extending up to four months.

Because of the low number of tag returns gained in the Suntag program and the present study, the results must be interpreted with caution. Many more recaptures are required before the interrelationships of the Queensland's fishing grounds can be established from tagging efforts. Future tagging programs focussing on black jewfish should aim to increase the number of fish tagged to compensate for the low rate of tag returns observed in the two programs. The results of the double tagging and captive trails should assist future work that attempts to estimate exploitation rates and the size of the black jewfish population.

5.4.4 Genetics

5.4.4.1 Introduction

Knowledge of the genetic structure of fish stocks is an important consideration when developing effective management strategies for a fishery. Although management arrangements typically reflect the jurisdictional boundaries of resource agencies, fish stocks may extend beyond these invisible lines or exhibit finer scale population structures. The burgeoning kit of molecular tools has allowed the identification of genetic differentiation within a species' ranges, thereby allowing the establishment of appropriate scale of management. In this chapter, I examine the spatial structure of black jewfish inhabiting the waters of Northern Cape York Peninsula by examining genetic variation and population subdivision.

In the decades since starch gel electrophoresis revolutionised the study of genetic polymorphisms, molecular markers have become increasingly powerful tools in the assessment of genetic variation both within and between populations (Powell et al. 1995). With the progressive development of more effective technologies, there has been a growing emphasis towards the examination of deoxyribonucleic acid (DNA) markers (Ferguson 1994). Techniques of visualising specific DNA fragments have provided the basis for uncovering a greatly expanded number of genetic markers, hence strengthening the statistical power of marker-based analysis.

The amplified fragment length polymorphisms (AFLP) technology combines: (1) the ability to screen a large number of DNA fragments using restriction enzymes, and (2) the ability to make copies of the DNA of interest using polymerase chain reactions (Vos et al. 1995). The resultant AFLP markers are in many ways superior to alternative molecular markers, particularly in terms of cost-efficiency, replicability and resolution (Mueller and Wolfenbarger 1999). Hence, AFLP technology has emerged as a powerful analytical tool with broad application in population studies (Mueller and Wolfenbarger 1999).

AFLP analysis has been extensively applied to the study of plant populations (e.g., Qi and Lindhout 1997), fungi (e.g., Van der Lee et al. 1997), bacteria (e.g., Janssen et al.

1997), mammals (e.g. Ajmone-Marson 1997) and birds (e.g. Liebers et al. 2001). The technique has also been applied to fish including blue catfish (*Ictaluru furcatus*) (Liu et al. 1999), rainbow trout (*Oncorhynchus mykiss*) (Felip et al. 2005; Zimmerman et al. 2005), ayu (*Plecoglossus altivelis*) (Kakehi et al. 2005) and Nile tilapia (*Oreochromis niloticus*) (Ezaz et al. 2004). Wang et al. (2005) attest to the value of AFLP as a promising tool for genetic resource and population analyses in teleosts.

I chose to use the AFLP technique because it is recommended for studies of genetic diversity where other markers, such as allozymes, show little or no variation (Krauss and Peakall 1998). In the sole study of genetic variation in black jewfish, Keenan (1997) using gel electrophoresis, found significant levels of homogeneity across collection localities on the east and west coasts of northern Queensland. However, the overall heterozygosity among the five suitable loci was low (H = 0.076) among the 37 samples analysed. Hence, statistical tests had little power, compounded by the low sample size. Keenan (1997) concluded further sampling was required to determine if this apparent uniformity of population structure is biologically accurate, merely a statistical artefact of an inadequate sampling regime, or a product of the lack of sensitivity to genetic variation of gel electrophoresis.

5.4.4.2 Aim

The aim of this study was to determine the level of genetic differentiation in black jewfish sampled in Northern Cape York Peninsula, using an appropriate genetic marker.

5.4.4.3 Methods

Sample collection

In 1999, samples from 51 black jewfish were collected for genetic analysis, comprising 27 samples from Northern Cape York Peninsula and 24 from the Northern Territory. Tracy Hay of the Northern Territory's Department of Primary Industries, Fisheries and Mines, organised the provision of samples from the Northern Territory. In 2000, an additional 58 samples were analysed from Muttee Head. Tissue samples were obtained by removing the upper half of the first three dorsal spines (with connecting membrane). All samples were collected from fish caught and retained in the Indigenous fishery. The collection of samples occurred independent of the reproductive and diet sampling. The samples were preserved separately in small vials of 80% ethanol or NaCl saturated dimethylsulfoxide (DMSO). The analysis of the genetic samples was conducted at James Cook University.

DNA extraction

Genomic DNA of black jewfish was isolated from a ~1 cm^2/3-10 mg section of dorsal fin membrane washed with ddH_20 to remove the preservation agent DSMO-NaCl buffer. Dry samples were preheated to 50°C in SE-buffer (3 ml 5 M NaCl, 10 ml 0.5 M EDTA, 5 ml 20% SDS, and 182 ml ddH_20) combined with 10 μL of proteinase-K. Reactions were mixed gently and incubated at 50°C for a minimum of three hours. One millilitre of 24:1 chloroform: isoamylalcohol and 290 μL of 5 M NaCl was added to each sample. The mixture was then gently shaken for 20 min. Following brief centrifugation, the aqueous phase was collected and precipitated with isopropanol. The samples were the washed in 70% EtOH, air dried and resuspension in TE (Tris 10 mM, EDTA (Na_2) 1 mM) buffer.

AFLP analysis

AFLP analyses were performed with a licensed kit (AFLP™ Analysis System I, Gibco-BRL), using *Eco*R1 and *Mse*I for restriction digestion and Qiagen Taq for Polymerase chain recreation (PCR) amplification. Reactions involving radioisotopes were performed in a PE Applied Biosystems GeneAmp PCR System 9700 thermal cycler. All other reactions were performed with an MJ Research PTC-200 thermal cycler. The protocol advocated by the manufacture of the AFLP kit was followed except that between 15 and 60 ng of DNA were used in each analysis.

Samples were electrophoresed on 6% polyacrylamide gels (20:1 acrylamide: bis, 7.5M urea, 1 x TBE buffer) for approximately two hours at 55W in 1 x TBE buffer. Gel visualisation was achieved either by autoradiography or by silver staining.

Autoradiographs were produced according to the recommended protocol, using Fujifilm DI-AT H100 dry imaging film (see Figure 5.7). Silver staining was carried out with a Promega Silver Sequence kit according to the manufacturer's instructions. Silver stained gels were scanned to provide a permanent, digital image record. Several samples were processed using both procedures to verify the consistency of the two methods.

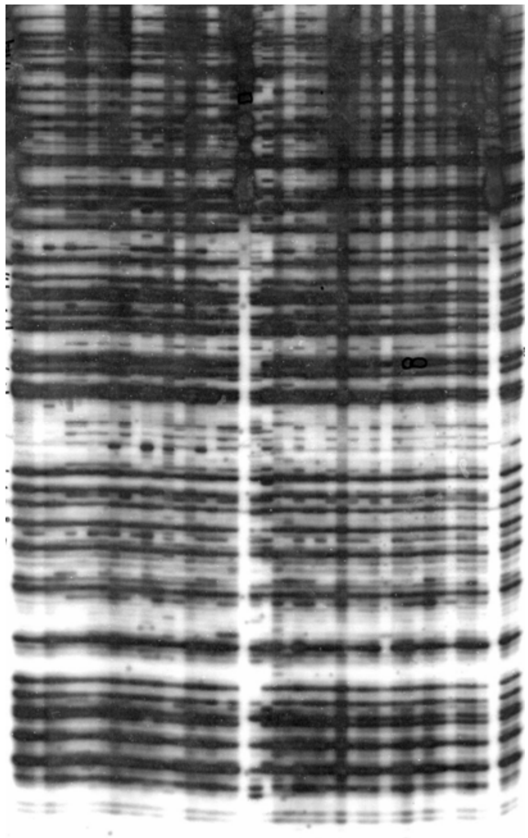

Figure 5.7: AFLP gel based on selective amplification E-AGG and M-CTG primers of 45 black jewfish sampled in 1999.

Sixteen primer pairs were screened with five samples for markers in the size range 75-450 bp. Only two primer pairs produced no bands. The remainder produced more than 60 bands. Screening of full sample sets was conducted using the three primer pairs giving clear consistent patterns. Reference samples were run on all gels for comparison of runs and to test reproducibility. DNA fragment size markers were also run on all gels to determine the exact size of all fragments produced. Scoring of banding patterns was conducted manually by comparing band positions calculated using the fragment size markers. A matrix of shared banding positions for all individuals analysed was created and used in analysis.

Analysis was conducted using the similarity matrix, with potential values from 0 to 1 indicating either no identity (no shared bands) to complete identity (all bands shared), pairwise genetic distances (Euclidian distance of Schneider et al. 1997) were calculated and used in AMOVA (Analysis of Molecular Variance, Excoffier et al. 1992) to determine genetic differentiation of the populations and sub-populations surveyed using the program ARLEQUIN (Schneider et al. 1997). Calculation of the minimum spanning tree of genetic distances based on Euclidian distances was also conducted using ARLEQUIN (Schneider et al. 1997). The presence/absence data were used also in a non-metric, multidimensional scaling plot of similarity using a Kruskal non-metric analysis (SPSS), and a clustering analysis (Euclidian distance measure) was conducted using PCOrd (McCune and Mefford 1999).

5.4.4.4 Results

The AFLP technique was successfully used to analyse 51 samples collected in 1999 and the 58 samples collected in 2000. Calculations of genetic diversity and gene flow among the 1999 samples were examined by Nei's analysis of gene diversity of the populations (see Table 5.5; for expanded results see Appendix 5). The results indicate a G_{ST} of 0.046 and a Nm of 10.210. These estimates indicate: (1) there was low genetic variability among the samples, and (2) that was a high level of gene flow between the two localities sampled. Multidimensional scaling ordination analysis demonstrated the lack of differentiation between the samples from Northern Cape York Peninsula and the Northern Territory (see Figure 5.8).

Specimens sampled in 2000 demonstrated a lower overall gene diversity (0.048±0.034) than among all samples in 1999 (0.088±0.045), and even lower when compared with the Cape York samples alone (0.117±0.058). The lower diversity index may be a result of the fewer markers that were available when screening the 2000 samples (as the samples were of a lesser quality due to poorer preservation), and hence these numbers are not directly comparable. To best represent the 2000 analysis, a minimum spanning network was constructed to demonstrate the relationship of genotypic data (see Figure 5.9). The network is centred on a large number of samples with a common genetic structure. Coming off this common genotype are a number of lower frequency genotype clusters that have significantly fewer individuals present.

Table 5.5: Estimates of genetic diversity and gene flow among samples from 2 populations of black jewfish sampled in 1999 (n = 50).

Based on estimates of gene diversity in subdivided populations provided by Nei (1987).

Ht: Total heterozygosity; Hs: Average heterozygosity; Gst: Proportion of genetic diversity between populations; Nm: Gene flow.

	Number	**Ht**	**Hs**	**Gst**	**Nm**
Mean	50	0.1160	0.1106	0.0467	10.2101
St. Dev		0.0360	0.0328		

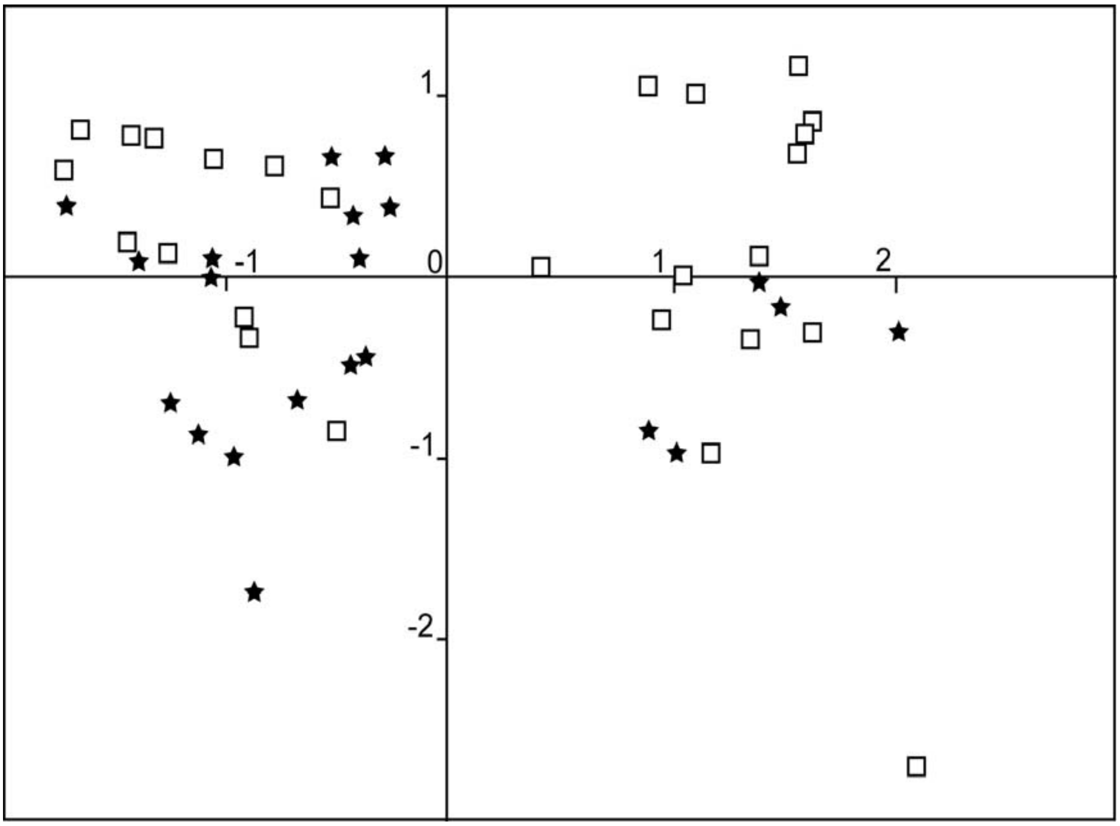

Figure 5.8: Non-metric multidimensional scaling analysis (SPSS 9.0) based on AFLP fingerprinting analysis of black jewfish samples collected in 1999.

The square boxes represent samples collected from Cape York Peninsula and stars represent samples collected from the Northern Territory.

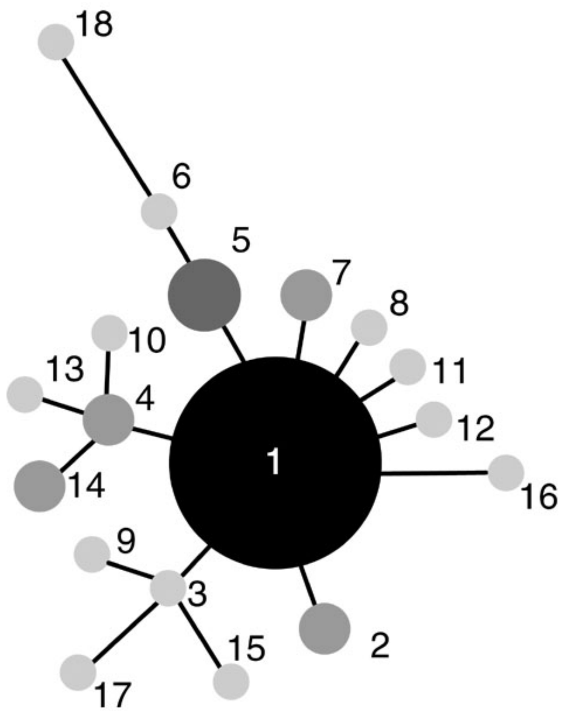

Figure 5.9: Minimum spanning tree of the AFLP fingerprinting genotypes.

5.4.4.5 Discussion

DNA fingerprinting of black jewfish demonstrated that genetic identity of fish can be determined using the AFLP genetic technique. The black jewfish sampled from Northern Cape York Peninsula and the Northern Territory in 1999 appeared to comprise one homogeneous population (G_{ST} 0.046). This was consistent with the findings of Keenan (1997) who identified a genetic distance (Rogers 1972) between sub-populations of black jewfish of 0.049. This result is supported by additional evidence of high levels of genetic similarity among the samples collected in 2000. Genetic analysis of a number of species inhabiting northern Australian waters has produced similar low levels of genetic diversity.

In northern Australian waters, extensive connections over large distances have been identified in red emperor (*Lutjanus sebae*), spangled emperor (*Lethrinus nebulosus*), rankin cod (*Epinephelus multinotatus*), sweetlip (*Lethrinus choerorynchus*) (Johnson and Joll 1993), and the Spanish mackerel (*Scomberomorus commerson*) (Shaklee et al. 1990). Homogenous populations of northern Australian stocks have also been identified in the spot-tail shark (*Carcharhinus sorrah*) and the Australian black tip shark (*C. tilstoni*) (Lavery and Shaklee 1989), four species of squid (*Photololigo spp*) (Yeatman and Benzie 1994), and in four species of prawn (*Metapenaeus ensis, Penaeus semisulcatus, P. esculentus, P. merguiensis*) (Mulley and Latter 1981).

Several models have been proposed to explain geographic genetic patterns, although none has received universal acceptance. Among the most popularly accepted is the 'habitat specialist-generalist model' proposed by Smith and Fujio (1982), which is supported by several marine studies (Smith 1986, Lavery and Shaklee 1989, Yeatman and Benzie 1994). The model implies that habitat specialists characteristically display high genetic diversity while habitat generalists display low genetic diversity. The black jewfish examined during the present study displayed little genetic diversity, and the species appears to fit the description of habitat-generalists provided by Smith and Fujio (1982):

1) <u>The species feeds on a wide variety of prey.</u> The present study demonstrated the varied diet of black jewfish, which included both invertebrates and teleosts (see Chapter 5.4.2). The opportunistic feeding pattern has also been described by Rao (1963), Bhatt et al. (1967), Dhawan (1971) and Thomas and Kunja (1981).

2) <u>The species occurs over a wide range of bottom substrates and wide depth range</u>. In Northern Cape York Peninsula, black jewfish have been caught from a variety of habitats and depths ranging from shallow sandy beaches and deepwater holes to rivers. In the Northern Territory, black jewfish are reportedly caught offshore to depths of 100 m (Steve Sly, Senior Aquatic Resource Manager, Northern Territory Department of Primary Industries, Fisheries and Mines, *pers comm.* 2005).

3) <u>The species displays few morphological adaptations</u>. Black jewfish display few morphological adaptations and Trewavas (1977) infers black jewfish would not be very different from the ancestral Nibeini in that it is both the least specialised of the tribe and has the widest distribution.

The additional data I obtained in 2000 support the apparent uniformity of population structure in black jewfish from Northern Cape York Peninsula. There is no evidence of a major temporal change in allele frequencies within regions in this study although this pattern has been reported in several other teleost species (Smith 1979, Dempson et al. 1988, Gyllensten and Ryman 1988). The high degree of genetic uniformity observed in the samples collected in 1999 and 2000, coupled with evidence that genetic diversity may in fact be decreasing, suggests that stock may have been experiencing a genetic bottleneck. Additional data from a wider range of sites and aggregations would be of particular value to determine the extent of genetic erosion that the species may have experienced.

The AFLP technique has proven to be a robust technique of direct DNA analysis, and the use of this tool should be considered when planning future fisheries research. Additionally, the sampling regimen of the AFLP technique offers the following advantages when studying teleosts:

- <u>Very little equipment and training is required from field collections.</u> The only equipment needed is a pair of wire cutters and sample tubes filled with 70-80% ethanol.

- <u>There is a lack of transport restriction on necessary sampling equipment.</u> Where transport regulations do restrict the transport of ethanol, dimethylsulfoxide (DMSO) solution may be substituted. My attempt to use samples for allozyme analysis proved impossible because of the need to use liquid nitrogen. This was because liquid nitrogen has a limited shelf life (less than two weeks in a dewar), and has restrictive transport requirements.

- <u>The high number of informative points generated per sample reduces the number of fish required for sampling</u>. This stems from the high multiplex ratio for AFLP markers, i.e., the large number of markers that can be generated in a single amplification reaction (Perkin-Elmer 1999). This requirement is of benefit in the genetic examinations of rare or endangered species where the collection of sufficient number of samples is a common problem.

- DNA fingerprints under AFLP can be generated from small starting quantities of DNA. Fifty nanograms of DNA were sufficient for producing a result, indicating the potential of the technique for the examination of juveniles and small teleosts.

The AFLP technique allows the adoption of a minimally invasive tissue sampling regimen for sampling teleosts. The sampling of fin-tips (1 cm * 1 cm sections) allows live fish to be released with minimal damage. High regeneration rates of fin-clipped fish have been recorded (see Morizot et al. 1990). The method does not necessitate the death of specimens (c.f. allozyme analysis which requires liver and muscle tissue samples, e.g., Keenan 1997), an advantage when examining endangered or heavily exploited stocks. Sampling may also be conducted in conjunction with tag and release studies or cannular biopsy studies.

These factors indicate that the AFLP technique provides a cost-effective means to examine the genetic structure of black jewfish, and could be a useful tool in genetic resource and population studies in other teleosts.

THESIS FLOW CHART

CHAPTER 1. INTRODUCTION

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CHAPTER 2. BACKGROUND INFORMATION

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CHAPTER 3. GENERAL METHODS

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CHAPTER 4. INDIGENOUS SUBSISTENCE FISHING SURVEY

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CHAPTER 5. FIRST BLACK JEWFISH ASSESSMENT

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CHAPTER 6. BLACK JEWFISH ASSESSMENT: 2002-2003

This chapter reports on a second review of the status of black jewfish inhabiting the waters of Northern Cape York Peninsula following the two year closure that resulted from the initial assessment (see Chapter 5).

In summary:

- The average length of the fish was found to have increased in 2003 to a size where they may contribute to the replenishment of the stock.
- Obtaining specimens proved difficult despite the extensive experience of the samplers.
- The results suggest that the dominant size/age cohort observed during this review should be granted the maximum amount of protection possible.
- A range of management options are presented.

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CHAPTER 7. GENERAL DISCUSSION

CHAPTER 6. BLACK JEWFISH ASSESSMENT: 2002-2003

6.1 Introduction

In 1997, the Fisheries Research and Development Corporation responded to the concerns of the Traditional Owners of the Northern Cape York Peninsula by providing funding to investigate the effects of a perceived increase in fishing effort targeting local black jewfish aggregations (see Chapter 5). Sampling commenced in late 1998 and was concluded in late 2000. The results of this assessment warranted serious concern for the future of the local fishery, and hence in September 2000, Injinoo's Elders and Land Trust requested that their people cease to harvest black jewfish for a period of two years (see Chapter 7). This community initiative developed into a regional agreement incorporating each of the communities of Northern Cape York Peninsula and the adjacent Torres Strait Islands.

The objective of the two-year area closure was to allow black jewfish inhabiting the waters of Northern Cape York Peninsula to reach a mature size so that prospects for the replenishment of the stock were improved. Each of the parties to this regional agreement acknowledged that the two-year period may not provide adequate time for the complete recovery of the proportion of the adults in the population. They also recognised that, even if there is a recovery in the short-term, unless exploitation levels are controlled in the future, there might be another decline in the fish stock. Consequently all parties advocated the commencement of a second assessment to review the stock condition at the end of the two-year period. In 2002, I gained additional funding from the Fisheries Research and Development Corporation to respond to these public expectations and research opportunities.

This chapter reports on the research I undertook in 2002 and 2003. Now that critical baseline information was available on the species, e.g. length at age, size at first maturity, etc (see Chapter 5), the assessment of the size/age structure of the black jewfish population provides an appropriate means to detect responses of the fish stock to given levels of fishing pressure. Length-frequency studies are cost-effective and simple, and were suited to this project due to: (1) the limited funds available, and (2) the need to adopt a monitoring method suitable for a community-based program. To ensure the maximum efficiency of project funds, I continued to adopt the participatory approach adopted in my earlier work.

6.2 Aim

The aim of this component of my study was to examine the length-frequency of black jewfish inhabiting the waters of the Northern Cape York Peninsula in 2002 and 2003. I also aimed to compare this data to the length-frequency data collected in 1999 and 2000, so that I could detect any changes that may have occurred since the implementation of the two year ban on the harvest of black jewfish.

6.3 Methods

Residents of Northern Cape York Peninsula undertook the task of collecting biological and fishery data. Minimal training was required for this step due to the ease of collecting the type of data required. The local fishers who participated in this phase were also heavily involved in the initial work undertaken during 1999 and 2000, and so were familiar with the protocols and standards required.

A local charter boat charter operator, Mr Gary Wright, provided great assistance to this assessment by making his experience and vessel available. Mr Wright is widely renowned among anglers from across the globe, and has fished the waters of Northern Cape York Peninsula for several decades. Mr Wright has long been a strong supporter of efforts which contribute to the sustainable future of local resources, and was well versed on the objectives and needs of this project.

Indigenous fishers from Injinoo Aboriginal Community participated in the sampling trips in order to conduct the necessary sample and data collection. These fishers were equipped with the necessary tools and training to provide both reproductive and genetic samples, as well as the length frequency data for the assessment of the size/age structure of the population. Gudang Elder, Mr Shorty Lifu, and Anggamuthi Traditional Owner, Mr Steven Ropeyarn, assisted on the sampling trips. Together they have decades of experience fishing the local black jewfish aggregations.

Eleven dedicated sampling trips were conducted in 2002 and 2003 (see Table 6.1). Each sampling trip was timed to coincide with the lunar, tidal and diurnal conditions most conducive to optimal catches. A variety of line sizes and hooks was used, and both squid and bait fish were utilised. Fishing trips focused primarily on Muttee Head (10° 54’ S, 142° 13’ E: see Figure 1.1), but also included Crab Island (10° 58’ S, 142° 06’ E: see Figure 1.1) and Peak Point (10° 43’ S, 142° 25’ E: see Figure 1.1). It should be noted that between the sampling trips, the charter operator regularly surveyed these sites using modern sounder equipment.

In 2002, the opportunity to fish in the period in which the aggregations traditionally commence forming was lost due to the delay in the issuing of the General Fisheries Permit (No. PRM03162C). However, sampling trips commenced well within the period in which the aggregation historically continued to form at the site (April to September). Following the lack of success in these sampling trips, I decided to conserve the project’s resources for a more opportune time. In 2003, sampling occurred through May to September.

6.4 Results

Despite the extensive experience of both the charter operator and the Indigenous fishers involved, only eleven black jewfish were harvested in ten sampling trips (see Table 6.1). However, from these limited catches, it appears that the mean size of the black jewfish inhabiting the waters of the Northern Peninsula Cape York Peninsula has increased significantly. Black jewfish harvested in 2003, were of a size large enough to be sexually mature (mean size 103.5 cm, range 77 cm to 112 cm TL).

Based on the work on Bibby and McPherson (1997), the specimens caught in 2003 were likely to have been predominantly four to five-year-old fish. These fish may be the same age cohort that dominated catches in 2000. The initial assessment I conducted on this species (see Chapter 5) revealed that one and two-year-old fish dominated catches of black jewfish in 2000. Juvenile black jewfish of an equivalent age were not observed in the sampling trips conducted during this assessment, and so the strength of the age structure of the population is unclear.

Table 6.1: Details of black jewfish sampled in 2002 and 2003.

Date	Moon phase	Location	Number	Size (cm TL)
18 Aug. 2002	3 days after 1st quarter	Muttee Head	0	
20 Aug. 2002	3 days before full moon	Muttee Head	0	
1 May 2003	2 days after 1st quarter	Muttee Head	2	~113, ~107.
11 May 2003	5 days before full moon	Muttee Head	1	112.
12 May 2003	4 days before full moon	Muttee Head	5	111, 102, 103, 101, 77.
13 May 2003	3 days before full moon	Muttee Head	2	~115, ~108.
14 May 2003	2 days before full moon	Muttee Head	0	
5 June 2003	3 days before 1st quarter	Muttee Head	1	90.
23 July 2003	2 days after last quarter	Crab Island	0	
18 Sept. 2003	1 day before last quarter	Peak Point	0	

Also consistent with the findings of the initial assessment (see Chapter 5), it appears that annual aggregation event has become increasingly compact in both temporal and numerical terms. Black jewfish were caught during only five of the sampling trips conducted in 2002 and 2003. In between these sampling trips, project staff periodically checked likely fishing locations using sonar equipment, yet no evidence of the presence of black jewfish was observed. These checks were continued beyond the period in which black jewfish continued to be caught in large numbers during previous years.

Through personal communications with residents of Northern Cape York Peninsula, I am aware that some black jewfish were harvested during the period of the two year closure. While the number of fish harvested during the closure could not be substantiated (as those fishers who harvested the species were not openly talking about their catches), it appears that the social pressure applied by the vast majority of the people limited the fishing effort targeting black jewfish to a small fraction of former levels.

6.5 Discussion

6.5.1 Determining the management objective

It appears that the black jewfish sampled in 2002 and 2003 were large enough to be sexually mature fish. Although the genetic identity and age of these fish was not examined due to budget constraints, it is plausible that fish caught in 2003, may be from the same cohort identified as the dominant size class in 2000. Research conducted two years prior in the initial assessment indicated that the dominant class was then two years of age.

The complete structure of the population and the strength of age class remain unclear. It is not known if younger age cohorts are present in the fish stock, and what proportion of the population they may represent. Therefore, given the limited information we have on the fish stock, it is important that the size class observed is provided with the greatest level of protection. This control is necessary to ensure that the prospects of stock replenishment are realised.

The Injinoo's Elders and Land Trust and have expressed their desire to maintain their role in the management of the fish stock. Their objectives incorporate a balanced approach in dealing with environmental, social and economic issues. This approach is not unlike the popular concept of 'ecological sustainable development' which has become increasingly fundamental to contemporary western natural resource management.

Central to the concept of ecological sustainable development is the ‘precautionary principle’ that advocates the adoption of a risk adverse approach to resource management. This principle provides that where there are threats of serious or irreversible environmental damage, the lack of scientific certainty should not be an impediment to the implementation of measures to prevent environmental degradation.

6.5.2 Options for the management of black jewfish

Several options are available to manage black jewfish in the waters of Northern Cape York Peninsula. Table 6.2 summaries each of the options, which range from no protection through to maximum protection. In the following pages, I discuss each of these options, and provide examples of each where they exist locally and nationally. The advantages and disadvantages of these management options are discussed in the context of the present situation, and recommendations have been presented as advice for the decision makers whose role it is to provide for the sustainable future of black jewfish in Northern Cape York Peninsula.

Table 6.2: Summary of the options available for the management of black jewfish stock inhabiting the waters of Northern Cape York Peninsula.

Management category	**Definition of category**	**Options within categories**
1) Unregulated fishing	No regulatory measures are applied	a) Maintain status quo
2) Input controls	Limits on fishing effort or equipment	a) Gear restrictions b) Temporary closures
3) Output controls	Limits quantities that may be harvested	a) Size limits b) Possession limits c) Access rights
4) Holistic controls	Ecosystem-based management	a) Marine protected areas b) Indigenous protected areas

6.5.2.1 Maintain status quo

Management category

Unregulated fishing.

Explanation

For centuries, fish in the sea were viewed as an unlimited source of food for human populations. More recently however, increasing competition for resources has led to a re-examination of this assumption and a search for new ways to manage marine fisheries (Ocean Studies Board 1999). Across the globe, the adoption of regulatory measures is now widely viewed as essential in present day resource management.

The renowned paper of Hardin (1968) captures the turning point in resource management thinking. Appropriately titled 'The Tragedy of the Commons', the logic of the Hardin's view is straightforward. He argues that when the use of a resource is not controlled, it tends to be poorly maintained, overused, or depleted. He suggests that without social or legal constraint, some people will maximise their personal benefit to the detriment of others and the resource, and consequently all of the users suffer. In essence, Hardin (1968) states that the system is vulnerable to failure when acts of responsible stewardship are not reciprocated by others.

Example: Black jewfish fishing in the Northern Cape York Peninsula

Prior to 2000, when a temporary closure was introduced to control the harvest of black jewfish in the Northern Cape York Peninsula, the fishery based on this species was unregulated in respect to Indigenous subsistence fishers who are largely exempt from regulations under the *Fisheries Act 1994* (Qld). However, it appears that in the decade prior to the management action of 2000, the composition of the local fish stock was negatively altered as a result of sustained fishing pressure by a number of user groups.

The custodians of this resource must ensure that the future harvest of the black jewfish remains sustainable, so that the benefits of the resource can be enjoyed by future generations. If the option of no regulation is adopted, there is a strong reliance on: (1) the persistence of a strong environmental ethos among the resource users, and (2) the resilience of the fish stock to unknown levels of fishing pressure. In the present case, the level of fishing pressure that can be sustained by the local black jewfish stock is uncertain.

Advantages

Places onus on individual fishers to ensure that they contribute to the sustainable harvest of the fish stock.

Disadvantages

The strong environmental ethos required by each and every fisher is likely to be challenged if one or more fishers are perceived not to be exercising fair restraint. This vulnerability delivers no certainty.

Suitability

Low.

Recommendation

Given the present status of the local black jewfish stock, the managers of the resource should opt for an alternative measure that provides greater assurance that the fishing pressure placed upon the stock will be controlled over a predetermined period.

6.5.2.2 Gear restrictions

Management category

Input control.

Explanation

Gear restrictions serve to limit the efficiency of fishing effort by managing the gear that may be utilised to harvest the species. For example, measures may be introduced to restrict the number or type of gear (such as setting a limit on the number of lines per vessel, setting a maximum number of hooks per line), or to restrict the use of a particular fishing method (such as surround netting or pre-baited detachable lines).

Typically gear restrictions are applied in conjunction with other management measures.

Example: Recreational fishing limits in Queensland

There are many examples of gear restrictions which apply to recreational fishers in Queensland. For example, when fishing from a recreational vessel no more than three lines are permitted per person, with a limit of six hooks per line applied. When crabbing no more than four crab pots or dillies may be used per person (must be at least 15 years old).

Recreational fishers in Queensland waters are not permitted to use monofilament gill nets. While bait nets are permitted, they must not be greater than 16 m in length, 3 m in drop and must have a mesh size no greater than 28 mm. These nets are not permitted to be anchored or fixed. Cast nets are to be no more than 3.7 m and must have a mesh size must be no greater than 28 mm.

Source: http://www.dpi.qld.gov.au/fishweb

Advantages

May be adopted to reduce catch rates while not limiting fishing effort. May be adopted to ensure that fishing methods that have the potential to increase catch rates are not introduced in the local fishery.

Disadvantages

Gear restrictions alone cannot ensure that the local harvest of black jewfish will be restricted to levels determined to be within an acceptable threshold.

Suitability

Medium.

Recommendation

Gear restrictions applied to current fishing methods cannot ensure that the local harvest of black jewfish will be restricted to an acceptable level. Therefore, given the current situation for this species, this option should be deemed unsuitable on its own, but may be adopted in combination with other options.

6.5.2.3 Temporary closures

Management category

Output control.

Explanation

A temporary closure on the harvest of a species may be applied to fish stocks known to be vulnerable at certain times. Such closures have proven to be an effective tool in managing aggregating fish stocks around the globe. They have successfully been introduced in a number of countries where overfishing of spawning aggregations has occurred (Samoilys 1997). This measure requires a fine understanding of the spatial and temporal attributes of the fish's aggregating behaviour.

Black jewfish have historically aggregated in the inshore waters of the Northern Cape York Peninsula during the period within April to September. However, focusing protection exclusively to set periods may not suffice if the stock is available to harvest outside of this period. In both 1999 and 2000, uncharacteristically large catches of black jewfish occurred during January. A temporary closure spanning 12 months or more would provide greater protection.

Example: Seasonal closures in Queensland waters

There are many examples of temporary closures that apply to recreational fishers in Queensland. One example in Queensland is:

Species:	Barramundi.
Location:	Gulf of Carpentaria and East Coast.
Period:	Variable from year to year to coincide with spawning peaks which are aligned with lunar and tide cycles.

Source: http://www.dpi.qld.gov.au/fishweb

Advantages

Temporary closures may be applied to periods when black jewfish are known to aggregate, or may be extending to incorporate the whole year. A closure of 12 months or more would provide immediate and comprehensive protection. The advantage of this option is the ease of public understanding, as well as simplified implementation and enforcement when compared with other options.

Disadvantages

The initial assessment that I conducted in 1999 and 2000 revealed significant numbers of black jewfish were harvested during the period outside of the mid-year aggregation season. These events demonstrated that although the formation of the annual mid-year aggregations was predictable, the movement patterns of these fish outside of this period were not. Therefore, a short seasonal closure may not provide sufficient protection.

Suitability

High.

Recommendation

It is my view that this option represents the most appropriate course of action given the apparent status of the resource. The greater the period of time, the greater the prospects for the sustainable future of the black jewfish stock in the Northern Cape York Peninsula waters. For ease of public understanding, any potential closure should aim to replicate the boundaries applied to the original two years.

6.5.2.4 Size limits

Management category

Output control.

Explanation

Limiting the size of the fish that may be retained is one of the oldest of all regulations applied to fishing (King 1995). Size limits are based on biological research into each species' reproductive cycles. Minimum size limits and maximum size limits may be introduced to protect certain cohorts. Minimum size limits are commonly set to ensure that the fish may spawn at least once and thereby to contribute to the growth of the population before capture. Maximum size limits are set to protect larger, more fecund individuals.

The concept of size limit regulation is simple and transparent. If the size of the fish is not within the size the fisher is permitted to retain, the fish must be released. The best practices for releasing fish are relatively simple, but an education program would be required for their universal adoption. For enforcement reasons, it is typically ruled that the fish must be released whatever its likelihood of survival, however, post-capture mortality has not been quantified for this species.

Example: Recreational fishing limits for black jewfish

Size limits apply to harvesting black jewfish across much of their distribution along Australian coastline. For example:

Queensland:	East Coast - 45 cm minimum. Gulf of Carpentaria - 60 cm minimum, 120 cm maximum, with no more than two greater than 100 cm.
Western Australia	45 cm minimum.

Advantages

A relevant tool given that this measure may provide maximum protection to a particular set of size cohorts.

Disadvantages

The survival rate among released fish is not known for this species. Enforcement may be difficult.

Suitability

Medium.

Recommendation

If a size limit is introduced for Indigenous fishers, it should replicate that applied to recreational fishers for ease of education and enforcement. However, greater protection would be provided by adopting longer size limits.

6.5.2.5 Possession limits

Management category

Output control.

Explanation

Possession limits introduce a total allowable catch that fishers are permitted to retain per fishing trip. Individual possession limits are applied per individual fisher, while boat limits set a maximum number of fish that may be harvested per vessel. The adoption of this tool requires a clear definition of the parameters of the possession limit, e.g., the term 'fishing trip' must be defined.

Boat limits are advantaged over individual limits in they are easier to prescribe and enforce in that no participation or age limits need be determined. While boat limits may be a very relevant tool in the Northern Cape York Peninsula (given the high number of fishers who participate in most vessel-based fishing trip), boat limits do not encompass land based fishing; hence a combination of the two limits may be required.

Examples: Recreational fishing limits for black jewfish

Possession limits apply to harvesting black jewfish across their distribution along Australian coastline. For example:

Queensland:	East Coast - Possession limit of 10. Gulf of Carpentaria – Possession limit of five fish with no more than two of a length greater than 100 cm. Plus, this species is listed among those that a person must not possess a combined total greater than 30 fish.

Northern Territory:	Possession limit of five fish, plus a 30 fish general personal possession limit. Hence, assuming no other fish have been caught, only 30 jewfish may be harvested even if there are greater than six persons on board.
Western Australia:	Possession limit of four fish combined with the southern mulloway (*Argyrosomus hololepidotus*), plus a general mixed bag limit of eight ‘prize’ fish.

Advantages

Allows the equitable harvest of the resource among all fishers.

Disadvantages

Presently there is not enough information available on the state of the black jewfish stock inhabiting the Northern Cape York Peninsula waters to confidently determine a sustainable level of harvest.

Suitability

Moderate.

Recommendation

If a possession limit is introduced for Indigenous fishers, the level should be as conservative as acceptable (at least in the immediate term until further information on the state of the fish stock is gained).

6.5.2.6 Access rights

Management category

Output control.

Explanation

The number of fish harvested may be regulated by a restriction in access rights to the resource. Various access right controls are available including: permits, licenses, total allowable catch (TAC) or individual fishing quotas (IFQ). Essentially each of these controls allows for the allocation of the right to harvest the managed species. Often this involves setting an acceptable annual catch level and dividing the rights to this catch among the fishers.

The form of access rights, and how they are defined, is of critical importance in determining whether the management objective will be met. For example, the distribution of access rights must occur on a fair and equitable basis for this option to be acceptable to fishers. Both implementing and managing each of the various access right options is administratively complex and time consuming (Burke 2000).

Example: Dugong hunting controls in the Great Barrier Reef Marine Park

The *Great Barrier Reef Marine Park Zoning Plan 2003* provides a mechanism for managing the traditional use of aquatic resources through the development of Traditional Use of Marine Resource Agreements (TUMRAs). TUMRAs are voluntary agreements developed by Traditional Owners, and once accredited by the Authority, become enforceable under the *Great Barrier Reef Marine Park Act 1975* (Cwlth). Provisions regulating the implementation and review of TUMRAs are prescribed in the *Great Barrier Reef Marine Park Regulations 1983.*

In July 2005, the Juru, Gia and Ngaro groups signed a TUMRA with the Environmental Protection Agency to formalise their self-imposed ban on dugong hunting and their self-managed hunting approval system for turtle hunting. The TUMRA applies to coastal waters between Ayr, Bowen and Proserpine.

Source: EPA Bulletin. 2005. Traditional owners to protect State's turtles and dugong. Queensland Environmental Protection Agency. Issue 19. Website: http://www.epa.qld.gov.au/about_the_epa/public_reporting/epa_bulletin/. Downloaded on 14 July 2005.

Advantages

Access restrictions may be adopted to limit the total harvest within a level deemed to acceptable.

Disadvantages

Devising fair methods of ensuring the equitable use of the resources through a access system can be complex and political. The implementation and administration of this approach requires a considerable investment in time and resources.

Suitability

Low.

Recommendation

The adoption of this management option would require a substantial commitment by the resource managers given the difficulty of ensuring equitable resource use. This approach is considered the least suitable option for managing black jewfish, but should be considered when reviewing the management of turtles and dugongs.

6.5.2.7 Marine protected areas

Management category

Holistic control.

Explanation

A ‘marine protected area’ is an area of sea especially dedicated to the protection and maintenance of biodiversity, and of natural and associated cultural resources. Typically these are managed through legal or other effective means, though the actual level of protection varies considerably. Funding is currently available to establish marine protected areas under the Commonwealth’s National Representative System of Marine Protected Areas.

Co-management of marine protected areas is typically achieved through the establishment of a Board of Management. Under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) that many marine protected areas are governed, permits must be issued for certain activities including those that may affect listed species or ecological communities (such as dugongs and turtles).

Example: Cobourg Marine Park

The Cobourg Marine Park in the Northern Territory is the first Australian marine park to be formally managed jointly by Aboriginal Traditional Owners and government agencies. Cobourg Marine Park and the adjoining Aboriginal-owned Gurig National Park are both governed by an eight person board made of up four Traditional Owners and four Northern Territory Government representatives. One of the Traditional Owners chairs the board and has the casting vote.

Source: http://www.erin.gov.au

Advantages

There are many potential advantages of establishing marine protected areas including:

- The size and abundance of exploited species may increase within closed areas.
- The creation of a recruitment source for surrounding areas via larval export or emigration.
- Ease of public understanding and simplified enforcement.

Disadvantages

Some management rights may be transferred to external agencies.

Suitability

Moderate.

Recommendation

The complexity and depth of the process required to declare a marine protected area prevents this option being viable for the management of black jewfish in the short-term, and so should be considered only if the Injinoo Land Trust opts for the development of a long term strategic direction.

6.5.2.8 Indigenous protected areas

Management category

Holistic control.

Explanation

The Indigenous Protected Area Program is part of the Commonwealth's National Reserve System Program. The program aims to establish a network of protected areas that includes a sample of all types of ecosystems across the country. Through this program, Indigenous landowners are being supported to manage their lands for the protection of natural and cultural features in accordance with internationally recognised standards and guidelines.

Indigenous protected areas must have legal or other effective means available to manage and protect the designated area. Legal mechanisms for protecting Indigenous protected areas might include Commonwealth or State legislation, which may be implemented through an agreement with the appropriate government agency. Customary Law is recognised as a form of management that satisfies the International Union for the Conservation of Nature guidelines.

Example: Deliverance Island Indigenous Protected Areas

Deliverance Island Indigenous Protected Area was declared in February 2001. Deliverance Island (9° 31' S, 141° 34' E) is recognised as one of the few places in the Torres Strait that has maintained its natural vegetation. The unusually well developed forests and dune vegetation on the island are important habitats and a major food source for fruit eating birds and a large number of sea birds.

Source: http://www.erin.gov.au/indigenous/ipa/currentprojects/deliverancepulu.html

Advantages

Funding and assistance are available for the creation of Indigenous protected areas and provide recognition of the unique entities of Indigenous peoples' perspective in natural resource use and management. The advantages listed for marine protected areas also apply to Indigenous protected areas.

Disadvantages

Possible transfer of some management rights to external agencies.

Suitability

Moderate.

Recommendation

The complexity and depth of the process required to declare an Indigenous Protected Area prevents this option being viable for the management of black jewfish in the short-term. The Injinoo Land Trust may wish to consider this tool in the development of a longer-term solution.

6.5.3 Summary of the management options

Prior to 2000 when a temporary closure was introduced to control the harvest of black jewfish in the Northern Cape York Peninsula, the fishery based on this species was unregulated with respect to Indigenous subsistence fishers. However, in the decade leading up to 2000, the structure of the local fish stock was negatively altered as a result of sustained fishing pressure. It appears that the fishery that started at Muttee Head in 1946 has grown to a stage where measures are now required to ensure the sustainable future of the resource.

Input controls may be applied to limit the efficiency of fishing effort, while providing no limit on the total catch. Input controls limit such things as the number of participants in the fishery, the type and amount of gear, and methods of fishing. In the future, these options may be viable, but in the immediate term may not provide sufficient protection given the status of the local black jewfish stock. Gear restrictions alone cannot ensure that the harvest of black jewfish will be restricted to within an acceptable threshold.

Limiting the size of the fish that can be retained may protect particular size cohorts so that they may contribute to the replenishment of the stock. Presently, the strength of the size cohorts of black jewfish is unknown, hampering the reliability of this option, and while simple and transparent, enforcement may be difficult. The concept of size limit regulation relies on fishers returning to the water any fish not within the size permitted to be retained. Presently, the survival rate of released black jewfish is unknown.

Possession limits may introduce a total allowable catch that each fisher may retain per fishing trip. This option would allow the equitable harvest of the resource among all fishers. However, the present state of the black jewfish stock inhabiting the Northern Cape York Peninsula waters makes it difficult to confidently predict the level of harvest that currently may be sustainable. Further, catch limits applied on a trip-by-trip basis cannot ensure that the total annual harvest will remain within the acceptable threshold.

Access rights may be allocated to limit the total annual harvest within a level deemed acceptable. Yet, the adoption of this type of approach would require a substantial commitment by the resource managers given the difficulty of ensuring equitable resource use. The administrative complexity of this option requires a considerable investment in time for both its establishment and implementation. Managing the harvest of black jewfish through access rights is currently the least practical tool available for this fishery.

A marine protected area or Indigenous Protected Area may be established as a means to enhance the protection of significant sites such as the aggregation grounds at Muttee Head, Peak Point and Cape York. However, the length and depth of the process required to establish such areas suggests that these tools are longer term propositions. The possible transfer of some management rights to external agencies may be offset by the prospect of sustained government assistance in the form of funding and expertise.

It is my view that a temporary closure replicating that initiated by the Northern Cape York Peninsula community in 2000, again represents the most suitable course of action. Given that significant catches of black jewfish may occur outside of the aggregation season, a closure that applies to the whole year would be most appropriate. The greater the period of time that catches are prohibited, the greater the prospects for the sustainable future of the black jewfish stock in the Northern Cape York Peninsula waters.

THESIS FLOW CHART

CHAPTER 1. INTRODUCTION

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CHAPTER 2. BACKGROUND INFORMATION

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CHAPTER 3. GENERAL METHODS

↓

CHAPTER 4. INDIGENOUS SUBSISTENCE FISHING SURVEY

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CHAPTER 5. FIRST BLACK JEWFISH ASSESSMENT

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CHAPTER 6. SECOND BLACK JEWFISH ASSESSMENT

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CHAPTER 7. GENERAL DISCUSSION

Chapter seven focuses on three elements: (1) The growing importance of Indigenous subsistence fisheries; (2) The outcomes and benefits of this project; and (3) What needs to be done in the future.

In summary:

- There is the potential for effort in Australia's Indigenous fisheries to increase rapidly.
- Outcomes from this project include implementing steps to reduce pig predation of turtle nests, and the implementation of a two year ban on the harvest of black jewfish to improve stock replenish.
- There is an extensive list of tasks which must be undertaken to enhance the sustainable future of Injinoo's subsistence fishery.

CHAPTER 7. GENERAL DISCUSSION

7.1 Outcomes delivered by this study

This study has delivered much information that will enhance the ability of resource uses and custodians to provide for the sustainable management of aquatic resources utilised by Indigenous subsistence fishers. In addition to this thesis, I have produced six other publications and nine presentations (see Appendix 6). While this study was conducted in Queensland, the benefits should have widespread application. The results of the survey of the subsistence fishery at Injinoo provide a baseline for comparisons with subsistence fisheries across Australia. Similarly, the findings of the research focusing on black jewfish should be applicable nationally for all fisheries which incorporate the species.

The comprehensive consultation process maintained throughout the lifetime of the study ensured that the implications of the research findings of this study were rapidly acted upon by the communities of the Northern Cape York Peninsula. It is notable that several Government agencies have acted upon the well developed public expectations that this study generated. In particular, the Queensland Environment Protection Authority, Queensland Department of Primary Industries and Fisheries and the Fisheries Research Development Corporation, have responded to the findings of this study. In the text below, I discuss how this project faired against its aims, and discuss the outcomes that were developed in response to the research findings.

7.1.1 Indigenous subsistence fishing survey

7.1.1.1 Fulfilling the aims of the fishing survey

This study was initiated to rectify the lack of data on type and quantity of aquatic resources harvested by Indigenous subsistence fishers in Northern Cape York. Prior to this study, the Queensland Department of Primary Industries and Fisheries had no reliable data on the type or quantities of aquatic resource harvested by the Indigenous subsistence fishers of Northern Cape York Peninsula (Tropical Fin Fish Management

Advisory Committee 1998). Therefore, the aim of this component of my thesis was to:

1) ***Conduct a qualitative survey of the utilisation of aquatic resources by the Indigenous subsistence fishers of Injinoo Aboriginal Community.***

   Key results**:** During 1998 and 2000, I conducted a series of surveys (total survey days = 72) (see Chapter 4). These surveys provided a comprehensive set of data on the fishery, and revealed many details including the;

   - number and length of marine and freshwater resources harvested (75 taxa),
   - rate of participation (95% of households participated),
   - number of people per activity (up to five when netting),
   - mean duration of activities (up to 4 hours when dugong hunting),
   - rate of harvest (up to 2.7 fish/person hr^{-1} when netting),
   - type of equipment and methods used (10 types of activities), and
   - location of effort (88% between Peak Point and Number Two River).

The comprehensive dataset on Indigenous subsistence fishing generated by this survey demonstrated the important contribution of this fishing sector to the total harvest of aquatic resources from Queensland waters. From a resource management perspective, there has long been a dearth of information on the demands placed upon the aquatic resources by the Indigenous fishing sector. This project has responded to the concerns of resources users and managers alike, by providing the fishery catch statistics integral to achieving responsible management of aquatic resources.

Although this quantitative survey was not designed to provide ethnobiological information on the maritime culture of the Indigenous community of Injinoo, I documented the cultural values that comprise inseparable components of the subsistence fishery. Throughout this thesis, I have included insights into the maritime culture of the Indigenous people of Injinoo Aboriginal Community. I included these so that reader may gain a better understanding of the environment in which this fishery was conducted. This information should enhance the ability of resource managers to relate to the beliefs and practices of Indigenous people when considering the suitability of future management options.

7.1.1.2 Delivering outcomes from the fishing survey

The data gained by this study will allow the subsistence fishery of Injinoo Aboriginal Community to be managed under the *Fisheries (Gulf of Carpentaria Inshore Fin Fish) Management Plan 1999*. The Plan states that ‘traditional and customary fishing needs of Aborigines or Torres Strait Islanders is to be reviewed if surveys of participation in traditional or customary fishing that are accepted by the Authority show a significant decline in catches or participation’. The results presented in this thesis provide the baseline data against which future surveys can be compared to identify changes over time.

This thesis has demonstrated the willingness of Indigenous communities to participate in monitoring programs assessing their use of aquatic resources when the research is conducted in a manner deemed appropriate by the community. The value of the Indigenous Subsistence Fishing Survey, which annotates the steps in developing appropriate methodology for conducting fishery surveys in Indigenous communities, was demonstrated by the high degree of cooperation received from the residents of Injinoo. The success this project had in developing a collaborative approach serves as a template for future surveys to be conducted in Indigenous communities.

The collaborative approach adopted by this project provided community members with a greater understanding of western science and provides a forum for their greater involvement in the fisheries management process. In essence, the approach of the project empowered the users and custodians of the resource to seek a greater role in the management of their local resources, and assert greater responsibility for the sustainable use. In such, this project has enhanced the ability of resource users and managers alike to participate in informed decision-making that may contribute to the viable future of the fishery.

As result of the findings of this project, Injinoo Aboriginal Community approached the Cape York Feral Animal and Weed Program to initiate a cull of feral pigs to reduce the predation of turtle eggs. The Council also considered options for the establishment of a pig-proof fence along areas of particular importance (such as the beach adjacent to Crab Island flatback turtle rockery). Addressing the problem of feral pigs is a difficult task due to the resilience of these animals (see Chapter 4.5.4), and unfortunately securing suitable funding has so far proved fruitless. However, the Queensland Environment Protection Authority recently removed feral pigs inhabiting Mia Island (10° 43’ S, 142° 36’ E: see Figure 1.1). This action has helped alleviate some of the heavy predation of turtle eggs that occurs in the region, but more work is required and should be afforded a high priority.

7.1.2 Black jewfish assessment: 1999-2000

7.1.2.1 Fulfilling the aims of the 1999-2000 assessment

This project was initiated in response to the concerns of the Traditional Owners of the Northern Cape York Peninsula regarding the perceived increase in fishing effort targeting the annual aggregations of black jewfish in the area. Therefore, the overall objective of this component of my thesis was to increase our understanding of the biology and harvest of black jewfish in the Northern Cape York Peninsula. In such, this assessment had several aims reflecting the diversity of studies conducted. These were:

1) ***Collate available information on historical catches of black jewfish in Northern Cape York Peninsula, and identify any trends in the fishery that may have occurred over time.***

   Key results**:** From the numerous historical accounts that I received from the residents of Northern Cape York Peninsula, I was able to construct a record of the fishery since its inception in 1946 (see Chapter 5.3.1). These records suggest that fishing effort targeting the aggregations of black jewfish had increased progressively over the last 50 years. These records also suggest that the fishery was previously based on much larger fish, many of which had ripe gonads. It appears that specimens close to the maximum size (150-180 cm TL) were last caught in 1994.

2) ***Collate available information of current catches of black jewfish in Northern Cape York Peninsula, and profile the aggregation events in terms of effort and distribution.***

Key results**:** I was able to record the harvest of 8.4 tonnes of black jewfish in 1999 and 2000 (see Chapter 5.3.2). Most of the recorded catch (88%) was harvested from three known aggregation sites (Muttee Head, Peak Point and Cape York) during the mid year period (April to September). Concerningly, the mean size/age of the black jewfish harvested decreased during 1999 (70-80 cm TL, believed to be three-year-old fish) and 2000 (59-69 cm TL, believed to be two-year-old fish). The study also recorded the shift in fisher's effort to several new locations.

3) ***Examine the reproductive traits of black jewfish in the waters of Northern Cape York Peninsula, and establish the relevance of the fish's reproductive strategy in the formation of the annual aggregations.***

Key results**:** Sexually mature black jewfish comprised only 4.4% of the catch examined (n = 270) in a sampling program biased towards the largest individuals available (see Chapter 5.4.1). The minimum size of maturity in females that I observed was 79 cm TL, representing a departure from the 92 cm TL reported by McPherson (1997). Sexually mature ovaries were observed between May and September, the period in which the aggregations form. However, no ripe or spent gonads were found so the exact timing and location of the spawning remains to be confirmed.

4) ***Examine the composition of food items in the stomachs of black jewfish collected from the waters of Northern Cape York Peninsula, and establish the relevance of the fish's diet in the formation of the annual aggregations.***

Key results**:** I observed a diverse range of animal taxa in the stomachs of black jewfish that I sampled (n = 256) (see Chapter 5.4.2). The variety of food items observed (fish to crustaceans) supports the description of an 'opportunistic predator' attributed to the species by Rao (1963). The stomach items observed during the aggregation period (April to September) did not differ from the rest of the year. I found no evidence to support Thomas and Kunja's (1981) assertion that the seasonal migration of black jewfish was related to the increased availability of prey items in the inshore waters.

5) ***Establish the value of tagging and releasing black jewfish by examining tag-induced mortality and tag loss, and identify the movement patterns of black jewfish in the waters of Northern Cape York Peninsula.***

   Key results**:** I observed no tag loss or evidence of tag-induced mortality during the captive trial conducted over 330 days (see Chapter 5.4.3). The wild tagging program (n = 114) produced a low rate of return (2.6%) but provided some very informative results. The tag returns revealed that some black jewfish remain at, or return to, the aggregation site at least into the following day, and also revealed the movement of an individual fish between two distinct aggregations. This behaviour, if normal, may increase the susceptibility of the species to capture during the aggregation period.

6) ***Determine the level of genetic differentiation among the black jewfish aggregations in the waters of Northern Cape York Peninsula.***

   Key results**:** The AFLP technique, which had never before been applied to teleosts in Australia, proved itself as a robust technique of direct DNA analysis, and presented many advantages available to fisheries science (see Chapter 5.4.4). No significant genetic variation was observed in black jewfish sample from the waters of Northern Cape York Peninsula. This finding suggested that adjacent aggregation sites are utilised by the same genetic stock. The genetic diversity of samples collected in 1999 (0.088) was greatly reduced in 2000 (0.048), and the samples displayed characteristics typical of bottlenecked populations.

In fulfilling the aims of this thesis, this study has helped alleviate the deficit of information on the biology and harvest black jewfish. Several aspects of the findings summarised in the text above, indicated that the state of the fishery had undergone a rapid decline. My results are the first to document the degradation of aggregations formed by fish of the family Sciaenidae. Many species of tropical fish are known to form annual aggregations (see Appendix 4), so the approach taken in gaining these results may serve as a template to address issues applicable to other fisheries.

7.1.2.2 Delivering outcomes from the 1999-2000 assessment

In response to the findings of the first assessment, the Injinoo Land Trust (representing the Traditional Land Owner Groups of the Anggamuthi, Atambaya, Gudang and Yadhaykenu Aboriginal people), in cooperation with the Injinoo Aboriginal Community Council, imposed a two-year ban on the taking of black jewfish from the inshore waters north of the southern boundaries of Crab Island (on the West Coast) and Albany Island (on the East Coast) (see Figure 7.1). The two-year ban was initiated following a series of community meetings, and commenced in September 2000.

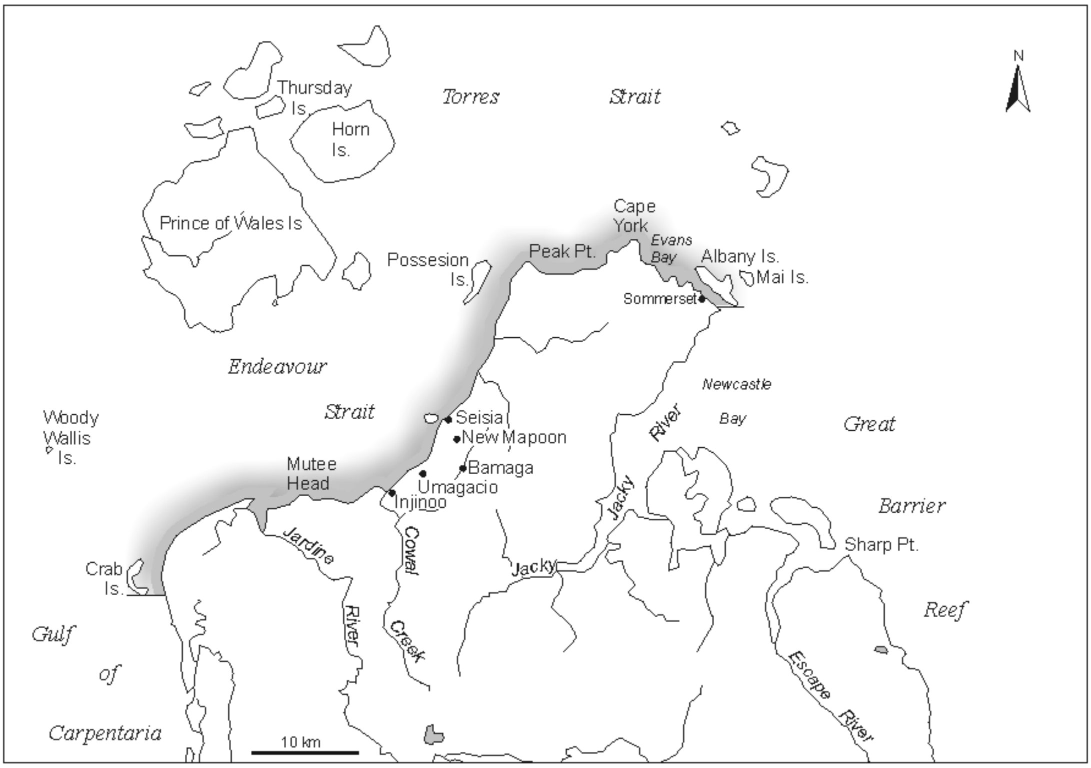

Figure 7.1: Location of area closed to the harvest of black jewfish under the regional agreement.

Through appropriate consultation, this community-based management initiative developed into a regional agreement with comprehensive support across Northern Cape York Peninsula. At the request of Injinoo's Elders, I visited each of the neighbouring communities to inform them of the findings of my research. Following a series of meetings, the Councils of Umagico Aboriginal Community, Bamaga Islander Community, New Mapoon Aboriginal Community and Seisia Islander Community agreed to participate in the two-year ban on the take of black jewfish.

Following a visit to the Torres Shire Council and the Kaurareg Traditional Owner Group of the adjacent Torres Strait region, the elected representatives of these organisations also agreed to participate in this agreement. Finally, each of the proprietors and operators of tourist accommodation and fishing charter boats operating in the region also pledged full cooperation. There were several businesses providing accommodation for tourists in the Northern Cape York Peninsula at the time the agreement was implemented, and the charter boat industry operating in the region was reportedly the second largest in Queensland outside of Cairns (Gary Wright, Charter Boat Operator, Seisia Islander Community, *pers comm*. 2000).

Adding to the uniqueness of this self-imposed management arrangement, the elected Chairmen of each of these Indigenous communities asked for legislative backing for this species-specific ban. Each of the Indigenous communities expressed a willingness to forfeit their statutory exemption to the relevant catch restrictions of the *Fisheries Act 1994* (Qld). The Queensland Department of Primary Industries and Fisheries responded to these public expectations by immediately sending its Senior Fisheries Manager, Mr Mark Elmer, to Northern Cape York Peninsula to gain a first-hand assessment of the situation. Over the two days of his visit, Mr Elmer and I visited the Elders, Traditional Owners, and the Chairs of the various Community Councils. We also spoke randomly to various community residents. Only one person expressed a dislike of the two year ban initiated by the Traditional Owners.

In September 2002, the Queensland Department of Primary Industries and Fisheries released a Marine Fisheries Regulatory Impact Statement which proposed amendments to the *Fisheries Regulation 1995* in relation to the management of black jewfish. The Statement indicated that in order 'to address concerns regarding the sustainability of these fish in the region arising from this research and to allow existing stocks to recover, it is proposed to prohibit the taking of black jewfish from the area through the introduction of a new closed waters provision'.

The *Fisheries Regulation 1995* was subsequently amended to incorporate closed waters provisions replicating the area adopted by the regional agreement. The boundaries of the area closed under Schedule 2 (Section 46a) and Schedule 3 (Section 44a) are described in Appendix 7. The closed waters prohibit the harvest of black jewfish by recreational and commercial fishers, but unfortunately do not apply to Indigenous subsistence fishers. I can only speculate as to why this decision was made, but it appears that reversing the Native Title rights of Indigenous people, even temporarily as requested by the Indigenous groups, was considered politically risky.

7.1.3 Black jewfish assessment: 2002-2003

7.1.3.1 Fulfilling the aims of the 2002-2003 assessment

The aim of the two-year ban implemented in response to the findings of the initial assessment was to allow black jewfish in the local area to reach a mature size so that prospects for the replenishment of stocks were improved. Each of the parties involved recognised that the two-year ban may not provide adequate time for the complete recovery of the proportion of the adults in the population. Hence, all parties advocated a review of the stock condition prior at the end of the two-year period, so that an informed decision can be made on future management needs. In 2001, the Fisheries Research and Development Corporation provided additional funding to respond to these public expectations. There aim of this component of my thesis was to:

1) ***Examine the length-frequency of black jewfish after the two year closure, and compare to the length-frequency data collected before the closure to identify any changes that may have occurred.***

    Key results**:** The mean size of black jewfish measured in 2003 (103.5 cm TL, believed to be five-year-old fish) was significantly larger that that observed in 2000 (59-69 cm TL, believed to be two-year-old fish). These fish may even represent the same cohort of fish. It appears that the two year closure has allowed black jewfish inhabiting the waters of Northern Cape York Peninsula to attain a size where they may contribute to the replenishment of the stock. However, catches of black jewfish were hard to come by despite the experience of the fishers, and may be indicate that the species may no longer be considered abundant.

This review of the state of the black jewfish stock following implementation of the two-year ban, provided rare data documenting the response of an over-exploited population granted temporary relief from fishing pressure. The initial responses of newly exploited fish stocks are commonly documented where previously unfished areas have became accessible; however, few studies have quantified the opposite situation (Jennings and Lock 1996). Importantly, this review provided timely data on the state of the fishery to lead further discussions on the future management needs of the fish stock.

The results of the review displayed some promising aspects, suggesting that the mean length of the fish had increased to a size where they may contribute to the replenishment of the stock. However, the difficulty in attaining specimens despite the extensive experience of both the charter operator and the Indigenous fishers who conducted the sampling work, highlights the fragile position of the fish stock. Therefore, I concluded that it is imperative that the dominant size/age cohorts observed during this review are provided with the maximum amount of protection possible.

7.1.3.2 Delivering outcomes from the 2002-2003 assessment

In May 2004, I met with the Chair of the Injinoo Land Trust, Mr Robbie Sallee, to discuss the results of the 2002-2003 assessment. Mr Sallee was provided with a copy of the results and a list of the future management options as reviewed in Chapter 6.5.2 of this thesis. The results of the assessment indicated that further management action was required to ensure the continued recovery of the black jewfish stock. However, the decision was made to continue to monitor the state of the fishery before further action is taken. This action is a result of the reduction of fishing effort targeting the species, and the promising signs of recovery displayed by the stock. As documented in Chapter 5, the average size of the black jewfish inhabiting local waters had increased significantly following the two year closure.

It is a credit to the people of the Northern Cape York Peninsula that despite the remoteness of the aggregation sites, and the reliance of social pressures alone for the enforcement of the regional agreement, the closure successfully alleviated the fishing pressure placed upon this fish stock. Despite the successes achieved to date, the sustained, careful management of the fishery is critical to preventing the irreversible degradation of this resource. There are examples in the literature of the recovery of aggregating stocks granted appropriate levels of protection (e.g., Beets and Friedlander 1998), however, exemplifying the challenge that we now face, there are no reports of the return of aggregations after their loss.

7.2 Future needs identified during this study

During this study, I identified the need for further research to enhance our capacity to sustainably manage Indigenous fisheries and black jewfish stocks. In the text that follows, these needs are listed according to their priority.

7.2.1 Indigenous subsistence fisheries research

7.2.1.1 Immediate research needs and objectives

I recommend that the further research should be undertaken immediately to:

1. Investigate the impact of the predation of turtle nests by feral pigs.

Further research should be implemented immediately to monitor feral pig predation of turtle nests. Documenting the extent of this problem would serve two important functions. Firstly, it would provide the data necessary for modelling the impact of reduced recruitment. Secondly, quantifying the extent to which feral pigs are destroying turtle nests in Northern Cape York Peninsula, should aid prospects of gaining funding to control or eradication programs, a task which also should be commenced as soon as is possible. The program should regularly monitor permanent transects along beaches in areas where feral pigs are hunted and areas where they are not. The number of transects would depend on the level of funding available for this program.

7.2.1.2 Medium-term research needs and objectives

1) ***Conduct a second monitoring survey of the Indigenous subsistence fishery of Injinoo Aboriginal Community to identify any changes that may have occurred.***

The Indigenous Subsistence Fishing Survey should be repeated at Injinoo Aboriginal Community to allow changes in the effort or the harvest to be detected. The survey results presented in this thesis provide the baseline against these changes can be detected. The importance of detecting change is highlighted in the *Fisheries (Gulf of Carpentaria Inshore Fin Fish) Management Plan 1999*. The Plan states that:

> 'The provision of a fishery that satisfies the traditional and customary fishing needs of Aborigines and Torres Strait Islanders is to be reviewed if surveys of participation in traditional or customary fishing that are accepted by the Authority show a significant decline in catches or participation'.

The second survey should replicate the approach conducted in the present study so that the results of the two can be directly compared.

2) ***Implement monitoring surveys in neighbouring communities so that a complete picture of the scale of Indigenous subsistence fishing can be gained.***

During the same period of time that the next Indigenous Subsistence Fishing Survey is conducted at Injinoo Aboriginal Community, similar surveys should also be implemented in each Community of Northern Cape York Peninsula and the adjacent Torres Strait Islands. The surveys may be conducted by one organisation, or run independent of each other, but should be conducted concurrently and in a similar manner so that they can be directly compared. Each of these Communities utilise the same areas and aquatic resources, so the data from these concurrent surveys provides a more appropriate scale at which to examine the effort and harvest of the Indigenous subsistence fishery.

7.2.1.3 Long-term research needs and objectives

1) ***Gain a sound understanding of the population dynamics of key aquatic animals that may serve as indicators of the state of Indigenous fisheries.***

The research that provided the catalyst for the regional agreement was a product of community concerns for the sustainability of black jewfish. That community fishers noticed the size of the fish being caught was gradually decreasing over the years, was a function of the large size of the fish and noticeable differences between year classes. However, not all exploited resources display such obvious indicators of the resources conditions. Additionally, many of the species exploited in the subsistence fishery have life-history stages that may conceal changes in the population structure for multiple years. For example, once turtles have hatched, four to seven years pass before they are found at benthic feeding grounds (Limpus and Chaloupka 1997, Zug and Glor 1998).

In multi-species fisheries as diverse as the Injinoo subsistence fishery, it is impractical to rely on the individual analysis of all exploited stocks to ensure their sustainable use. This is largely a product of the unavoidable time frame involved between the commencement of projects (i.e. designing the research program, and raising funds for its implementation) and their completion (i.e. reporting of findings to interest groups, and development of management responses). For example, the concurrent two year assessment of the local black jewfish stock (1999-2000) actually represents six years from the time the need for the project was identified, and the result first became available to the resource managers (1995-2001).

Relying on individual stock assessments is also impractical because of the limited availability of research funds in Australia. Exemplifying this, in 2004-2005 only 50% of applications received by the Fisheries Research and Development Corporation (Australia's principal fisheries research funding agency) were successful in gaining funding (FRDC 2005). As an alternative, efforts should be concentrated on gaining a sound understanding of the population dynamics of a select group of species that may serve as indicators of the state of the fishery. The list of species chosen as indicator species should be a combination of the most commonly harvested species (such as mullet and snappers) and species that warrant special attention because of their conservation status (such as dugong and turtles).

7.2.2 Black jewfish research

7.2.2.1 Immediate research needs and objectives

I recommend that the further research should be undertaken immediately to:

1) ***Re-examine the length-frequency of black jewfish inhabiting the waters of Northern Cape York Peninsula to identify any changes that may have occurred.***

As the future of the black jewfish stock inhabiting the waters of the Northern Cape York Peninsula remains uncertain, further assessment must be commenced as soon as possible to monitor the situation. Future studies on the species may continue to operate in the manner adopted in the 2002-2003 assessment (see Chapter 6.3). That is, they may continue to monitor the length-frequency of the black jewfish in the region. Length-frequency studies are suitable for extended resource monitoring programs in that they are simplistic and cost-effective. Given the high degree of involvement in this study by many fishers in Northern Cape York Peninsula, future monitoring programs could be conducted by local community groups with a minimum of training. The benefits of a collaborative approach are numerous, and include allowing the most efficient use of project resources, and the generating community ownership of the project.

Length-frequency studies also provide the opportunity to further develop our knowledge of the species' biological traits. By adopting minimally-intrusive sampling techniques, samples can be collected for biological studies without having to harvest any fish. For example, the genetic structure of the fish stock can be examined by collecting small tissue samples ($<1cm^2$) from dorsal fin, and reproductive status of the fish can stock can be examined with sampled collected via cannular biopsy. This study identifies the need for further investigation of the observed genetic erosion (see

Chapter 5.4.4) and calls for further investigation of the reproductive status of black jewfish (see Chapter 5.4.1). Tag and release studies may also be continued, although based on this results of this study, a low rate of recapture should be anticipated particularly if fishers are not targeting the species as part of the management arrangement.

7.2.2.2 Medium-term research needs and objectives

I recommend that the medium-term objectives of future research on black jewfish should be to:

1) Establish the number and proximity of aggregations.

Mapping the location of aggregations of black jewfish would open numerous research and management opportunities. From a research prospective this would present opportunities to compare the common features of aggregating sites, or the timing of aggregation events. Most importantly, knowing the location of the aggregation sites would greatly increase the efficiency of future assessments by allowing effort to be allocated to the most appropriate areas (see long term recommendations below). Likewise, future management arrangements could focus on the most important areas as decreed by factors such as the size of the aggregation, its proximity to fishing grounds, and its proximity to other aggregations.

Presently, information about the spatial scale of black jewfish aggregations is scant. However, passive acoustics offer the potential to define the exact location of aggregation sites. This approach employs a series of hydrophones to triangulate the source of sound, and has proven more efficient in defining aggregation sites than traditional methods such gonad analysis or the collection of eggs, larvae or juvenile (Luczkovish et al. 1998). Sound production has been recorded in many sciaenids (e.g. Vance et al. 2002, Cruz and Lombarte 2004, Tu et al. 2004), and has been noted with black jewfish (Grant 1997). Passive acoustics has been successfully employed to identify the location of spawning areas used by the weakfish (*Cynoscion regalis*), spotted seatrout and red drum (Connaughton and Talyor 1995; Luczkovish et al. 1998, 1999).

2) Establish the broad-scale cycles of abundance at the aggregation sites.

Expanding our understanding of the temporal scale of black jewfish aggregations would complement work to undertake to map their spatial scale. Fortunately, hydroacoustics can be used not only to locate the aggregation sites, but to also reveal the cycles of abundance of soniferous fish at these sites. This approach requires the establishment and maintenance of temporary or permanently moored hydrophone stations (i.e. replacing of batteries, clearing fouling biota, etc), but otherwise provides a cost effective method of covering a network of aggregation sites. Hydroacoustics have already been successfully applied in the investigation of aggregation cycles in several sciaenids (e.g., Saucier and Baltz 1993, Connaughton and Taylor 1995).

3) Further describe the aggregating behaviour of black jewfish.

Studies focusing on aggregations of fish capitalise on the spatial compression of otherwise widespread animals, however, the absolute effect of fishing will remain difficult to assess unless the relationship between the aggregating fish and the overall population can be developed. Active acoustics (acoustic tags) hold the potential to reveal such information. They can provide information on: (1) residence times (i.e., how long individual fish stay at aggregation site/s), (2) catchment distances (i.e., how large an area do the aggregations service), and (3) participation rates (i.e., the proportion of the population participating in the aggregation).

Acoustic tags are either external or internally fitted, and emit acoustic pulses that are recorded by receivers either temporarily or permanently in situ. These active acoustic stations may utilise the same moorings adopted for the passive acoustics studies also recommended (see above). However, areas away from the aggregation sites should also be examined in order to generate information on participation rates. The tags may also be equipped with temperature or pressure sensors to reveal further information on the movement patterns of the fish. Acoustic tags have been successfully adopted in many studies of teleosts (e.g., Szedlmayer 1997, Arendt et al. 2001).

7.2.2.3 Long-term research needs and objectives

I recommend that the long-term objective of future research on black jewfish should be to:

1) ***Develop the means to rapidly assess the status of black jewfish on a broad spatial scale.***

It is imperative that an effective method of rapidly assessing the status of black jewfish is developed. The present study is a perfect example of the need for a more rapid assessment method than offered by traditional approaches. Within the period starting from when concerns regarding black jewfish were first raised in 1994, and extending through to 2000 when management responses where rapidly implemented following the release of the initial assessment, the structure of the local stock changed dramatically. In 1994, full sized adult fish (150-180 cm TL) where caught for the final time from Muttee Head, and by 2000, catches were based on one and two-year-old fish (~40-70 cm TL). The time required to initiate and conduct traditional stock assessments is too great to rely on.

Ideally, the method would be:

- Rapid and cost effective so that it may be applied across a broad spatial scale. The results of the genetic analysis presented within this thesis attest to the need of managing this species on a broad scale (see Chapter 5.4.4).
- Independent of fisheries so that it may avoid potential biases.
- Minimally intrusive so that it does not add to pressure already on the fish stock.
- Capable of meeting current and future management needs. For example, the *Fisheries (Gulf of Carpentaria Inshore Fin Fish) Management Plan 1999* states the management of aggregating fish ‘may be measured only by the abundance of juvenile target species’.

It is my view that active acoustics (sonar) holds the greatest potential to meet each of the needs listed above. Acoustic survey methods are used across the globe to provide fisheries-independent assessments of many economically importance fish stocks (e.g. Jech and Luo 2000, Axenrot and Hansson 2004). Although most commonly used to estimate the abundance of the fish in an area, active acoustics may also be used to estimate the size of the fish in the water. The potential of active acoustics deserves to be investigated as soon as the immediate and medium-term research objectives suggested above are fulfilled.

Black jewfish appear to be perfect candidates for this type of assessment, as:

1. Their location is spatially and temporally predictable, and
2. The size increments separating juvenile age classes (10 cm to 15 cm) exceeds the error margins of current size estimate studies (e.g., Yule 2000 was able to refine errors to within 5 cm).

If the medium term research objectives I listed in the section above are met, the information from these studies will allow researchers to examine a series of aggregation sites at the most appropriate times. The number and proximity of sites that would need to be visited, together with the duration and frequency of the visits, would depend on the cycles of abundance, residence times, etc.

7.3 Adoption of greater collaboration in research and management

7.3.1 Greater collaboration in environmental research

Australian fisheries have a history of being managed and monitored in cooperation with commercial and recreational fishing groups, a process which has until recently neglected the values intrinsic to Indigenous subsistence fishers. Cultural values now manifest in contemporary environmental management will be ensured by the increasing involvement of Indigenous people in fisheries management. Aquatic resource management agencies across northern Australia have a growing number Indigenous liaison staff, and have an expanding realm of Indigenous consultative committees. Although the value of holistic approaches to resource management has increasingly been recognised, the value of collaborative partnerships in fisheries research has often been ignored.

Collaborative research is based on the inclusion in the process of the study the users of the fishery, that is the fishers themselves. As the people who spend the greatest amount of time interacting with marine ecosystems, fishers hold untold knowledge of the environment and its use. Their inclusion in the research process facilitates the incorporation of their knowledge and experiences, and allows a broader assessment of the fishery to occur. For example, the involvement of the Indigenous fishers in this project not only provided historical and contemporary catch details, but also revealed the intrinsic relationship of the social, economic and cultural values of subsistence harvesting activities.

The participative approach of this study also allowed the more efficient use of the project's resources. For example, drawing on the fine scale knowledge the fishers had of the aggregating behaviour of the black jewfish, proved very useful in developing effective monitoring and sampling programs. This type of assistance is particularly useful in remote waters that are rarely visited by researchers. The voluntary nature of much of the assistance gained by this project demonstrates the willingness of fishers to contribute to scientific research. However, for collaborative research to be successful, the researcher must invest in developing a relationship with the community.

Based on my experience with this study, I recommend the following steps be undertaken in collaborative research:

- Clearly identify the issues of concern to the community to ensure the relevance of the research.
- Ensure the transmission of clear objectives so that the direction of the project is clear to all.
- Involve interested parties as far as possible in all aspects of the project.
- Provide recognition of the relevant cultural and social values held by the various groups, among other reasons to ensure appropriate methodology is adopted.
- Liaise with all of the stakeholders at all stages to ensure a politically neutral and open process.
- Ensure results are made available in transparent manner acceptable to the various groups.
- Provide an appropriate forum for the input of users and stakeholders in the development of management outcomes that result from the research findings.

I believe that the outcomes from this study would not have been achieved if a collaborative approach had not been adopted. It is my view that the black jewfish area closure was a product of the communities' understanding, participation and ownership of the research process. The comprehensive consultation process conducted as part of this partnership ensured the implications of the research findings were fully recognised by both the users and custodians of the fishery. This outcome demonstrates that mutually beneficial relationships may be developed between Indigenous communities and scientific researchers, and should serve as a catalyst for the greater involvement of Indigenous people in environmental research.

7.3.2 Greater collaboration in natural resource management

Many of the coastal clans of Australia's Aboriginal nations identify themselves as 'salt water people', and their traditional estates typically extend beyond the coastal zone and into the sea. In general, these coastal people view the sea as a cultural landscape; an extension of land, with similar inherent responsibilities (Tanna 1996). In Australia, recognition of the importance of 'land' to Aboriginal cultures is still a relatively new concept. Less than fifteen years have passed since the Australian High Court decision (*Mabo and Others -v- Queensland, 1992*) which acknowledged the native title rights of Indigenous Australians. The legal validity of Aboriginal 'sea estates' is even more recent, having been recognised only in 1998 (*Mary Yarmirr & Others -v- Northern Territory of Australia & Others, 1998*).

Following these landmark High Court decisions, the inherent rights and responsibilities of Indigenous people under customary law, are now recognised under Australia's common law (Crisp and Talbot 1999). Consequently, the rights of Indigenous peoples to utilise their traditional marine resources is central to sound coastal and marine resource administration. Exemplifying this, fisheries legislation across northern Australia now protects the welfare of Indigenous fishers by providing precedence over recreational and commercial fishers. For example, the *Fisheries (Gulf of Carpentaria Inshore Fin Fish) Management Plan 1999* states that the traditional or customary fishing needs of Aborigines and Torres Strait Islanders 'is to be achieved by measures under this plan that regulate commercial and recreational access to fin fish'. It is therefore, in the best interests of the whole community to ensure that our Indigenous subsistence fisheries are managed in an equitable and sustainable manner.

While the Indigenous population comprise only around 2% of the total population of Australia, this proportion is nonetheless growing rapidly (Australian Bureau of Statistics 2001). In the last decade, there has been a 45% increase in the number of people who identify themselves as an Indigenous Australian (Australian Bureau of Statistics 2001). There exists a multitude of reasons behind this dramatic increase. A major reason is a birth rate greater than the national average (Kinfu and Taylor 2002). Exemplifying this, 49% of the population at Injinoo was under eighteen years of age at the time this study was conducted (Aboriginal Coordinating Council 2000). It follows that in the immediate future there is the potential for a rapid increase in the fishing pressure placed upon local resources.

This notion appears more pressing when coupled with the improving economic situation among many of Australia's Indigenous communities. At Injinoo, for example, there were five powered vessels in the community in 1990, ten years later the number had increased to 42; at the same time there were 48 houses in the community. By comparison, in 1999 it was estimated that only 11% of all Queensland households owned a boat used for personal fishing (Roy Morgan Research 1999). The great importance the Indigenous community places on subsistence fishing is also substantiated by the high participation rate in activities that utilise aquatic resources. This study found that 95% of households participated in such activities, with 77% participating in the fishery at least weekly (see Chapter 4.4.1). In comparison, 33% of all Queensland households participate in fishing activities, and of these only 7% fished at least weekly (Roy Morgan Research 1999).

It times past, the Aboriginal owners of Cape York regularly monitored their land and sea country to prevent the act of trespass and unsanctioned use of resources (Rigsby and Chase 1998). Today in Northern Cape York Peninsula, the use of aquatic resources by persons outside the Traditional Owner groups is commonplace. In addition, areas recognised by the people of Injinoo as their customary maritime estate, are now controlled by State and Federal legislative regimes. However, the Indigenous community of Injinoo continues to express their strong desire to maintain their obligations to protect their customary sea estates, and ensure the sustainable use of its aquatic resources.

Unlike some of the Aboriginal communities of Cape York that are relatively isolated in the context of neighbouring resource user groups, there are four other communities in Northern Cape York Peninsula. Bilateral utilisation of resources also occurs between the people of Northern Cape York Peninsula and the adjacent Torres Strait Islands. Collectively, these communities present well-established Indigenous subsistence, recreational and commercial interests. The cooperation of each of these user groups is therefore integral to ensuring the sustainable use of local resources, and the most amicable way forward appears to be the collective development and implementation of common goals and initiatives.

While the Fisheries Research and Development Corporation funded this project, it is not practical to rely on the individual assessments to ensure the sustainable use of all harvested species (see Chapter 7.2.1.3). Instead, the custodians and users of the fishery must adopt a proactive approach to management. I recommend that Traditional Owners of Northern Cape York Peninsula build on the success of the collaborative approach of this study, and continue to build common goals and initiatives with neighbouring communities. I believe that this would be the most effective way to ensure the sustainable future of the resources utilised by all Indigenous subsistence fishers and all other user groups.

The development of the regional agreement banning the harvest of black jewfish for a period of two years (see Chapter 7.1.2.2) demonstrated that the capacity of the Traditional Owners and residents of Northern Cape York Peninsula and the adjacent Torres Strait Islands to collaborate for a common cause, thereby ensuring the sustainable future of local aquatic resources. The principal funding agency of this project, the Fisheries Research and Development Corporation, acknowledged the significance of this unique outcome. The inside cover of the agency’s 2001-2002 Annual Report lists this outcome as one of the four most significant of the year. At the time, the Fisheries Research and Development Corporation were managing a total of 768 projects (FRDC 2003).

CHAPTER 8. LITERATURE CITED

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CHAPTER 9. APPENDIXES

Appendix 1: Scientific name, common name and Injinoo Creole name of the taxa identified in the monitoring surveys

Scientific Name	Common Name	Injinoo Creole
Fish		
Acanthopagrus berda	Pikey bream	Black bream
Alectes indicus	Diamond trevally	Lady pis
Arius armiger	Cat fish	Moustach catpis
Atherinomorus ogilbyi	Hardyhead	Beat pis
Caesio cuning	Red-bellied fusilier	China pis
Carangoides and *Caranx* spp.	Trevally	Whitepis
Cephalopholis boenack	Brown-banded cod	Black Australia
Chirocentrus dorab	Wolf herring	Ribbin pis
Choerodon albigena	Blue tuskfish	Duckal bila
Choerodon schoenleinii	Blue-spot tuskfish	Blue pis
Choerodon spp.	Tuskfish	Bila
Cymbacephalus and Platycephalus spp.	Flathead	Kuadal tobu
Decapterus spp.	Scad	Hazee
Diagramma pictum	Blackall	Whopper pis
Eleutheronema tetradactylum	Blue threadfin	Threadfin
Elops hawaiensis	Giant herring	Bone pis
Epinephelus fasciatus	Black-tipped cod	Red Australia
Epinephelus quoyanus	Long-finned cod	Rock cod
Family Hemiramphidae	Garfish	Jarberr
Family Mugilidae	Mullet	Mouragoudarle
Hemiramphus far	Black-barred garfish	Tatoo jarberr
Herklotsichthys spp.	Herring	Sardine
Lates calcarifer	Barramundi	Barramundi
Lethrinus spp.	Sweetlip	Snapper
Lutjanus argentimaculatus	Mangrove jack	Mangrove jack

Scientific Name	**Common Name**	**Injinoo Creole**
Lutjanus carponotatus	Stripey	Thorre
Lutjanus russelli	Moses perch	Warmmindenu
Lutjanus sebae	Red emperor	Emperor
Lutjanus spp.	Snappers	Tanicke
Lutjanus vitta	Striped sea-perch	Stripey
Megalops cyprinoides	Tarpon	Bone pis
Monodactylus argenteus	Butter-bream	Plate pis
Neoniphon sammara	Blood-spot squirrel-fish	Big eye greedy pis
Platax novaemaculatus	Short-finned batfish	Butterpis
Plectorhynchus flavomaculatus	Gold-spot blubber lips	Kuikumark
Plectropomus and *Variola* spp.	Coral trout	Withy
Plectropomus maculatus	Bar-cheeked coral trout	Blue-spot withy
Polynemus sheridani	King threadfin	Threadfin
Pomacanthus sexstriatus	Six-banded angelfish	Pokerpis
Pomadasys spp.	Grunter	Grunter
Protonibea diacanthus	Black jewfish	Jewpis
Rachycentron canadus	Cobia	Pilot pis
Rhabdosargus sarba	Tarwhine	Silver bream
Sargocentron rubrum	Red squirrel fish	Blad pis
Scarus spp.	Parrot fish	Blue bone
Scleropages jardini	Saratoga	Jardine
Scolopsis mongramma	Barred-face spinecheek	China pis
Scomberoides commersonianus	Queenfish	Queenpis
Scomberomorus commerson	Spanish mackerel	Mackerel
Scomberomorus munroi	Spotted mackerel	Dabore
Selenotoca multifasciata	Stripped butterfish	Karramiue
Siganus doliatus	Barred spinefoot	Parraser
Siganus lineatus	Golden-lined spinefoot	Hajame
Siganus rivulatus	Spotted spinefoot	Quebeam
Sillago spp.	Whiting	One dunge
Sphyraena barracuda	Barracuda	Barracuda
Terapon and *Pelates* spp.	Banded trumpter	Greedy pis
Toxotes chatareus	Archerfish	Boat pis

Scientific Name	Common Name	Injinoo Creole
Trachinotus blochi	Snub-nosed dart	Pumken head
Tylosurus acus melanotus	Longtom	Biyage
Sharks		
Carcharhinus amblyrhynchos	Silver shark	Not identified
Carcharhinus melanopterus	Black-tip reef shark	Poury
Stingrays		
Pastinachus sephen	Cowtail ray	Flat tail ray
Himantura granulata	Mangrove ray	Pelcup
Marine mammals		
Dugong dugon	Dugong	Dangal
Aquatic reptiles		
Chelonia mydas	Green turtle (adult)	Waru
Chelonia mydas	Green turtle (eggs)	Waru kakur
Eretmochelys imbricata	Hawksbill turtle (eggs)	Unuwa kakur
Family Chelidae	Long necked tortoise	Not identified
Natator depressus	Flatback turtle (eggs)	Wane kakur
Crustaceans		
Panulirus spp.	Crayfish	Caxyurr
Portunus pelagicus	Sand crab	Not identified
Scylla serrata	Mud crab	Gitalige or Gorrbar
Molluscs		
Anadara sp.	Mud cockle	Not identified
Pinctada margaretifera	Blacklip oyster	Not identified

Appendix 2: Results of the interview style survey

Date: December 1998 **Number of households surveyed:** 44

Sex of household the representative surveyed:	Male	64%
	Female	36%

Question 1: Should monitoring of subsistence fishing commence in your community?

A) Yes 98%

B) No 2%

Question 2: Should the monitoring surveys examine:

A) Fish	0%
B) Dugong	0%
C) Turtle	0%
D) Crustaceans	0%
E) All of the above	100%

Question 3: Where would you prefer the monitoring of aquatic resources to occur?

A) On site at your fishing spot while you are fishing	30%
B) At a road-side interview station	43%
C) At your house when you come back from fishing	27%

Question 4: Are there any cultural protocols that must be adhered to while conducting monitoring surveys?

A) At the fishing spot	Nil identified
B) At a road-side station	Nil identified
C) At a household	Nil identified

Question 5: Who would you prefer to conduct the monitoring surveys? Please indicate male or female if preferred:

A) An Indigenous person;	82%
1. Any Indigenous person from Injinoo	59%
2. Any Indigenous person	0%
3. Leading member of your clan	0%
4. Leading member of another clan	0%
5. Any community person of your clan	14% (4% male)
6. Any community ranger	9% (7% male)
7. Any council employee of Injinoo	0%
8. Government person from outside	0%
B) A non-Indigenous person;	2%
1. Any non-Indigenous person	2%
2. Council employee	0%
3. Regional agency employee	0%
C) Any non-Indigenous or Indigenous person	5%
D) One non-Indigenous and one Indigenous person	11%

Appendix 3: Results of the door to door survey

Date: December 1998 **Number of households surveyed:** 44

Sex of the household representative surveyed: Male 64%

Female 36%

Question 1: Has anyone in this household participated in fishing, hunting, or gathering activities, within the last 12 months?

A) Yes 95%

B) No 5%

Question 2: Did the person/s participate in these activities for subsistence purposes?

A) Yes 100%

B) No 0%

Question 3: Did the person/s participate in these activities for fun?

A) Yes 9%

B) No 91%

Question 4: What is the primary use of the catch?

A) Self consumed 2%

B) Immediate family share 27%

C) Extended family share 68%

D) General community share 13%

E) Other; e.g., bait. 0%

Question 5: How often the person/s participate in these activities?

A) Daily (3-7 times/week) 14%

B) Weekly (1-2 times/week) 67%

C) Monthly (once a month) 19%

Question 6: What is the average duration of these activities?

A) Day	100%
B) Two to three days	0%
C) More than three days	0%

Question 7: Did that person/s participate in these activities:

A) Alone	5%
B) As part of a group	95%

Question 8: How many members where there in the group/s on average?

A) Two	14%
B) Three	24%
C) Four	19%
D) Five	24%
E) More than five	19%

Question 9: What equipment did the person/s use?

A) Handline	100%
B) Fishing rod	0%
C) Hand spear	86%
D) Spear gun	24%
E) Gill net	71%
F) Cast/bait net	0%
G) Fish trap	0%
H) Crab pot/cage	2%
I) Others	0%

Question 10: Does anyone in this household own a seaworthy boat?

A) Yes	61%
B) No	39%

Question 11: Does anyone in this household own a car?

A) Yes	69%
B) No	31%

Appendix 4: Documented lunar periodicity in aggregations of tropical teleosts

Species	Location	Moon phase	Spawning	Source
Acanthurus coeruleus (Acanthuridae)	Puerto Rico	Full moon (peak) to new moon	Observed	Colin and Clavijo (1988)
Casesio teres (Caesionidae)	Marshall Islands	Full moon	Observed 1 day before and on the second after full moon	Bell and Colin (1986)
Crenimugil crenilabis (Mugilidae)	Saipan, Palau, and Chuuk	Full moon or new moon	Believed to be concurrent from gonad state observed	Johannes (1981)
Epinephelus fuscoguttatus (Serranidae)	Palau	1 to 7 days prior to new moon (peak)	Believed to be concurrent from gonad state	Johannes et al. (1999)
Epinephelus guttatus (Serranidae)	St Thomas, U.S. Virgin Islands	Full moon	Believed to be concurrent from gonad state observed	Beets and Friedlander (1998)
Epinephelus guttatus (Serranidae)	Puerto Rico	Full moon or new moon	Believed to be concurrent from gonad state observed	Sadovy et al. (1994)
Epinephelus guttatus (Serranidae)	Puerto Rico	Full moon	Believed to be concurrent	Shapiro et al. (1993)
Epinephelus guttatus (Serranidae)	West Indies	Full moon	Observed 1 day after full moon	Colin et al. (1987)
Epinephelus guttatus (Serranidae)	Virgin Islands	Full moon	Believed to be concurrent from gonad state observed	Olsen and LaPlace (1978)
Epinephelus itajara	Gulf of Mexico	Full moon	Observed day of full moon	Colin (1994)

(Serranidae)				
Epinephelus polyphekadion (Serranidae)	Palau	3 to 6 days prior to new moon (peak)	Believed to be concurrent from gonad state observed	Johannes et al. (1999)
Epinephelus striatus (Serranidae)	Cayman Islands	Full moon	Observed 2 days before and 19 days after full moon	Tucker et al. (1993)
Epinephelus striatus (Serranidae)	Bahamas	Full moon	Observed 1 day prior until 3 days after full moon	Colin (1992)
Epinephelus striatus (Serranidae)	West Indies	Full moon	Believed to be concurrent from gonad state observed	Colin et al. (1987)
Epinephelus striatus (Serranidae)	Virgin Islands	Full moon	Believed to be concurrent from gonad state observed	Olsen and LaPlace (1978)
Lutjanus analis (Lutjanidae)	Florida and West Caicos	Three days over full moon period	Believed to be concurrent from gonad state observed	Domeier and Colin (1997)
Lutjanus cyanopterus (Lutjanidae)	Florida Keys	Full moon to last quarter	Believed to be concurrent from gonad state observed	Domeier and Colin (1997)
Lutjanus jocu (Lutjanidae)	Belize	Full moon to last quarter	Believed to be concurrent from gonad state observed	Domeier and Colin (1997)
Mycteroperca bonaci (Serranidae)	Florida Keys	Full moon and new moon	Observed courting behaviour	Eklund et al. (2000)
Mycteroperca tigris (Serranidae)	Puerto Rico	Full moon	Observed on day of full moon	Sadovy et al. (1994)

Plectropomus areolatus (Serranidae)	Palau	2 to 6 days prior to new moon (peak)	Believed to be concurrent from gonad state observed	Johannes et al. (1999)
Plectropomus areolatus (Serranidae)	Solomon Islands	Last quarter moon	Believed to be concurrent from gonad state observed	Johannes (1988)
Plectropomus leopardus (Serranidae)	Great Barrier Reef	New moon	Observed (no details of timing provided)	Samoilys (1997)
Siganus canaliculatus (Siganidae)	Palau	Following full moon	Believed to be concurrent from gonad state	Hasses et al. (1977)

Appendix 5: Results of the genetic analysis

Estimates of genetic diversity and gene flow among samples from 2 populations of black jewfish sampled in 1999 based on Nei (1987) estimates of gene diversity in subdivided populations.

Locus banding position	**Sample size**	**Total heterozygosity**	**Average heterozygosity**	**Diversity between populations**	**Gene flow**
E-ACC, M-CAC primer pair					
.1	50	0	0		
.2	50	0	0		
.3	50	0.259	0.258	0.007	70.251
.4	50	0	0		
.5	49	0.450	0.423	0.061	7.689
.6	50	0.176	0.157	0.108	4.099
.7	50	0	0		
.8	50	0.467	0.466	0.001	312.113
.9	50	0	0		
.10	50	0	0		
.11	49	0.479	0.474	0.010	48.662
.12	50	0.060	0.059	0.004	111.559
.13	50	0	0		
.14	50	0.098	0.098	0.003	152.610
.15	50	0	0		
.16	50	0	0		
.17	50	0.225	0.224	0.007	68.820
.18	50	0	0		
.19	50	0.038	0.037	0.020	24.490
.20	50	0	0		
.21	50	0.368	0.287	0.219	1.774
.22	50	0.456	0.449	0.015	31.857
.23	50	0	0		
.24	50	0	0		

.26	50	0	0		
.27	50	0.496	0.423	0.145	2.931
.28	50	0	0		
.29	50	0	0		
.30	50	0.057	0.055	0.030	15.818
.31	50	0.098	0.098	0.003	152.610
.32	50	0.481	0.443	0.079	5.764
.33	50	0	0		
.34	50	0	0		
.35	50	0	0		
.36	50	0	0		
.37	50	0.152	0.151	0.004	112.452
.38	50	0	0		
.39	50	0.176	0.157	0.108	4.099
.40	50	0	0		
.41	50	0	0		
.42	50	0	0		
.43	50	0	0		
.1	50	0	0		
.2	50	0	0		
.3	50	0	0		
.4	50	0.446	0.446	0.009	632.307
.5	50	0	0		
.6	50	0	0		
.7	51	0	0		
.8	49	0.374	0.363	0.029	16.671
.9	50	0	0		
.10	50	0	0		
.11	50	0	0		
.12	50	0	0		
.13	50	0	0		
.14	50	0	0		
.15	50	0.483	0.467	0.033	14.541
.16	50	0	0		
.17	50	0	0		

.18	50	0	0		
.19	50	0.499	0.490	0.017	28.176
.20	51	0	0		
.21	51	0	0		
.22	51	0	0		
.23	51	0	0		
.24	51	0	0		
.25	51	0	0		
.26	51	0	0		
.27	51	0	0		
.28	51	0.477	0.471	0.012	40.778
.29	51	0.496	0.496	0.000	760.047
.30	51	0	0		
.31	51	0	0		
.32	51	0	0		
.33	51	0	0		
.34	51	0	0		
.35	51	0	0		
.36	51	0	0		
.37	51	0	0		
.38	51	0	0		
.39	51	0	0		
.40	51	0	0		
.41	51	0	0		
E-AAT, M-CTA primer pair					
.1	50	0	0		
.2	48	0.405	0.402	0.009	55.217
.3	46	0	0		
.5	50	0	0		
.6	48	0	0		
.8	50	0	0		
.9	50	0	0		
.10	50	0	0		
.11	50	0	0		
.12	50	0	0		

.13	49	0	0		
.14	48	0.451	0.446	0.012	41.214
.15	48	0.447	0.428	0.042	11.214
.16	50	0	0		
.17	50	0.320	0.320	0.0001	0
.18	50	0.019	0.019	0.009	50.495
.19	50	0	0		
.20	50	0	0		
.23	48	0.371	0.367	0.009	51.448
.24	50	0	0		
.25	49	0.463	0.432	0.066	6.987
.26	50	0	0		
.27	50	0	0		
.28	50	0	0		
.29	50	0	0		
.30	50	0	0		
.31	48	0.424	0.408	0.038	12.407
.32	50	0.478	0.404	0.154	2.741
.33	50	0.487	0.474	0.026	18.454
.34	49	0.079	0.078	0.010	47.131
.35	48	0.491	0.476	0.030	15.801
.36	49	0.490	0.488	0.003	135.94
.37	50	0	0		
.38	50	0.176	0.157	0.108	4.099
.39	50	0.241	0.241	0.002	192.056
.40	48	0.476	0.406	0.146	2.918
.41	50	0	0		
.42	48	0.471	0.470	0.003	157.155
.44	50	0.496	0.459	0.074	6.250
.45	50	0	0		
.46	49	0.499	0.448	0.101	4.429
.47	50	0	0		
.48	50	0	0		
Mean	50	0.116	0.110	0.046	10.210
St. Dev		0.036	0.032		

Appendix 6: List of publications and presentations resulting from this study

Publications

1	Author	Phelan M.J.
	Year	*In press*.
	Title:	Tropical fish aggregations in an Indigenous environment in northern Australia: An example of successful outcomes through collaborative research.
	Publication:	Blackwell Science Publications.
2	Author	Phelan M.J.
	Year:	2005.
	Title:	Fishery biology and management of black jewfish, *Protonibea diacanthus*, (Sciaenidae) aggregations near Injinoo Community, far northern Cape York. Stage 2: Management needs following the two year closure implemented under a regional agreement.
	Publication:	Report to Injinoo Aboriginal Community and the Fisheries Research Development Corporation.
	No. of pages:	52.
3	Author	Phelan M.J.
	Year:	2003.
	Title:	Development, outcomes, and future of an area closure implemented by the Indigenous communities of Northern Cape York Peninsula.
	Publication:	Proceedings of the World Congress on Aquatic Protected Areas. Cairns, Australia 2002.
	No. of pages:	7
4	Author	Phelan M.J.
	Year:	2003.
	Title:	Sciaenid aggregations in Northern Australia: An example of successful outcomes through collaborative research.
	Publication:	Putting Fisher's Knowledge to Work, Conference Proceedings. Vancouver, Canada, August 2001.
	No. of pages:	9
5	Author	Phelan M.J.
	Year:	2002.

	Title:	Fishery biology and management of black jewfish, Protonibea diacanthus, (Sciaenidae) aggregations near Injinoo Community, far northern Cape York. Stage 1: Initial characterisation of the aggregations and associated fishery.
	Publication:	Report to Injinoo Aboriginal Community and the Fisheries Research Development Corporation.
	No. of pages:	76
6	Author	Phelan M.J.
	Year:	2002.
	Title:	Indigenous subsistence fishing survey. Injinoo Aboriginal Community, far northern Cape York Peninsula.
	Publication:	Report to Injinoo Aboriginal Community and the Fisheries Research Development Corporation.
	No. of pages:	74

Presentations

1	Presenter:	Phelan M.J.
	Year:	2005.
	Title:	The Indigenous Subsistence Fishing Survey Kit: Monitoring Indigenous subsistence fisheries on a community scale.
	Venue:	Australian Society for Fish Biology Conference, Darwin.
	Purpose:	Presentation of final results to peers.
2	Presenter:	Phelan M.J.
	Year:	2004.
	Title:	Sciaenid aggregations in an Aboriginal environment: Outcomes of a community developed closure.
	Venue:	Australian Society for Fish Biology Conference, Adelaide.
	Purpose:	Presentation of final results to peers.
3	Presenter:	Phelan M.J.
	Year:	2004.
	Title:	Managing coastal and marine resources.
	Venue:	Northern Territory University, Darwin.
	Purpose:	Presentation during intensive course.
4	Presenter:	Phelan M.J.

	Year:	2004.
	Title:	Indigenous Subsistence Fishing in Northern Cape York
	Venue:	James Cook University, Townsville.
	Purpose:	Exit seminar.
5	Presenter:	Phelan M.J.
	Year:	2002.
	Title:	Development, outcomes, and future of an area closure implemented by the Indigenous communities of Northern Cape York Peninsula.
	Venue:	World Congress on Aquatic Protected Areas, Cairns
	Purpose:	Presentation of preliminary results to peers.
6	Presenter:	Phelan M.J.
	Year:	2001.
	Title:	Sciaenid aggregations in Northern Australia: An example of successful outcomes through collaborative research.
	Venue:	International Conference on Putting Fisher's Knowledge to Work. Vancouver, Canada.
	Purpose:	Presentation of preliminary results to peers.
7	Presenter:	Phelan M.J.
	Year:	2000.
	Title:	Presentation of the preliminary results.
	Venue:	Injinoo Community Hall.
	Purpose:	Public meeting to discuss management options for black jewfish.
8	Presenter:	Phelan M.J.
	Year:	2000.
	Title:	Presentation of the preliminary results.
	Venue:	Injinoo Community Hall.
	Purpose:	To discuss management options with Traditional Owners.
9	Presenter:	Phelan M.J.
	Year:	2000.
	Title:	Presentation of the preliminary results.
	Venue:	Injinoo Aboriginal Community Council.
	Purpose:	To discuss management options with Community Council.

Appendix 7: Amendments made to the *Fisheries Regulation Queensland 1995* in 2002 as a result of this research

Schedule 2, Section 46A: Waters adjacent to north Cape York

(1) Waters within the following boundary -

- from where latitude 10º 44.97' south intersects the mainland shore at Fly Point to where longitude 142º 37.26' east intersects the southern tip of Albany Island
- along the southern and western shore of Albany Island to where latitude 10º 42.96' south intersects the shore at the Island's north-western tip
- to the navigational light on Eborac Island, approximately at latitude 10º 40.95' south and longitude 142º 31.96' east
- to where longitude 142º 24.40' east intersects the northern tip of Possession Island
- along the northern and eastern shores of Possession Island to where longitude 142º 23.16' east intersects the shore at the Island's southern tip
- to the intersection of latitude 10º 52.87' south with the eastern shore of Woody Wallis Island
- to where longitude 142º 06.56' east intersects the northern shore of Crab Island along the western shore of Crab Island to where longitude 142º 06.46' east intersects the shore at the Island's southern tip
- to where latitude 10º 59.84' south intersects the mainland shore south of Slade Point along the mainland shore in a northerly and easterly direction to where latitude 10º 44.97' south intersects the mainland shore at Fly Point

(2) Subsection (1) applies only to black jewfish.

Schedule 3, Section 44A: Waters adjacent to north Cape York

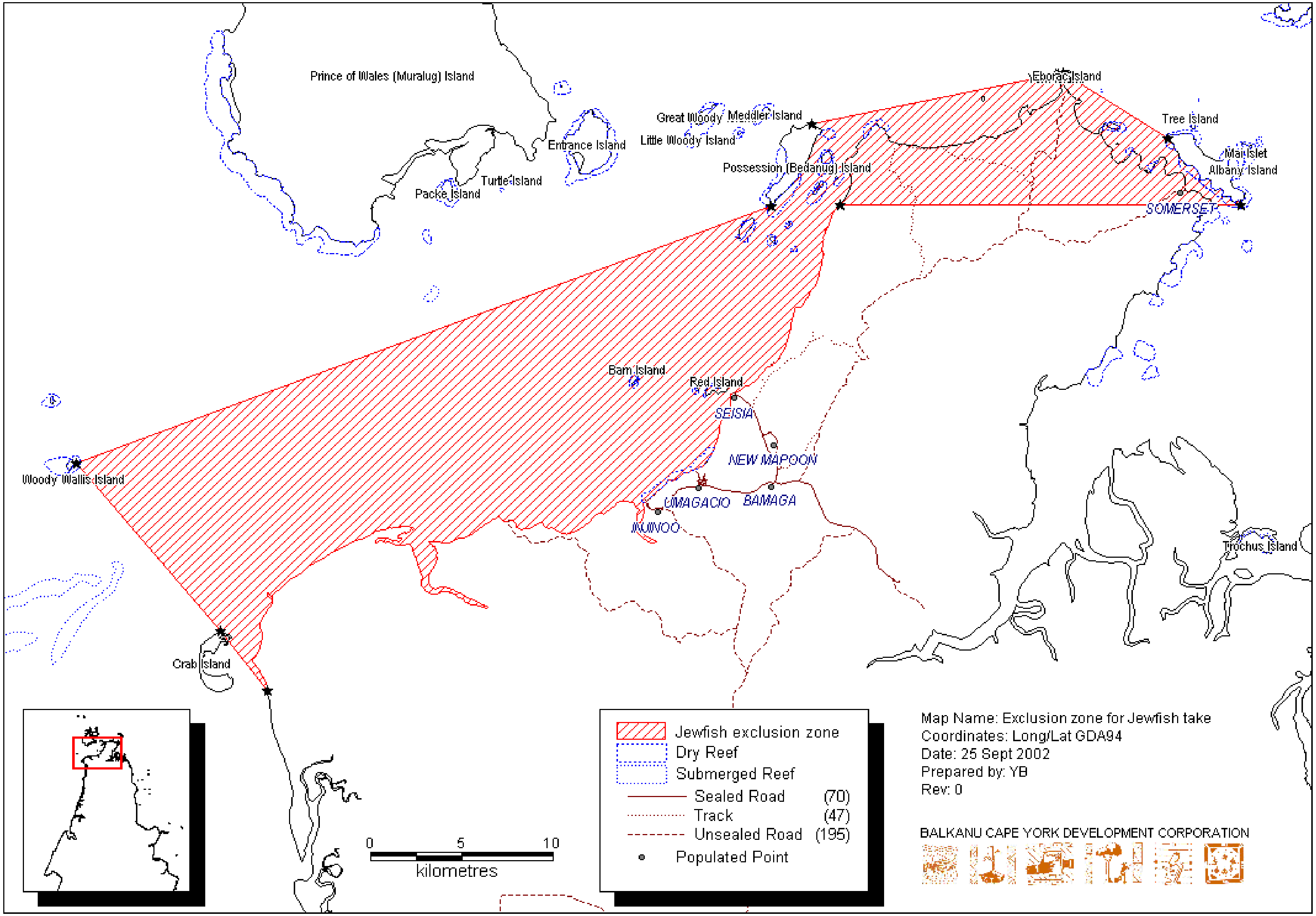
(3) Waters within the following boundary -

- from where latitude 10º 44.97' south intersects the mainland shore at Fly Point to where longitude 142º 37.26' east intersects the southern tip of Albany Island
- along the southern and western shore of Albany Island to where latitude 10º 42.96' south intersects the shore at the Island's north-western tip
- to the navigational light on Eborac Island, approximately at latitude 10º 40.95' south and longitude 142º 31.96' east
- to where longitude 142º 24.40' east intersects the northern tip of Possession Island

- along the northern and eastern shores of Possession Island to where longitude 142º 23.16' east intersects the shore at the Island’s southern tip
- to the intersection of latitude 10º 52.87' south with the eastern shore of Woody Wallis Island
- to where longitude 142º 06.56' east intersects the northern shore of Crab Island along the western shore of Crab Island to where longitude 142º 06.46' east intersects the shore at the Island’s southern tip
- to where latitude 10º 59.84' south intersects the mainland shore south of Slade Point along the mainland shore in a northerly and easterly direction to where latitude 10º 44.97' south intersects the mainland shore at Fly Point.

(2) Subsection (1) applies only to black jewfish.

A MAP OF THESE COORDINATES IS PROVIDED ON THE NEXT PAGE.


Prince of Wales (Muralug) Island
Entrance Island
Turtle Island
Packe Island
Great Woody
Meddler Island
Little Woody Island
Possession (Bedanug) Island
Eborac Island
Tree Island
Mai Islet
Albany Island
SOMERSET
Bam Island
Red Island
SEISIA
NEW MAPOON
UMAGACIO
BAMAGA
INJINOO
Trochus Island
Woody Wallis Island
Crab Island
0
5
10
kilometres
Jewfish exclusion zone
Dry Reef
Submerged Reef
Sealed Road (70)
Track (47)
Unsealed Road (195)
Populated Point
Map Name: Exclusion zone for Jewfish take
Coordinates: Long/Lat GDA94
Date: 25 Sept 2002
Prepared by: YB
Rev: 0
BALKANU CAPE YORK DEVELOPMENT CORPORATION