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.

January 2002

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FRDC PROJECT NUMBER 98/135

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Fishery Biology and Management of Black Jewfish *Protonibea diacanthus* (Sciaenidae) Aggregations near lnjinoo Community, far northern Cape York.

Stage 1: Initial Characterisation of the Aggregations and Associated Fishery.

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98/135 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.

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OBJECTIVES:

1. To collate available historical data on the fishery to establish trends over time.

2. To undertake a preliminary survey of the fishery for Black Jewfish in Injinoo Community waters, far northern Cape York. To characterise the Black Jewfish fishery of the NPA in terms of catch and effort by the various user groups through on-ground surveys.

3. To characterise the annual Black Jewfish aggregation events in terms of the time of formation and dispersal, reproductive status and resource condition.

4. To determine the level of genetic relatedness among individuals, identification of population differentiation and gene flow in Black Jewfish in the waters adjacent to the NPA, Gulf of Carpentaria and northern East Coast of Queensland.

5. To advise the Injinoo Community and the Queensland Fisheries Service on current resource condition, sustainability indicators for long term monitoring in the fishery, and options for management on a sustainable basis.

NON-TECHNICAL SUMMARY:

OUTCOMES ACHIEVED

The comprehensive consultation process conducted throughout the lifetime of this project ensured the implications of the research have been recognised by the fisheries management authorities and the communities of the Northern Peninsula Area (NPA). In response to the findings of the present project, the Injinoo Land Trust (representing the Traditional Land Owner Groups of the Anggamuthi, Atambaya, Gudang and Yadhaykenu Aboriginal people), in cooperation with the Injinoo Community Council, have self-imposed a two-year ban on the taking of Black Jewfish (*Protonibea diacanthus*). The area of closure incorporates the inshore waters of the NPA north of the southern boundaries of Crab Island (on the West Coast) and Albany Island (on the East Coast).

The aim of the two-year ban is to allow local stocks of Black Jewfish to reach a mature size with an objective of improving the reproductive capacity. With much consultation, this initiative has developed into a regional agreement with comprehensive support across the NPA. Representing each of the communities of the NPA, the Community Councils of Umagico, Bamaga, New Mapoon and Seisia, have undertaken to participate in the two-year ban on the take of Black Jewfish. Further, Torres Shire and the Kaurareg Nation based on Horn Island are also signatories to the ban. Proprietors and operators of all tourist accommodation and fishing charter boats operating in the NPA region have also pledged full cooperation with the initiative.

Adding to the uniqueness of this self-imposed management arrangement, the elected Chairmen of these Indigenous communities have asked for legislative backing for this species-specific ban. Each of the Indigenous communities have expressed a willingness to forfeit their statutory exemption to the relevant catch restrictions. The Queensland Fisheries Service is well informed of the local stock condition and associated public expectation. Their Senior Fisheries Manager, Mr Mark Elmer, has assessed first-hand the situation having visited the NPA at the time of the development of the regional agreement. The outcomes appear unique among Australian fisheries, being the only example we know of in the modern context in which Indigenous communities have initiated the long-term ban on harvest of a fish species.

Anecdotal evidence suggests intensive fishing effort has severely impacted on several annual aggregations of Black Jewfish along the East Coast of Queensland (Bowtell 1994, Bowtell 1998). The apparent recent increase in effort targeting Black Jewfish in far northern Cape York Peninsula (CYP), has prompted concerns from the Injinoo community, which has custodial responsibilities for that stock, and from the Queensland Fisheries Service, who must provide for managing fisheries in Queensland on a sustainable basis. Aggregations of Black Jewfish, which form annually off Muttee Head (situated on the north-west coast of the NPA), have been exploited by Indigenous subsistence fishers for over fifty years.

The tendency of Black Jewfish to aggregate annually in large numbers at well defined times and locations, appears to facilitate the harvest of the species. In 1999, 88% of the recorded annual catch of Black Jewfish in the NPA (3.91 tonnes) occurred between April and August, the period in which historical accounts suggest Black Jewfish aggregate in the area. In 2000, 89% of the recorded annual catch (4.46 tonnes) occurred between May and September. Catches in 1999 and 2000 commonly exceeded 50 Black Jewfish per boat, and Catch Per Unit Effort (CPUE) ranged up to 224.5 kg boat h^{-1}. The relative ease of catching Black Jewfish when aggregating may render them susceptible to over-exploitation.

In 2000, the Black Jewfish caught at Muttee Head were significantly ($P<0.001$) smaller than those caught at the site in the 1999. Catch records demonstrated that the fishery in 1999 was dominated by fish 700-800 mm TL (believed to be three-year-old fish), and in 2000, the dominant size class was 590-690 mm TL (believed to be two-year-old fish). Historical records reveal specimens close to the maximum size (>1500 mm TL) were being caught up until 1994. These data support the notion of a rapid change in the NPA Black Jewfish resource, and warrants concern for the state of the resource given that the fishery was previously based on adult stock.

Sexually mature Black Jewfish comprised only a small component (12 fish out of 270 = 4.4%) of the NPA catch examined in a sampling program that was biased towards the largest individuals available. The present study observed a minimum size at first maturity of 790 mm TL for female Black Jewfish. This represents a departure from the previous observed first length of maturity in Queensland waters of 920 mm TL, reported by McPherson (1997). Sexually mature ovaries were observed in specimens sampled from aggregations formed in the waters of CYP in the period between May and September 2000. However, no ripe or spent gonads were found in the present study, so the timing and location of the spawning season in northern Australian waters remains unknown.

Food items observed in the analysis of the diet of Black Jewfish include a variety of teleosts and invertebrates. The range of animal taxa represented in the prey items support the description of an 'opportunistic predator' attributed to the species by Rao (1963). The limited data gained in this study presents no evidence to support the notion that the seasonal 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 did not contrast from that observed outside of the aggregations periods.

The tag and release component of the present study provided limited data on the movement patterns of individual Black Jewfish in the NPA waters. Tag returns provide that some of the fish remain at, or return to, the aggregation site at least into the following day. The recaptures also revealed the movement of an individual fish between two distinct aggregation sites. If this behaviour is normal for Black Jewfish, this activity may increase the susceptibility of the species to capture during the aggregation period. Since tag returns were scant, this interpretation must be treated with caution. The low rate of tag returns (2.6%) from the wild stock tagging program contrasted with the high retention rate of tags and the zero mortality of the captive program.

DNA fingerprinting of Black Jewfish demonstrated that the genetic identity and stock structure can be determined using the novel Amplified Fragment Length Polymorphisms (AFLP) technique. The Black Jewfish stock sampled from CYP and the Northern Territory appear to comprise one homogeneous population (G_{ST} 0.046). No significant genetic variation was revealed between Black Jewfish sampled from Muttee Head and Peak Point, suggesting that the adjacent aggregation sites are utilised by the same genetic stock. The AFLP technique proved itself as a robust technique of direct DNA analysis with many advantages available to fisheries science.

The species-specific area closure that developed as a result of the findings of the research presents many unique opportunities and obligations for research and management agencies alike. Parties to the regional agreement of the NPA each recognise that the two-year closure may not provide adequate time for the complete recovery of the proportion of the adult fish in the population. Continued investigation of the local stock has been requested by all parties in order that decision-makers will be adequately informed to review management needs at the conclusion of the two-year period. This situation provides a rare opportunity to quantify the response of an over-exploited population granted a temporary relief from fishing pressure.

KEYWORDS: Aggregations, Black Jewfish, Biology, Harvest, Indigenous Fishing.

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LIST OF ACRONYMS

CPUE	Catch Per Unit Effort
CYP	Cape York Peninsula
FRDC	Fisheries Research Development Corporation
GOC	Gulf of Carpentaria
NPA	Northern Peninsula Area
TL	Total Length

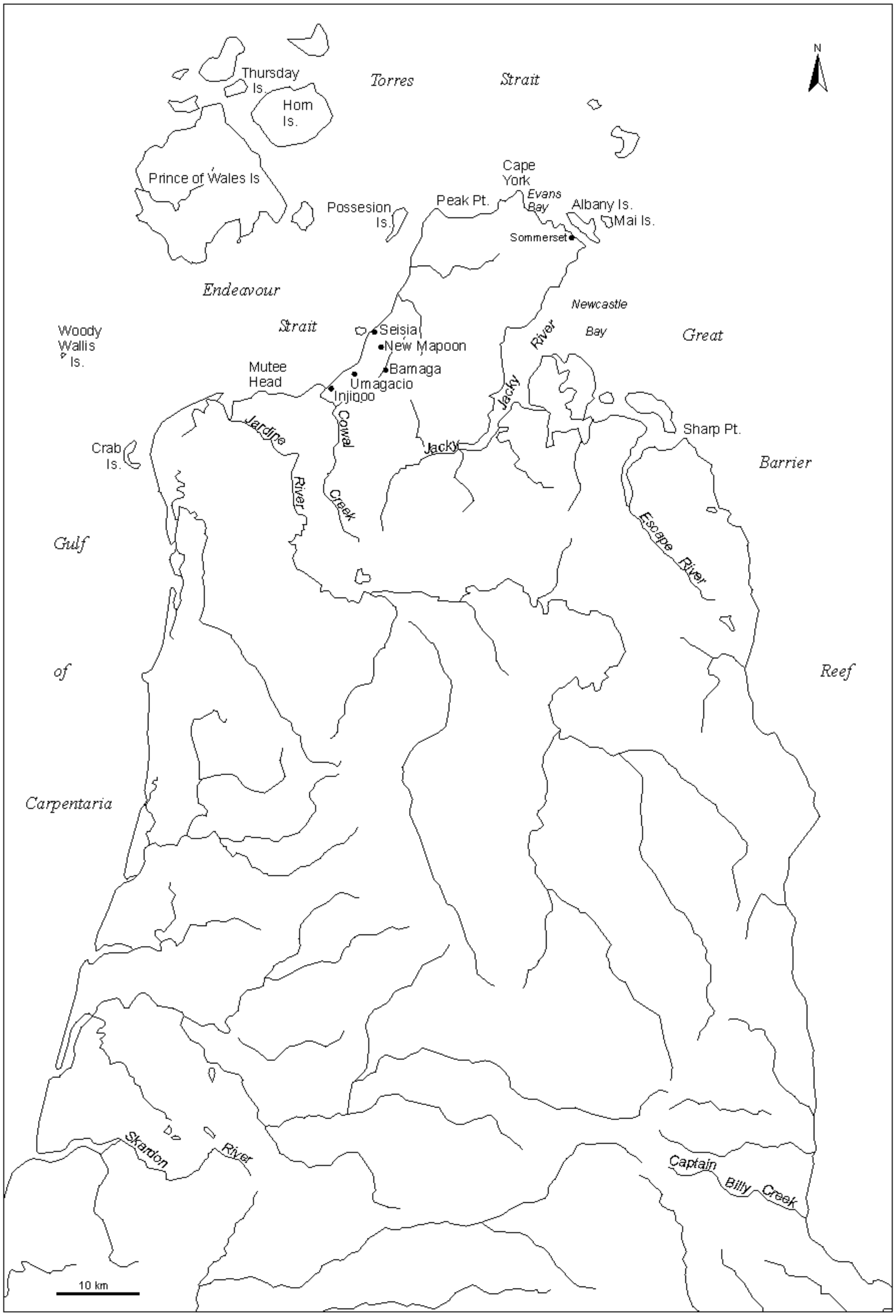


Figure 1. Map of the Northern Peninsula Area.

1. INTRODUCTION

1.1 BACKGROUND

The Black Jewfish, *Protonibea diacanthus*, is an important component of the inshore gillnet fishery catch in the Gulf of Carpentaria (GOC). However, commercial catches of the Black Jewfish in the GOC have declined dramatically in recent years, from 37 t in 1990 to 12 t in 1995 (Williams 1997). Over the same period, Black Jewfish have increasingly become the focus of line-fishing effort in northern Australia, especially during the mid-year aggregations that have been reported at a number of locations (McPherson 1997).

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 fin fish in Queensland is obtained through the targeting of aggregations formed for migration, feeding or spawning (Beumer *et al.* 1997).

In many tropical marine species, the intensive fishing of aggregations has had demonstrated negative effects on the proportion of reproductively active fish and consequent future fishery yields (Olsen and LaPlace 1978, Shapiro 1987, Colin 1992, Sadovy 1994, Zeller 1998, Johannnes *et al.* 1999). Sustained fishing pressure has been attributed to the disappearance of the annual aggregations of several tropical fin fish species (Olsen and LaPlace 1979, Carter 1989, Beets and Friedlander 1992, Colin 1992, Sadovy 1993, Coleman *et al.* 1996, Aguilar-Perera and Aguilar-Davila 1996).

The apparent heavy exploitation in recent years of the annual Black Jewfish aggregations formed off Muttee Head, in northern CYP, has prompted concerns from the Injinoo community, which has custodial responsibilities for that stock, and from the Queensland Fisheries Service, who must provide for managing fisheries in Queensland on a sustainable basis. Black Jewfish are currently exploited in the NPA by local Indigenous subsistence fishers, local and transient recreational fishers, and by tourist anglers from all over Australia and the world.

From a resource management perspective, there is a dearth of information on northern Australia's Black Jewfish and the demands made on those stocks by the various fishery sectors. The biological basis and importance of the annual aggregations of Black Jewfish is yet to demonstrated, as is the location and period in which Black Jewfish spawn in Australian waters. Further, the genetic stock structure of the species across its Australian distribution requires investigation. Fishery harvest data for the species are limited. In particular the contribution of Indigenous subsistence fishers to the total catch is unknown.

1.2 NEED

The reason for the decline in the total annual catch of Black Jewfish in the GOC Set Net fishery is unclear (Williams 1997). The reduction in the GOC catches does not appear to be unique, with anecdotal evidence suggesting catches of Black Jewfish on the Capricorn and Central Coasts of Queensland have also declined over a number of years (Bowtell 1994, 1998). Exemplifying the acute effects of population decline, the once flourishing fishery for Black Jewfish along the Gujarat-Maharashtra coast of north-west India has recently become non-existent (James 1992).

It appears Black Jewfish may possess life-history characteristics which render them particularly vulnerable to over-exploitation. The species appears to form spatially and temporally predictable aggregations, which may facilitate increased fishing effort. Because intensive fishing of aggregations may seriously compromise the viability of fish stocks, they should be accorded particular attention for research and management (Sadovy 1996).

Indigenous, recreational and commercial fishers all derive benefit from the exploitation of the Black Jewfish in northern Australian waters. Yet little information is available to inform resource managers of the condition of the resource and how to use it in a sustainable manner. The project detailed in this report has responded to the concerns of resource managers and resources users alike, by providing the biological information and fishery catch statistics integral to achieving responsible management of the resource.

The initiatives introduced in this project aimed to unveil key aspects of the biology of Black Jewfish. These include: establishing the biological basis and importance of the aggregation events; demonstrating the period and location in which Black Jewfish spawn; and, determination of the genetic stock structure. Initiatives were also undertaken to rectify a major deficiency of data sets on the significance of subsistence fishing. It was anticipated that the participatory nature of present project would provide a template for the greater involvement of Indigenous people in fishery management processes.

Australian fisheries have a long history of being managed, researched and monitored in cooperation with non-Indigenous commercial and recreational fishing groups, a process which has until recently neglected the cultural and socio-economic values of fishing intrinsic to Indigenous Australians. Inclusion of Indigenous groups in a broad-based fisheries management network will provide these agencies with a truly comprehensive basis for future management decisions and strategic directions which should enjoy the widest possible public support.

While the geographical setting of this study is Queensland, the results of the current study will have significant application nationally to fisheries for Black Jewfish. Target fishing occurs on aggregations of other inshore fish species in tropical Australian waters, so the approach taken here might suggest a tool to address management issues applicable to other species.

1.3. OBJECTIVES

The objectives as stated in the project agreement were to:

1. To collate available historical data on the fishery to establish trends over time.

2. To undertake a preliminary survey of the fishery for Black Jewfish in Injinoo Community waters, far northern Cape York. To characterise the Black Jewfish fishery of the NPA in terms of catch and effort by the various user groups through on-ground surveys.

3. To characterise the annual Black Jewfish aggregation events in terms of the time of formation and dispersal, reproductive status and resource condition.

4. To determine the level of genetic relatedness among individuals, identification of population differentiation and gene flow in Black Jewfish in the waters adjacent to the NPA, Gulf of Carpentaria and northern East Coast of Queensland.

5. To advise the Injinoo Community and the Queensland Fisheries Service on current resource condition, sustainability indicators for long term monitoring in the fishery, and options for management on a sustainable basis.

Following raised awareness of the concerns held by the Traditional Owners of the NPA (see Section 1.1), Balkanu Cape York Development Corporation approached the Queensland Department of Primary Industry on behalf of Injinoo Community. At a later stage James Cook University was also to become involved in the project. Together they successfully sourced funding from the Fisheries Research Development Corporation (FRDC).

It is notable that this was the first time that the FRDC had funded research principally devoted to examining an Indigenous fishery (Alex Wells, Projects Manager, FRDC, pers. comm.). In addition to assessing the Black Jewfish stock, funding was also provided to concurrently document the harvest of all aquatic resources utilised by the Indigenous subsistence fishers of Injinoo Community. The comprehensive dataset gained by this element of the project is presented in a separate, stand-alone report (see Phelan 2002).

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

The continued involvement of local fishers proved integral to the success of the project. Not only did they provide detailed information on the history of the fishery (see Section 2.1), they also assisted greatly in quantifying the current harvest by making available their catch for examination (see Section 2.2). The Indigenous fishers also assisted in the biological sampling conducting to examine the stock's reproductive biology (see Section 3.1), diet (see Section 3.2), movement (see Section 3.3) and genetic population structure (see Section 3.4). In each of these efforts the Indigenous fishers made available their catch for sampling, assisted in the sampling process, and provided catch details.

From the onset it was immediately clear that the Indigenous fishers of the NPA were not familiar with the methods and tools of western science. For example, while fish tags are very familiar items among recreational and commercial fishers across Australia, the Indigenous people of the region had never been exposed to such methods. This increased the importance of community awareness programs and called for slight alterations to some of the methods. The fish tags for example, were simply printed with a prompt alongside the normal contact details, which reminded the fisher to 'record tag number, date, place, and fish length'.

Prior to the commencement of sampling, project staff had made a substantial commitment in time meeting the community residents and promoting the objectives of the project. Although seemingly unproductive in terms of annotated results, this period was essential to gaining the understanding of community members. Initiatives undertaken to raise the profile of the project within the community included:

- the personal introduction of the project biologist to members of the community by a Balkanu staff member who had previously resided in the community,
- a drawing competition organised to create awareness of the project with the younger members of the community, and
- the introduction of the project's objectives and methods in an interview broadcast on the local community radio service, in a public meeting held in the community hall, and with posters displayed throughout the NPA.

It is undoubtable that the project benefited greatly from the decision for the project's biologist to reside in the community for the most part of the project's duration. Injinoo 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. However, to reside in the community for such an extended period of time, required considerable support from the community given the limited resources such as accommodation and office facilities.

By residing within the community the biologist was able to achieve a stronger personal and working relationship with its residents and with time this generated a much greater understanding. This was not only from the perspective of the community's understanding of the research and results, but also of the studies' understanding of the community. Adopting this method serves to bridge the skills held by biologists and those necessary to understand the ethnobiological information which Johannes (1981) advocates as critical for the integration of contemporary and traditional practices.

In order to maintain the high level of community ownership of the project, the community was consulted throughout all stages, with the results released as soon as they became final. The project's staff liased directly with the community's Council Clerk, who also represented the interests of the community by serving on the project's steering committee. The steering committee comprised of elected representatives of each of the stakeholder groups linked to the fishery (see Appendix 2). The committee guided the progress and direction of the project and also served to ensure the transmission of the results to all stakeholder groups.

A General Fisheries Permit (number PRM00814A) was issued by the Queensland Fisheries Service to conduct authorised activities (as stated within the permit conditions) necessary to accomplish the objectives of this project.

1.4 SPECIES IDENTIFICATION

Five specimens (size range 610 to 640 mm TL) collected from the Muttee Head and Peak Point aggregations in July 1999 were examined (and preserved) by taxonomist Dr Jeff Johnson of the Ichthyology Department at the Queensland Museum. The identity of these fish was confirmed as Black Jewfish, *Protonibea diacanthus*. A single specimen (size 180 mm TL) of slightly differing external appearance was also examined by Dr Johnson. This specimen, collected from Big Creek in the Escape River tributary in December 1999, was confirmed to be a Silver Jewfish, *Johniops volgeri*. This exercise demonstrated the ability of project staff to distinguish between similar species of Jewfish.

In Australia, the colloquial term Jewfish refers to a grouping of several tropical and temperate marine teleosts. Jewfish are also collectively known in Australia as Jewelfish, derived from their pearly otoliths (Pollard 1980), and Drums or Croakers, originating from the amplified sound they can produce with sonic muscles or the pharyngeal plates (Connaughton and Talyor 1995). The common name of Black Jewfish reflects the tendency of the bodies of members of the species to darken upon death (Grant 1999). The species is also known in Australia as Northern Mulloway (Recreational Fishing Program 1998), Spotted Croaker (Sainsbury *et al.* 1985), and Blotched Jewfish (Grant 1999).

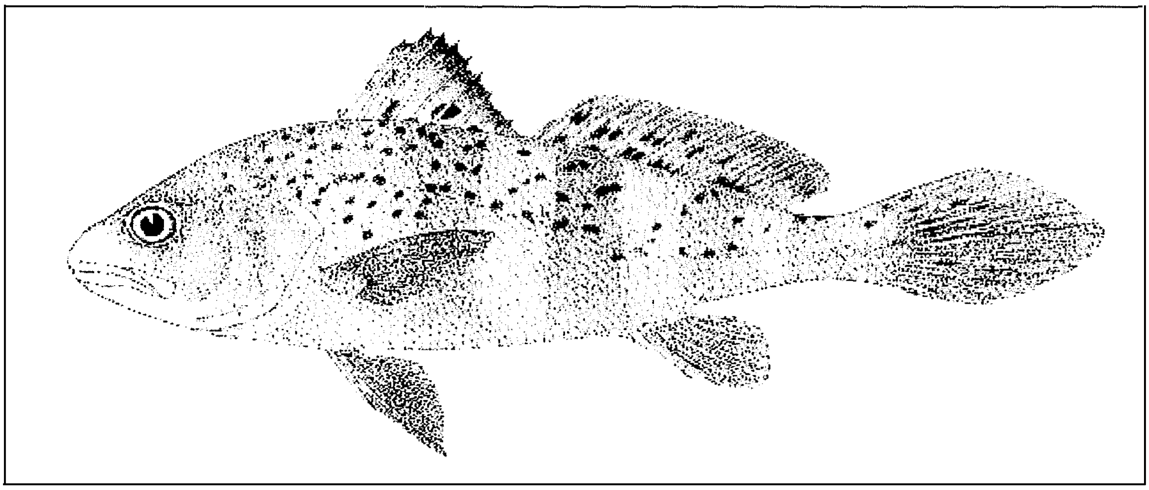


Figure 2. Juvenile Black Jewfish *Protonibea diacanthus.* Source: FOA Fishbase.

Trewavas (1977) positioned *P. diacanthus* 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 found in GOC and northern Australia waters, *Nibea squamos* and *N. microgenys*, have since been described by Sasaki (1992) and added to the tribe Nibeini described by Trewavas (1977). Garrett (1997) suggested that prior to their identification, these two species might have been previously recorded in Queensland commercial catch logs under the umbrella of 'Black Jewfish'. Neither of the latter two species was recorded in the present study.

2. PROFILE OF THE BLACK JEWFISH FISHERY IN THE NORTHERN PENINSULA AREA.

2.1 HISTORICAL DATA OF THE BLACK JEWFISH FISHERY.

2.1.1 Introduction

The aggregations of Black Jewfish which form annually off Muttee Head (~15km south-west of Injinoo) have been subjected to growing levels of fishing pressure in recent years (Bligh 1994, Bligh 1995, Bowtell 1995, Bligh 1996, Ford 1999, Mondora 2000). Black Jewfish stocks are currently exploited in the NPA by local Indigenous subsistence fishers, local and transient recreational fishers, and by tourist anglers from all over Australia and the world. The resident Aboriginal and Torres Strait Islander population of CYP is approximately 15000, with the vast majority living near the coast and participating in day to day activities involving traditional marine resource harvest (Tanna 1996).

Achieving responsible and sustainable use of fishery resources requires an understanding of the dynamics of the resource in relation to each of the pressures placed upon it (Garrett 1997). However, comprehensive fishery databases available to resource managers are presently limited to the recreational and commercial harvest in Queensland waters. The management and monitoring of fin 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 lack 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.

This aim of this section of the study was to collate all available historical information on the Black Jewfish fishery of the NPA. Such data provides background information for understanding of and accounting for the economic, cultural and social characteristics of the fishery, and helps identify trends in the fishery that have occurred over time.

2.1.2 Materials and Methods

Oral and recorded accounts were received from Elders and Traditional Owners of the study area, and from long-term Indigenous and non-Indigenous residents of NPA and adjacent Torres Strait Islands. Oral accounts were received in both formal and informal interviews, and recorded accounts in the form of photographs and fishers' diaries. Every effort was made to ensure 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.

2.1.3 Results

Historical accounts of the exploitation of Black Jewfish in the coastal waters and tributaries of the NPA provide a clear picture of the fishery since it began. The Black

Jewfish fishery originated when the deep-water jetty at Muttee Head became accessible to local Indigenous subsistence fishers at the end of WWII. 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 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 in the modern context.

The Traditional Owners of the land and waters of CYP north of the 12°S parallel had come together of their own volition at the turn of the century, and established by themselves the Community of Injinoo at the mouth of Cowal Creek (Sharp 1992). The Injinoo Community was founded by the clans of the Anggamuthi (Seven Rivers, western), Atambaya (MacDonnell, central), Wuthathi (Whitesand, south-eastern), Yadhaykenu/Yadaigana (Cairn Cross, eastern), and Gudang (Red Island-Somerset, northern), all of whom shared a common language but with differing dialects (Byrne 2000).

The traditional language word for the Black Jewfish is 'Unyunguthi' in the Yadaigana dialect of the Injinoo Ikya (Harper 1992), or 'Ambu' in the Wuthathi language (Gordon Pablo, Wuthathi Elder, pers. comm.). In the Creole language of the NPA, which presently is 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 clan name Anggamuthi (Gary Wright, Seisia Charter Operator, pers. comm.).

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 to Muttee Head in order to fish for Jewfish from the jetty (Shorty Lifu, Gudang Elder, pers. comm.). The fish, kept fresh by burying in the sand, were carried back to be cut up at the Community and eaten immediately (Angus Pablo, pers. comm.). 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 at the time (Gordon Pablo, Wuthathi Elder, pers. comm.).

Over the same period, four additional Indigenous communities were established within the NPA. The first of these, the Torres Strait Islander Community of Bamaga (now established at Ichirru), was initially settled at Muttee Head. The establishment of the four additional Deed of Grant in Trust (DOGIT) communities, coupled with the gradual return to the region of non-Indigenous residents following their evacuation during WWII, greatly increased the number of people residing in the NPA. At the time of press, the population of Injinoo was less than 400 people, while the greater population of the NPA was composed 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 at Muttee Head 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 to the site. Deepwater harbours and artificial reefs in northern Australian waters are well known habitats for Black Jewfish (DPIF 1999, 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 area to catch Jewfish, and is said to be the greater source of the Black Jewfish catch taken in recent years (Tex Nona, Injinoo resident, pers. comm.). Some local residents believe the deepwater holes at Muttee Head were created by the Defence Force personnel exploding surplus ammunition at the end of WWII.

With the progressive introduction of outboard-powered dinghies in the NPA, new areas producing good Jewfish catches were discovered in the last two decades, first near Pajinka and then in the Escape River, and most recently near Peak Point (David Epworth, Balkanu, pers. comm.). 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 Council, pers. comm.).

Ownership of vessels has increased dramatically in the last decade. In 1990 there was five powered dinghies at Injinoo (Danny Salee, Community Police Officer, Injinoo, pers. comm.), by 1995 there was twelve vessels on the community fishing vessel register, and in August 2000, the number had increased to 42 vessels (at the same time there was 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 in the 1960s were small one-cylinder engine models (Gordon Pablo, Wuthathi Elder, pers. comm.), the latest purchases include 100 hp models.

While the Black Jewfish fishery has expanded in the last two decades to several different locations in the region, Muttee Head with its predictable annual mid-year aggregation remained the site where most of the total annual catch of Black Jewfish was taken in the NPA (Doyle Sebasio, Community Police Officer, Injinoo, pers. comm.). Typically, the aggregation of the fish at Muttee Head extended from late April through to early/late August (Shorty Lifu, Gudang Elder, pers. comm.). Anzac Day is well known at Injinoo as the start of season for Black Jewfish (Gordon Solomon, Deputy Chairman, Injinoo Council, pers. comm.).

When conditions were suitable during the aggregation period, in excess of twenty vessels fishing Muttee Head per night was not uncommon (Jackson Sailor, Australian Quarantine and Inspection Service, pers. comm.). The dinghies were often tied side-by-side in order to fish the trenches and holes (Robbie Salee, Regional Chair, ATSIC, pers. comm.). Catches were frequently well in excess of fifty Black Jewfish per boat per night (Dale

Salee, Injinoo Councillor, pers. comm.). Exemplifying the ease with which Black Jewfish can be caught, specimens have reportedly been landed using metal bolts in place of hooks (the late Daniel Ropeyarn, Anggamuthi Elder, pers. comm.).

Black Jewfish of a mature size with ripe ovaries were caught during the period of the annual aggregations (Tex Nona, Injinoo resident, pers. comm.). The Indigenous subsistence fishers of the NPA 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, pers. comm.). Black Jewfish up to 1500 mm in length were said to be commonly caught in the last few decades (Shorty Lifu, Gudang Elder, pers. comm.), greatly exceeding the observed length at first maturity (920 mm TL) in female Black Jewfish inhabiting North Queensland waters (McPherson 1997).

In 1994, a catch of two Black Jewfish caught at Muttee Head barely fitted into the commercial freezer at the community service station, suggesting these specimens were over 1500 mm TL (Joel Nona, Injinoo Community Police, pers. comm.). 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, Injinoo Community Councillor, pers. comm.). Juveniles (<300 mm) were reportedly caught within the Jardine River and Jacky Jacky/Escape Rivers (Tex Nona, Injinoo resident, pers. comm.).

As a testament to the large size of the Black Jewfish caught in the earlier years, it was said that thick wire cable found in the area of the old military base at Muttee Head had to be used to land the Jewfish while fishing the old jetty (the late Daniel Ropeyarn, Anggamuthi Elder, pers. comm.). As the size of the fish being caught decreased, clothes-line wire or whipper-snipper line was commonly used in the early to mid-1990s (Pedro Steven, Mayor of Torres Shire, pers. comm.). Presently, 100 lb line is most commonly used by the Indigenous fishers.

Private diary records accessed by the author reveal 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, Seisia Charter Operators, pers. comm.). 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, Seisia Charter Operator, pers. comm.).

2.1.4 Discussion

The historical accounts of the Black Jewfish fishery in NPA 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 over a fifty-year period present anecdotal evidence of a gradual reduction in the size of the fish caught during the aggregation period. It appears that the aggregation fishery was previously based on specimens which included sexually mature fish, whereas catch records collected in 1999 and 2000 as part of this study (see Section 2.2.3) demonstrate the fishery is now based almost exclusively on juvenile fish. These data support the notion of a significant change in the NPA Black Jewfish resource.

CPUE has reportedly remained relatively steady during the annual midyear fishery at Muttee Head. Catches in 1999 and 2000 still commonly exceeded 50+ Black Jewfish (see 2.2.3). The persistence of the CPUE despite the apparent decline in other measurable characteristics of the aggregation was not surprising. Samoilys and Gribble (1997) have suggested that in scenarios where the exploited species aggregates, CPUE can remain relatively steady until the last school of fish is removed.

Private diary records show the period over which large schools of Black Jewfish may be encountered at Muttee Head has became much reduced through the years. Consequently, both the catch and effort at Muttee Head have increasingly become concentrated into a shorter period of time. This trend was believed to be responsible for the shift in the majority of the fishery effort in 1999 to Peak Point, a site apparently never before exposed to intensive fishing effort (see Section 2.2.4).

The changing circumstances of the NPA fishery appear similar to accounts of the Black Jewfish fishery 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.....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."

2.2 CATCH COMPOSITION OF THE BLACK JEWFISH AGGREGATIONS IN 1999 AND 2000.

2.2.1 Introduction

From a resource management perspective, there is presently a dearth of information on the condition of northern Australia's Black Jewfish stocks and the demands placed on them by the various fishery sectors. Anecdotal evidence suggests intensive fishing has severely impacted on several annual aggregations of Black Jewfish along the East Coast of Queensland (Bowtell 1994, Bowtell 1998). The heavy fishing over recent years of the annual aggregation formed off Muttee Head has raised concerns of the sustainability of the current levels of exploitation.

An extensive body of evidence derived from stocks throughout the tropics indicates that target fishing of aggregations can rapidly undermine fishery production. Chronic effects of aggregation fishing have included the truncation of population size and age structure (e.g. Rowling 1990, Beets and Friedlander 1992), deterioration of the stock's reproductive capacity (e.g. Eklund *et al.* 2000, Koenig *et al.* 2000), and altered genetic composition (e.g. Altukhov and Salmenkova 1991). Acute effects have included the total loss of aggregations (e.g. Olsen and LaPlace 1979, Bohnsack 1989, Beets and Friedlander 1992, Sadovy 1994a, 1994b, Koenig *et al.* 1997, Sadovy and Ekland 1999)

In order to maintain fish stocks in a viable condition, harvest levels must not exceed the maximum sustainable yield in which the resource's capacity to renew itself is not impaired (Fisheries *Gulf of Carpentaria Inshore Fin Fish* Management Plan 1999). Stock assessment through the monitoring of the catch and effort of the resource user, should provide resource managers the means to review the suitability of current management arrangements governing the Black Jewfish fishery in the NPA. The aim of this element of the present study was to describe the utilisation by Black Jewfish stocks in the region of the NPA, characterising the local fishery in terms of catch and effort by the various user groups. The annual jewfish aggregation event was also to be described in terms of the time of formation and dispersal as revealed by catch data.

2.2.2 Materials and Methods

Project biologist, Mr Michael Phelan resided at Injinoo Community for much of the duration of the project in 1999 and 2000 in order to monitor the catch of Black Jewfish in the NPA. While at Injinoo, the project biologist conducted dedicated fishing trips to Muttee Head on a daily to weekly basis in order to assess the presence/absence of Black Jewfish at the site. Details of Black Jewfish catches in the region were obtained from local Indigenous subsistence fishers and recreational fishers of the communities of Injinoo, Umagico, Bamaga, New Mapoon, and Seisia, and charter boat operators from New Mapoon and Seisia. All catches were made by line fishing, with a wide variety of hooks, baits and methods used.

Access to catch data involved visiting fishers either on the water or at their homes. Local residents of the NPA assisted greatly in providing information by reporting details of observed catches, and providing access to catches for sampling. 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 age of the fish was estimated from length/age keys determined by Bibby and McPherson (1997) for Black Jewfish in Queensland waters.

2.2.3 Results

In the period extending from the 1st of January 1999 to the 31st of December 2000, Black Jewfish catches recorded in the NPA by the project biologist amounted to 4031 individual fish (Figure 3 and 4). About 15% of this catch were measured (410-1030 mm 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 NPA amounted to 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}.

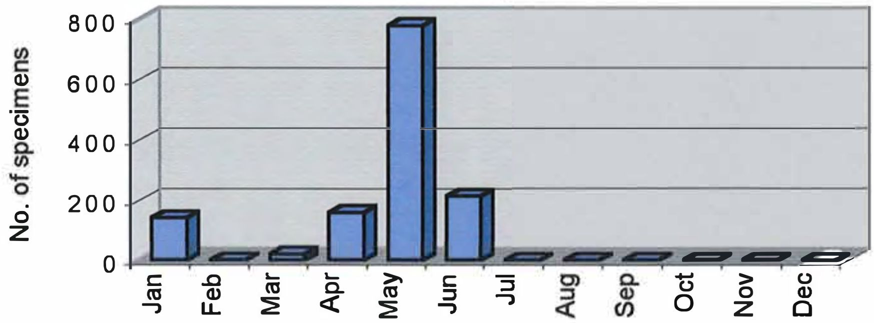


Figure 3. Number of Black Jewfish harvested each month of 1999 from the coastal waters and tributaries of the Northern Peninsula Area.

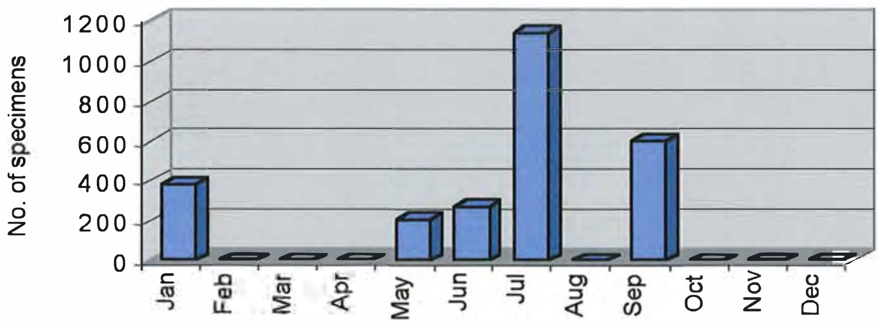


Figure 4. Number of Black Jewfish harvested each month of 2000 from the coastal waters and tributaries of the Northern Peninsula Area.

Catches of Black Jewfish in 1999 and 2000 occurred in patches at a range of locations across the NPA. Black Jewfish were caught during January 1999 off Seisia, followed by catches off Muttee Head in March through to May 1999. Catches of the fish occurred at Peak Point during April and May 1999. The last catches in 1999 were off Horn Island in June. In January 2000, the species was again caught off Seisia, as well as at Muttee Head and the Jardine River mouth. 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 occured off Seisia in September.

The number of Black Jewfish harvested at Muttee Head peaked in 1999 during the period of 21st-31st of May (catches between 10-74 Black Jewfish per boat/day, average 36). In 2000, catches at Muttee Head peaked between 13th-18th of July (13-111 Black Jewfish per boat/day, average 50). In 1999, 88% of the total catch of Black Jewfish in the waters of the NPA occurred from April through to August, the period in which historical accounts (see Section 2.1.3) suggested that the species aggregate in the area. In 2000, 89% of the total NPA catch of Black Jewfish occurred between May and September.

During the April-August period of the year in which Black Jewfish have historically aggregated off Muttee Head, comparable high catches of the species were obtained in 1999 at Peak Point, a site never before exposed to intensive fishing effort. Catches of Black Jewfish at Peak Point peaked in 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 as a consequence of rough weather and inaccessibility. Hence in 2000 catches from Peak Point failed to form an appreciable component of the annual catch.

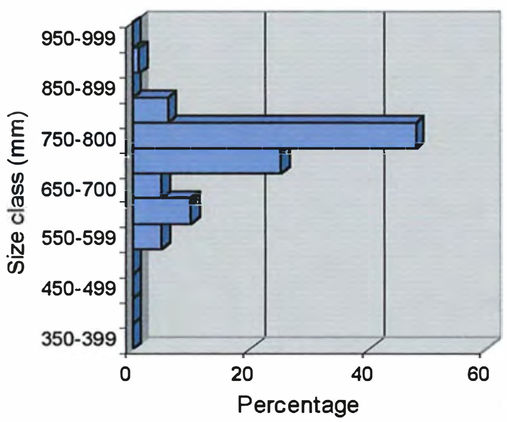


Figure 5. Composition of the size classes of Black Jewfish harvested off Muttee Head in 1999.

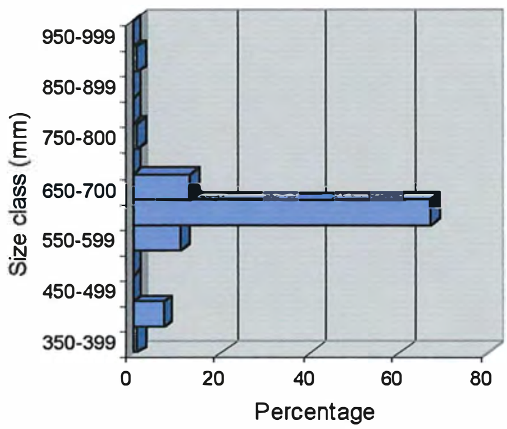


Figure 6. Composition of the size classes of Black Jewfish harvested off Muttee Head in 2000.

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.)). This can be seen graphically in Figures 5 and 6. In 1999, 79% of Black Jewfish obtained from Muttee Head had a total length between 700-800 mm. In 2000, 92% of the catch of Black Jewfish was represented by specimens 590-690 mm TL. In both years, the remainder of the catch was composed almost exclusively of smaller specimens.

Based on length-age keys developed by Bibby and McPherson (1998), catches from the NPA appeared to be represented by one-year-old through to five-year-old fish (Figure 7). The predominate age class represented in catches from Muttee Head during the aggregation period fell from three-year-old stock (~700-850 mm TL) in 1999 to two-year-old stock (~500-650 mm TL) in 2000. Catches at Peak Point in 1999 had been composed exclusively of two-year-old stock, and catches at Crab Island in 2000 were exclusively one-year-old stock (~350-450 mm TL). McPherson (1997) reported the size of the first observed maturity in female Black Jewfish from the adjacent GOC occured at four-years-old stock (920 mm 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 the NPA.

Size at first maturity →
(McPherson 1997)

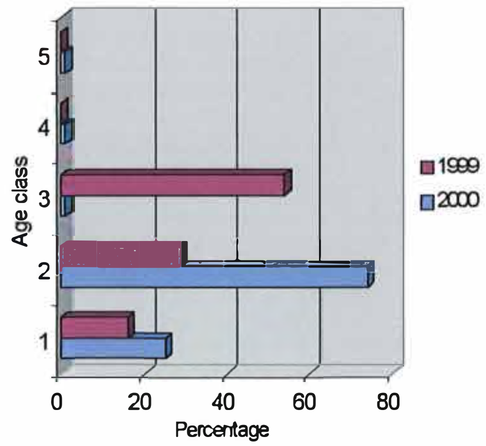


Figure 7. Composition of the age classes of Black Jewfish harvested the Northern Peninsula Area in 1999 and 2000.

2.2.4 Discussion

The Black Jewfish fishery of the NPA in both 1999 and 2000, was based almost exclusively on fish representing immature size classes. Less than one percent of the stock harvested in the fishery was larger than 920 mm TL, the length that McPherson (1997) determined as the minimum size female Black Jewfish attain sexually maturity. The high representation of juveniles in the Black Jewfish fishery of the NPA warrants concern for the state of the resource given that historical data reveal the fishery was previously based on adult stock (see Section 2.1.3).

Changes in the structure of the fished stock appear to have occured quite rapidly. In 1999, catches were dominated by three-year-old fish (one year class below which 50% of females become sexually mature), in 2000, the dominant size class was two-year-old stock (half the age of the breeding class). Historical records reveal specimens close to maximum size (>1500 mm TL) were still being caught up until 1994 (see Section 2.1.3). These data suggest a major reduction in the proportion of adults in the population has occurred within the last five years.

In 1999, the present study recorded a shift of the majority of the fishers' effort to targeting juvenile stock at Peak Point, 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 the light use that had previously occurred at the site, and which also occurred in 2000.

Amplified Fragment Length Polymorphism genetic analysis undertaken in the present study, revealed specimens sampled from both Muttee Head and Peak Point show little genetic variability between them (see Section 3.4.3). Hence fishing pressure at both sites should be considered as targeting the same genetic stock, and should be managed as such. The linkage of both sites was further evidenced by the movement of a specimen that was tagged at Peak Point and recaptured at Muttee Head (see Section 3.3.3).

The apparent absence of adult fish in the NPA fishery gives rise to concerns about its sustainability. Turnbill and Samoilys (1997) provide that estimates of the critical stock density which must be maintained for future stock replenishment vary in tropical fin fish between 20% of the virgin spawning biomass (Goodyear 1989), to the more conservative estimate of 30-40% (Caddy and Mahon 1995). While the critical stock density for Black Jewfish has not been determined, our findings that less than one percent of the catch were mature fish, challenges existing management measures if recruitment overfishing is to be avoided.

Establishing trends in abundance of Black Jewfish in the NPA was made difficult by the lack of long-term catch and effort data. However, boat ownership in the region has increased markedly over the last decade. At Injinoo Community, for example, there was only five powered dinghies in 1990, by 1995 there was twelve vessels, and by 2000 the number of vessels had risen to 42 (see Section 2.1.3). Unfortunately there was insufficient catch data available to test for a correlation between increased boat use and catch.

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, Johannes *et al.* 1999). The migratory behaviour of fish is widely speculated to be characterised by a combination of temporal and environmental variables (e.g. Baltz 1990, Suacier and Baltz 1993, Johannes *et al.* 1999). Climatic or changing hydrological conditions may account for some of the observed variation in the formation and dispersal of the annual midyear aggregations of Black Jewfish in the inshore waters of the NPA.

Based on historical records monthly average water temperatures near Thursday Island range between 24.5-28.4°C over the year (Source: Ray Berkelmans, Australian Institute of Marine Science/GBRMPA, 2002.). During the period in which highest catches of Black Jewfish were attained from the aggregation in 1999 (21/05-31/05), the mean daily water temperature was 27.31°C (daily minimum and maximum ranged from 26.96-27.78°C). In 2000, the mean daily temperature during the period of peak catches (13/07-18/07) was 25.0°C (range = 24.34-25.73°C). The two means differed by 2.31°C. Figures 8 and 9 illustrate the temperature of the water recorded near Thursday Island (adjacent to Muttee Head and Peak Point) during 1999 and 2000 respectively.

Acha *et al.* (1999) postulates that the sciaenid *Micropogonias furnieri* may form aggregations for the purpose of spawning in temperatures ranging between 16-26.8°C. Saucier and Baltz (1993) demonstrates that the sciaenids *Cynoscion nebulosus* and *Pogonias cromis* form spawning aggregations in waters temperatures ranging between 24.5-33.5°C and 15.0-24.0°C respectively. However, teleosts inhabiting tropical waters may be expected exhibit a narrower range reflecting the lower intra-annual variation in water temperature. Exemplifying this notion, spawning aggregations of *Epinephelus striatus* are believed to be confined to the narrow temperature range of 25.0-26.0°C (Colin 1992, Tucker *et al.* 1993).

The nearby Jardine River (catchment area 2421.0 km^2) is acclaimed to have the greatest runoff of any river in Queensland (Wagner 1989). Monthly mean stream discharge (cumecs/24 hours) from the Jardine River range between 16.835 megalitres in February and 172.764 megalitres in June (Source: Henry McDermott, Department of Natural Resources, 2002). During periods of high runoff freshwater plumes reach Muttee Head from the Jardine River during easterly flowing currents (*pers. obs.*). In both years catches of Black Jewfish from the aggregation sites commenced following the peak of water discharge from the river (see Figure 10 and 11). During the period in which catches of Black Jewfish were highest in 1999 (21/05-31/05) the mean daily water discharge at the

Figure 8 and 9: Sea surface temperature at Thursday Island during the period of 1st of January to the 31st of December 1999 (above) and 2000 (below). Source: Ray Berkelmans, Australian Institute of Marine Science/GBRMPA.

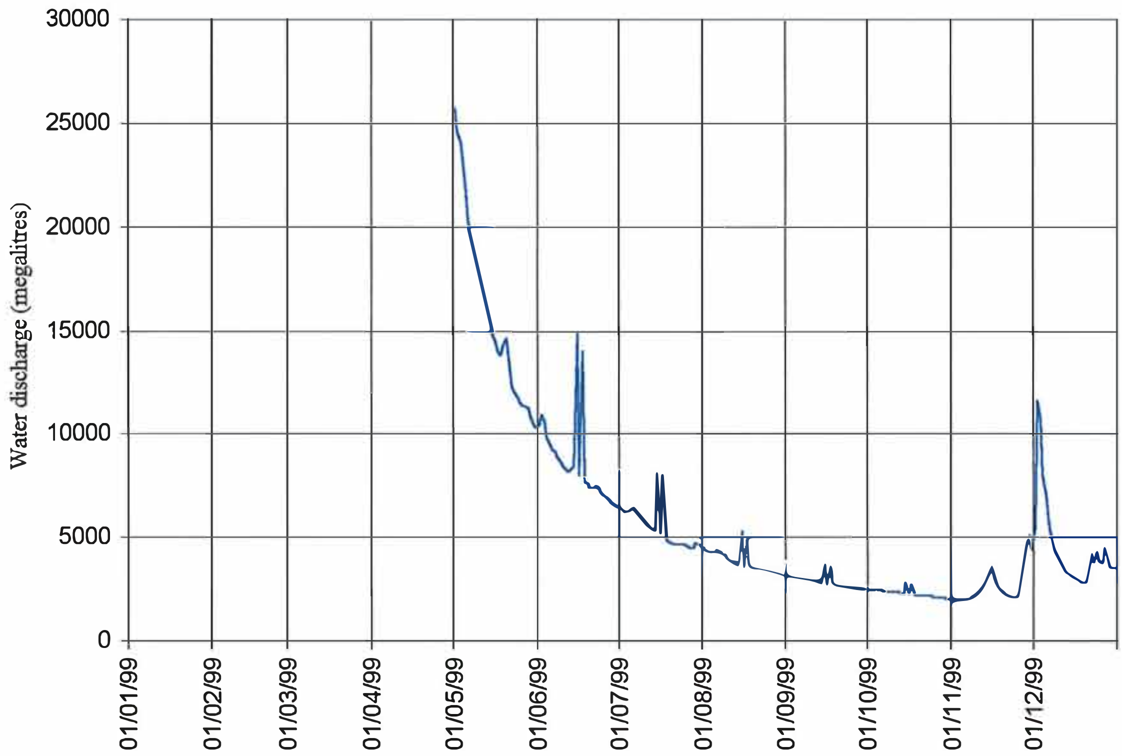
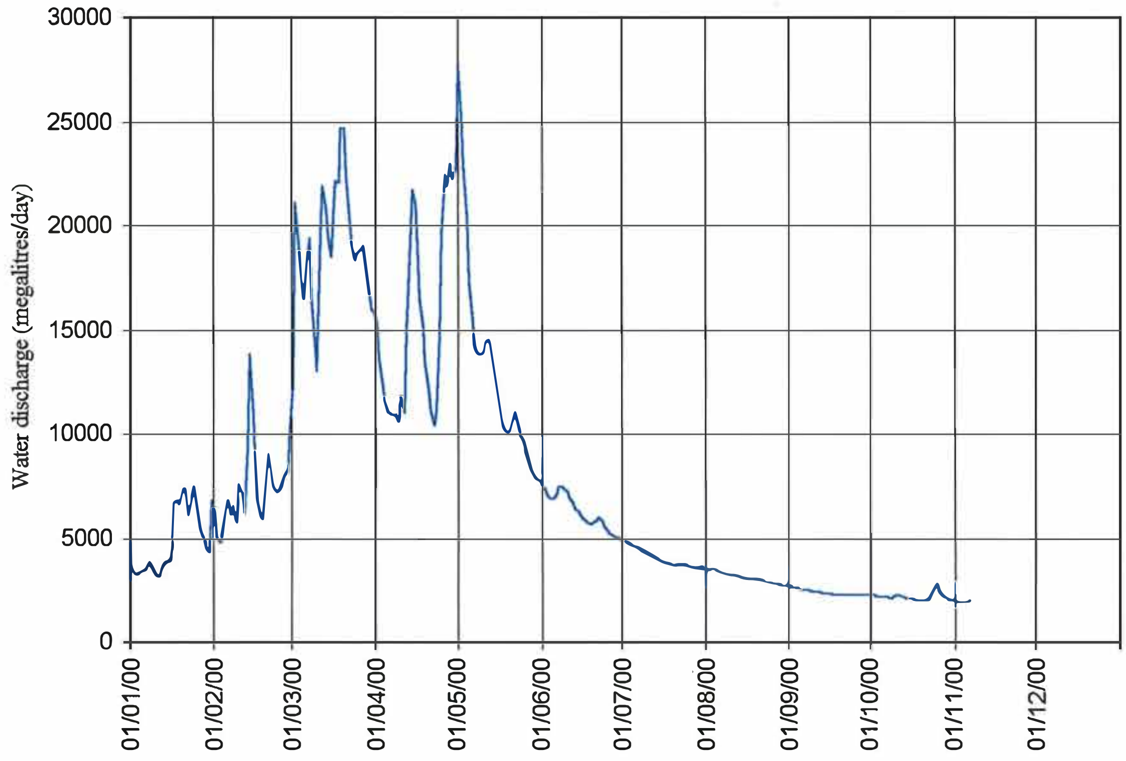


Figure 10 and 11: Rate of freshwater discharge from the Jardine River during the period 1st of January to the 31st of December 1999 (above) and 2000 (below). Source: Henry McDermott, Department of Natural Resources.



Jardine River was 11534.4 megalitres (range = 13719-10323). In 2000 the mean daily water discharge during the period of peak catches (13/07-18/07) was 3910 megalitres (range = 4060-3791). The two means differed by 7624 megalitres.

Catches of Black Jewfish were very closely correlated with the state of the tide. Black Jewfish came on the bite once the tidal current had changed direction (following the peak of the flood or bottom of the ebb tide) and had attained some momentum. The harvest continued only as long as the current allowed the fisher's tackle to reach near the bottom of the water column. Typically this window was only 30-45 minutes in duration. Currents at Muttee Head can reach speeds of 6-9 knots. The greatest catches of Black Jewfish were obtained during the spring tide periods (when the sun and the moon are lined up with the earth at the new and full phases of the moon).

Catches of Black Jewfish at Muttee Head and Peak Point were greatest during periods at which the moon was near full. Typically, larger catches began three days prior to the full moon and typically remained high for at least six or seven days following. During this period the number of fish harvested each day appeared more related to the number of fishers present that a finer definition of the moon phase. The lunar and tidal patterns had long been common knowledge among fishers, but have hereto remained undocumented. Lunar periodicity in the timing of aggregations has been demonstrated for a large number of teleost species but appears to be limited to large pelagic fish that migrate to spawn (e.g. Olsen and LaPlace 1978, Colin 1992, Shapiro *et al.* 1993, Tucker *et al.* 1993, Samoilys 1997, Domeier and Colin 1997).

3. BIOLOGICAL CHARACTERISATION OF THE BLACK JEWFISH AGGREGATIONS IN 1999 AND 2000

3.1 REPRODUCTIVE BIOLOGY OF BLACK JEWFISH

3.1.1 Introduction

A significant characteristic of sciaenid life cycles is the seasonal aggregation of adult fish for the purpose of spawning (McPherson 1997). Midyear 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 the annual aggregation of Black Jewfish has 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 (e.g. Olsen and LaPlace 1978, Shapiro 1987, Colins 1992, Sadovy 1994, Zeller 1998, Johannnes *et al.* 1999). Exemplifying this, the largest member of the family Sciaenidae, *Totoaba macdonaldi*, is now considered critically endangered as a consequence of fishing activities targeting the annual migration to inshore spawning grounds (True *et al.* 1997).

A sound knowledge of the reproductive strategies employed by fin 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.

The aim of this component of the study was to identify the period and location at which peak reproductive activity of the species occurs in the waters of the NPA. With this information, the relevance of the species reproductive strategy to the formation of the annual aggregation event could then be described.

3.1.2 Materials and Methods

The gonads of Black Jewfish were sampled from specimens caught by Indigenous subsistence fishers and recreation fishers in the NPA. All fish were caught by handlines at bottom depths ranging between 30 to 70 ft. At each opportunity, the largest specimens of each sex were sampled. Sampling the largest specimens was necessary due to the high representation of juveniles in the catches of 1999 and 2000 (see Section 2.2.3). The fishers retained the fish and were reimbursed for their assistance whenever possible with a gift of hooks or sinkers. Additional material, when unavailable otherwise, was obtained by the project biologist from dedicated fishing trips. Fish caught in these exercises, once sampled and the internal cavity cleaned, were donated to members of the Injinoo Community.

Between January and June 1999, 122 specimens (size range 550-800 mm TL) were sampled from Muttee Head and Peak Point. In January 2000, 37 specimens (700-755 mm TL) were sampled from catches collected at Muttee Head. Between May and July 2000, a further 97 specimens (600-925 mm TL) were sampled from catches collected from Muttee Head, Peak Point, Crab Island and the Escape River. An additional 14 samples were obtained in August 2000, from an aggregation which forms annually off Cullen Point near the Old Mapoon Community. In all, 270 specimens were sampled from catches made in the inshore waters and tributaries of the northern CYP.

Sampled fish were measured (total length in millimetres) and weighed (whole weight in grams) before the gonads were removed. Macroscopic observations on the gonads were recorded before they were fixed in 10% formalin FAACC solution. Seventy-nine preserved gonads (64 females, 15 males), representative of the various stages of the two sexes were sectioned along the sagittal plane for histological analysis. Each gonad sample was dehydrated and then embedded in paraplast, before sections were cut at 5μm and stained with Mayers haemotoxylin and Youngs Eosin. Nomenclature for stages of oogenesis followed that of Roa (1963), West (1990) and observations made during the present study (see Table 1). The state of maturity was classified by the most advance type of occyte present, regardless of how numerous they are. Estimates of age of the fish were made length/age keys developed by Bibby and McPherson (1997).

Table 1. Ovary maturity stages of *Protonibea diacanthus*.

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 oocyctes 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 I in external presence.

	Micro: The light nucleus of the perinucleolar stage oocyte increases is size and may show multiple peripheral nucleoli its periphery. 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. Active	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 under H&E 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. Developing	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 and straited.

Diving at the fishing sites to observe the aggregating behaviour of the fish, was not considered a feasible option due to the combination of high turbidity, strong currents (up to 8 knots), and the common presence of sharks at the site. During the year of 2000, a local professional diver had made available a shark cage and underwater video camera in the evident ideal conditions were presented, however they did not become available in the period the fish were aggregating in the area.

3.1.3 Results

All Black Jewfish specimens collected in 1999 displayed no evidence of sexual maturation and were deemed to be sexually inactive. All fish collected in 1999 were below 920 mm TL, the size of the first previously observed length at first maturity in female Black Jewfish (McPherson 1997). The reproductive status of the females collected in 1999 was confirmed in 20 histological sections of ovaries from the largest of the Black Jewfish (750-800 mm TL) sampled in 1999. Most (80%) of these ovaries were at stage I (see Table 1), with fewer ovaries (20%) at stage II.

From the specimens caught in the NPA in 2000, a further 30 ovaries were examined histologically. Stages I and II ovaries were observed between January and June 2000 in 13 (43%) specimens (<755 mm TL). Stage III ovaries were observed in 9 (30%) specimens (<690 mm TL) caught between May and July. The ovaries of four (13%) specimens (920-925 mm TL) caught between May and June, were classed at stage IV and determined to be sexually mature. These ovaries were sampled from the largest fish known to have been caught at Muttee Head in 2000. A further four (13%) specimens (790-825 mm TL) collected at Muttee Head in July, were also deemed to be sexually mature having ovaries at stage IV.

Four (28%) of the 14 female specimens (790-800 mm 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 were determined to be ripe or spent. Data on the status of male Black Jewfish will become available following the analysis of the histological preparations made from 15 males (10 in 1999, 5 in 2000) taken during the project.

3.1.4 Discussion

Black Jewfish displaying sexual development comprised only a small component (12 fish out of 270 = 4.4%) of the NPA catch examined in a sampling program that was biased towards the largest individuals available. Catches of Black Jewfish in the present study were composed almost exclusively of specimens one to two years below the mature size-classes (see Section 2.2.3), 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.

Sexually 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. In monitoring the condition of the gonads of Black Jewfish, Rao (1963) concluded the spawning season in north-west India is protracted from June to through to August. However, no ripe or spent gonads were found in the present study, 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 aggregations (see Section 2.1.3).

The present study observed a minimum size of first maturity at 790 mm TL for female Black Jewfish. This represents a significant departure from the previously observed first length of maturity in Queensland waters of 920 mm TL, reported by McPherson (1997). However, the observed size range of maturity in the NPA Black Jewfish fits observations of Indian Black Jewfish reported by Rao (1963). Rao (1963) found 5% of fish were mature in the 750-800 mm group, 36.8% in 800-850 mm, 91% in 850-900 mm, and 100% in 900-950 mm size classes.

McPherson (1997) adopted the logistic model of Saila *et al.* (1988) to calculate the length at which 50% of individuals (l_{50}) attained sexual maturity. The most parsimonious fit provided an l_{50} estimate of 978 mm TL, which coincided with the observed length at first maturity for females Black Jewfish at 920 mm TL. Given that the length at first maturity has been shown to be different, reassessment of the parameter appears warranted. Too few specimens of a mature size were obtained in the present study to make this possible with current data.

If the limited data presented within this report was truly representative of the status of the Black Jewfish resource in the NPA, then concern must be held for the future viability of the stock. Very few reproductively active females were observed in the extensive sampling of specimens recruited into the subsistence and recreational fishery in both 1999 and 2000. Controls on fishing are necessary if the Black Jewfish population structure determined in this study truly represents the situation in the wild.

3.2 DIET OF THE BLACK JEWFISH

3.2.1 Introduction

In September 1973, a large aggregation of Black Jewfish was harvested by a purse seiner off Goa, north-west India. The total number of specimens caught was 2309, with the total weight of the catch estimated at 30.24 tonnes. It was noted that 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 1/2 to 3/4 full, containing between 8 to 22 sole. Reporting on this event, Thomas and Kunja (1981) suggested that the seasonal availability of food in the inshore waters govern the annual inshore migration of Black Jewfish.

The diets of the main predatory fishes inhabiting tropical Australia's inshore waters have been described (Salini *et al.* 1998), however, the Black Jewfish is not included among this list. Despite penaeid prawns composing a significant component of the species' diet in waters of north-west India (Rao 1963), the 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). The aim of this component of the study of Black Jewfish was to examine the composition of food items in the stomachs of specimens collected from the coastal waters and tributaries of the NPA.

3.2.2 Material and Methods

Gut contents were examined from the same 270 Black Jewfish sampled for reproductive status. The specimens were obtained from Indigenous subsistence fishers and dedicated fishing trips by the project biologist. All fish sampled in 1999 were line fished at Muttee Head and Peak Point from depths of 30-70 ft. In the following year, further sampling was conducted at Muttee Head, and expanded to locations within the Jacky Jacky/Escape Rivers, and off Crab Island. The fish were measured and weighed, and the stomach and mouth were inspected in each of the specimens. Macroscopic observations of the gut contents (stomach fullness, content items) were recorded on site and food items were preserved in 80% ethanol.

3.2.3 Results

The stomach contents of 256 Black Jewfish (429-825 mm TL) were examined in 1999 and 2000, with catches in the NPA revealing a wide range of prey items including fish, prawns, crabs, and gastropods (see Table 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 seemingly constant presence of sharks on the fishing grounds.

Table 2. Frequency of occurrence of the prey categories observed in the diet of Black Jewfish *Protonibea diacanthus* from the NPA waters. LR: length range; *N*: no. of stomachs examined; *N*F: no. of stomachs with food; Mo: mollosca; Cr: crustacea; Pen: penaeidae; Tel: teleostei; Oth: other.

Month	***N***	***N*F**	**Mo**	**Cr**	**Pen**	**Tel**	**Oth**
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**

3.2.4 Discussion

The range of taxa represented in the food items 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. Food items observed in the present study also include both a variety of teleosts and invertebrates. That crustaceans was the most dominant taxa observed in this study, may be a result of slower digestion relative to less protected taxa. In all crustacean food items (predominantly *Portunus pelagicus*) the carapace was still intact.

Teleosts also proved an important component of the diet of the Black Jewfish. Rao (1963) observed specimens >500 mm displayed a strong piscivorous tendency, with the percentage of prawns much higher in juveniles. Predatory fish commonly switch from invertebrate to teleost prey when they become adults (Kwei 1978, Blaber and Cyrus 1983, Dall *et al.* 1990). The change in diet at around the 500 mm may reflect the transition of the fish from the nursery areas to deeper water habitats. While Black Jewfish were not recruited into the inshore fishery of the NPA until a size of ~420 mm (see Section 2.2.3), Suntag data reveals that virtually all tagged specimens less than one year old (~420 mm TL) were predominantly caught in estuarine areas and bays (see Section 3.3.4). Sciaenids are commonly reported to utilise estuarine areas as nurseries during their first of life (Levy *et al.* 1998, Cazorla 2000, Adams and Tremain 2000).

That Black Jewfish develop into capable predators of other fin fish is well demonstrated. Both Rao (1963) and Jacob (1948) reported finding whole mackerel (*Rastrelliger kanagurta*) in the stomach of this species. The predatory ability of adult Black Jewfish is further demonstrated in accounts of Thomas and Kunju (1981), who observed Black Jewfish contained in their stomachs up to 22 Malabar sole. Their opportunistic nature is well demonstrated by Newman (1995), who describes Black Jewfish off Western Australia taking lures while being preyed on themselves by whales.

A large number of stomachs were found to be empty (excluding those with expanded swim bladders) during the aggregation events at Muttee Head and Peak Point. The aggregation events of Black Jewfish at Muttee Head may involve thousands of individual fish (see Section 2.2.4), and to sustain this number of fish would require a large volume of prey. The limited data gained in this study presents 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, did not contrast with that observed in January and September.

3.3 MARK AND RECAPTURE

3.3.1 Introduction

Fin 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 (Blaber *et al.* 1990, Rhodes 1998), and often form the basis of commercial and recreational fisheries throughout the world (Gray and McDonnall 1993). Catches of Black Jewfish, one of the largest tropical sciaenids, forms 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 the 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). Anecdotal evidence suggests that the predictable seasonal aggregation of Black Jewfish in inshore waters of northern Australia facilitate the harvest of the species (Bowtell 1995, 1998).

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 (how far individuals move to specific aggregation sites), aggregation fidelity (whether fish move between different aggregations), participation rates (proportion of the population which participates in an aggregation event), residence times of individual fish at aggregation sites, and any potential differences between the sexes in any of the above (Zellar 1998, Johannes *et al.* 1999). The movement of the aggregating species is best examined through the mark and release of individuals.

The tagging and subsequent recapture of fish can provide data on a 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 parameters (Timmons and Howell 1995).

The aim of the tag and release component of the present study was to reveal the movement patterns of individual Black Jewfish in the NPA waters, and to provide preliminary data for the future estimation of the exploitation parameters and population size of jewfish. The placement of two tags in the same fish was adopted in order to obtain data for estimation of the tag loss rate. In conjunction with double tagging of wild stock, several specimens were retained in holding ponds to allow the closer examination of tag retention and tagging mortality.

3.3.2 Methods and materials

Double Tagging - Injinoo

The tag and release program for Black Jewfish was to be conducted at Muttee Head and Peak Point before, during, and after the anticipated aggregation period of late April to early August in 1999 and 2000. However, in 1999, Black Jewfish were tagged only in the period January to June while the species was available locally. No further tagging was conducted in 2000 due to the brevity of the periods in which Black Jewfish were caught in high 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 saltwater. Excess gas in the swim bladder was released using a hypodermic needle and the fish length then measured in millimetres. 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 to the dorsal musculature with a sharpened stainless steel applicator, which was withdrawn upon the barb of the tag lodging behind the pterygiophores. The tags were inserted at an angle of 45 degrees to the longitudinal axis of the fish, with the exposed section 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. Tagging was ceased when sharks became attracted to hooked fish at the fishing location.

The polypropylene tubing of the tag was marked with unique numbers at both ends of the tubing. Between these sets of 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 and run over the duration of the program. A recorded message asked the caller to provide details of the catch and was also prompted with which details to leave. A random prize draw was established to encourage complete reporting of tags. Sunstate Airlines donated the major prize of a return flight for two passengers to travel from Thursday Island to Cairns.

The tagging program and the associated prize draw were advertised on the Injinoo BRACS 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 numerous locations in the region of the NPA.

Captive Double Tagging - Karumba

Members of the Gulf Barramundi Restocking Association collected ten Black Jewfish (size 350-400 mm TL) in March 1999, by line fishing at the mouth of the Norman River. 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. The Black Jewfish were quarantined (two weeks) and placed in a 10-tonne capacity fibreglass tank equipped with a recirculating estuary water supply and biological filter. Grunter, *Pomadasys kaakan*, also occupied the tank. 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 330 days.

3.3.3 Results

In 1999, 114 Black Jewfish (size range 565-790 mm TL) were double tagged and released in the waters of the NPA. 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. Two additional specimens were deemed unfit for release, both of which had taken the hook deep in the throat (which was usually successfully avoided by quick reaction of the fisher following the bite). Six specimens were lost to sharks before being landed. Recaptures of tagged fish are detailed in Table 3.

The greatest movement identified by the return of tag details from recaptured specimens was from a fish that showed a westerly movement 30 km direct distance or 36 km along the coastline. This specimen was tagged when sampling an aggregation of Black Jewfish at Peak Point, and was recaptured 13 days later by subsistence fishers fishing a separate aggregation at Muttee Head. A further two specimens (tagged on separate days) were both recaptured within two days of release at the same aggregation site of Peak Point.

Table 3. Recaptures of Black Jewfish tagged in the Northern Peninsula Area.

Tag Number	Date of Release	Days Out	Total Length	Tag Location	Recapture Location	Movement Distance
058 Yellow 308 Orange	10 May 99	13	650	Peak Point	Muttee Head	30 km west
070 Yellow 320 Orange	15 May 99	2	650	Peak Point	Same area	0
079 Yellow 329 Orange	15 May 99	2	650	Peak Point	Same area	0

In the few tagged fish recaptured in the program (three recaptures of 114 tagged and released = 2.6%), both primary and secondary tags remained *in situ*. The double tagging experiment at the Karumba Holding Facility revealed a 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.

3.3.4 Discussion

The movement of a specimen from Peak Point to Muttee Head (30 km direct) represents the greatest recorded movement of a Black Jewfish in Queensland waters. More significant, is that the data represents the movement of an individual fish between two distinct aggregation sites. This 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 facilitate an increased susceptibility of the fish to exploitation. Since only one instance was recorded, this interpretation must be treated with caution.

The remaining two tags 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 at least into the following day. Again, if this was the normal behaviour of Black Jewfish, 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 (Zellar 1998, Johannes *et al.* 1999).

Analysis of the genetic population structure was conducted on specimens collected from both Muttee Head and Peak Point, and serves to extend the scant results of the present tagging program (see Section 3.4). 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. Samples from Muttee Head were also examined on a temporal scale, revealing no identifiable differences in stock structure over the duration of the aggregation event.

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 no tag-induced mortality was recorded. 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.

This first raises the question of the effectiveness of the avenue to receive information about recovered tags from the public. The freecall phone number printed on the tag was specifically 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 which may be called back upon. This was not suitable for a tagging program in the NPA as phone ownership in households was low (estimated to be less than 50% of households).

Hence, a dedicated line was adopted and a message recorded asking the caller to provide details of the catch. The recorded message prompted details to leave, as did the tag itself, which displayed printed instructions. This was deemed necessary because of the previously low exposure of the local people to fish tagging. Alternatively, the fishers had the option of returning tags directly to the Injinoo Community Council, or to the project biologist who was permanently located at Injinoo throughout the period in which Black Jewfish were being captured in 1999 and 2000.

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 the sites associated with other communities. While this scenario cannot be overlooked (many of Injinoo's residents have been officially recognised as the Traditional Owners of much of the NPA), there was no evidence to suggest that this situation had occurred in the present study. 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.

From the inception of the tagging program effort was applied to encourage fishers to provide details of the recaptured fish. A prize-draw was established in which the names of all fishers contributing tag returns were entered. The major prize, a return flight for two from Thursday Island to Cairns, was donated by Sunstate Airlines. Further, the tagging program and the prize-draw was extensively publicised in the region though numerous posters, the local BRAC's radio station, the local Torres News newspaper, and a public meeting held at Injinoo Community.

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) who 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

Perhaps the tagged Black Jewfish had migrated outside of the area were recapture was likely. In the NPA large areas of coastal and offshore waters are rarely fished (Phelan 2002). Certainly, several other sciaenids have demonstrated the ability to transit 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. O'Brien 1995, Peterson *et al.* 2000).

Further information on the movement of individual Black Jewfish in Queensland waters is also available through the National Fish Tagging Database administered by Suntag in a joint program between the Queensland Department of Primary Industries and the Australian National Sportfishing Association (see Table 4). The program also displays a below average recapture rate. As of March 1999, 153 black jewfish have been tagged and released in Queensland waters (size range 180-1180 mm), with ten recaptures (6.5 % return, state multiple-species average 8.6%).

Table 4. Recaptures of Black Jewfish tagged by the Suntag Program.

Tag Number	Date of Release	Days Out	Total Length	Tag Location	Recapture Location	Movement Distance
F874405	06 Dec 87	1	380	Off Karumba	Same area	0
B002092	07 Dec 87	1	380	Off Karumba	Same area	0
S22731	31 Jan 88	2	200	Mary Rv	Down Rv	15 km
Z62841	14 Apr 93	14	390	Fitzroy Rv	Same area	0
Z54935	15 Sep 93	-9	350	Fitzroy Rv	Same area	0
Z73376	08 Sep 93	116	350	Fitzroy Rv	Same area	0
K20503	28 Sep 95	7	290	Fitzroy Rv	Same area	0
K20504	05 Oct 95	19	300	Fitzroy Rv	Same area	0
K20205	14 Jul 95	8	315	Fitzroy Rv	Same area	0
K81108	01 Aug 98	131	420	Boundary Ck	Same area	0

The tagging and recaptures in the Suntag program have been made throughout the year, however only one revealed a significant movement over periods extending up to several months (see Table 4). Of the ten specimens recaptured (200-400 mm) one had moved slightly from the release site during 116 days at liberty. The remainder (one specimen excluded for insufficient data) were recaptured near to the same site they were tagged, including a specimen at large for 131 days. The Suntag data suggests that juvenile specimens, less than one year old, tend to remain in restricted areas for period extending up to four months.

Because of the low number of tag returns in the present study and the Suntag program, the results recorded in the present study must be interpreted with caution. Many more recaptures are required before the interrelationships of the Queenslands 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.

3.4 FISH STOCK GENETICS

This section was co-authored by Dr. Michelle Waycott

3.4.1 Introduction

In the decades since starch gel electrophoresis (Smithies 1955) 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 direct examination of DNA markers (Ferguson 1994). Novel 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 newly developed Amplified Fragment Length Polymorphisms (AFLP) technology combines the ability of screening a large number of DNA fragments using restriction enzymes and the ability to make copies of the DNA of interest using the polymerase chain reaction (Vos *et al.* 1995). The resultant AFLP markers are in many ways superior to alternative molecular markers, particularly in terms of the cost-efficiency, replicability and resolution at which markers of can be generated (Mueller and Wolfenbarger 1999). Hence, AFLP technology has began to emerge 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), and bacteria (e.g. Janssen *et al.* 1997). The technique has also been applied to insects (Zebitz *et al.* 1998), rats (Otsen *et al.* 1996), cattle (Ajmone-Marson 1997), birds (Questiau *et al.* 2000) and shrimp (Triantaphyllidus *et al.* 1997). Recently AFLP has been applied to the channel catfish *Ictalurus punctatus* and the blue catfish *I. furcatus* in the examination of reproductive traits (Dunham and Argue 2000) and in genetic linkage mapping (Liu *et al.* 1999). Liu *et al.* (1999) attests to the value of AFLP as a promising tool for genetic resource and population analyses in teleosts.

The technique has been described as a particularly powerful tool in 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 or merely a statistical artefact of an inadequate sampling regime.

The aim of this study was to use the AFLP technique (never before used in Australia on teleosts) to develop an efficient AFLP fingerprinting protocol for Black Jewfish in order to determine the levels of genetic differentiation in stocks which aggregate off Muttee Head in far northern CYP.

3.4.2 Methods and Materials

Sample collection

In 1999, material from a total of 51 Black Jewfish was collected for genetic analysis, comprising 27 samples from the NPA and 24 from the Northern Territory. Tracy Hay of the Northern Territory's Department of Primary Industries and Fisheries 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) and 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 *P. diacanthus* was isolated from ~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 3 h to overnight. To each sample 1 ml of 24:1 chloroform:isoamylalcohol and 290 µL of 5 M NaCl were added and gently shaken for 20 min. Following brief centrifugation the aqueous phase was collected and precipitated with isopropanol or before washing in 70% EtOH, air drying 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 PCR's. 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 AFLP kit manufacturer's protocol was followed except that between 15 and 60 ng of DNA were used in each analysis. Repeated analyses established the consistency of analyses using between 5 and 100 ng of DNA, and with either thermal cycler.

Samples were electrophoresed on 6% polyacrylamide gels (20:1 acrylamide:bis, 7.5M urea, 1 x TBE buffer) for approximately 2 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 AFLP kit's recommended protocol, using Fujifilm DI-AT H100 dry imaging film. Silver staining was carried out with a Promega Silver Sequence kit according to 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.

Sixteen primer pairs were screened with 5 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 3 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 comparison of 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 complete 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).

3.4.3 Results

Genetic diversity of Black Jewfish using AFLP analysis was readily assessed among the 51 samples analysed in 1999 (Figure 8) and the 58 samples analysed in 2000. Calculations of genetic diversity and gene flow among the CYP and Northern Territory populations from the 1999 samples was examined by Nei's analysis of gene diversity of the populations (Table 5, see Appendix 3 for expanded results). The results indicate a G_{ST} of 0.046 and a Nm of 10.210. These estimates indicate two things, the first, low genetic variability among the samples obtained, the second, that there is a high level of gene flow between the two localities samples were obtained. Multidimensional scaling ordination analysis is provided (Figure 9) demonstrating the lack of differentiation between the Northern Territory samples and the NPA.

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, hence these numbers are not directly comparable. To best represent the 2000 analysis, we have

Table 5. 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.

Ht = total heterozygosity; Hs = average heterozygosity; Gst = proportion of genetic diversity between populations; Nm = gene flow (Slatkin, 1987).

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

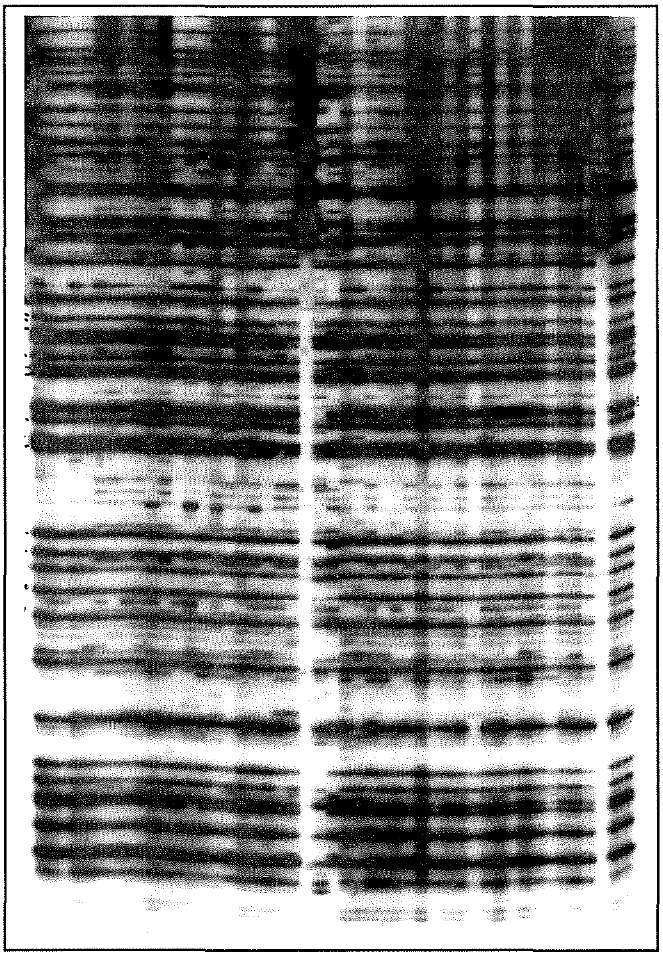


Figure 13. AFLP gel based on selective amplification E-AGG and M-CTG primers of 45 Black Jewfish sampled in 1999. The centre lane is a DNA size marker.

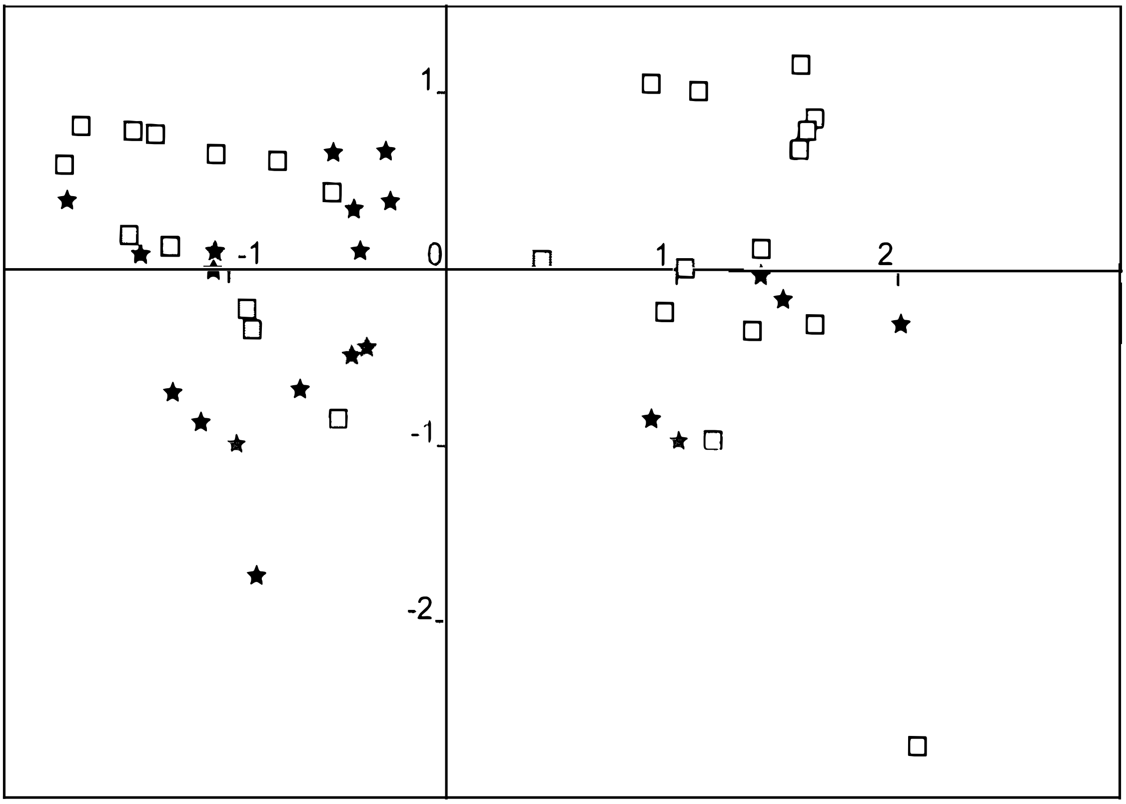


Figure 14. Non-metric multidimensional scaling analysis (SPSS 9.0) based on AFLP DNA fingerprinting analysis of Black Jewfish samples collected in 1999. Square boxes were samples collected from Cape York Peninsula, stars from the Northern Territory.

constructed a minimum spanning network (Figure 10) which demonstrates the relationship of genotypic data obtained. The network is centred around a large number of samples with a common genetic structure (see Table 6). Coming off this common genotype are a number of lower frequency genotype clusters that have significantly fewer individuals present. This 'star-like' minimum spanning tree is typical of populations that have been severely bottlenecked.

Table 6. Shared genotypes among the 2000 data based on AFLP Fingerprints of Black Jewfish from Muttee Head. Numbers in the first column refer to the genotype cluster numbers on the minimum spanning tree on Figure 10.

Minimum spanning tree genotype cluster	**Sample numbers**	**Number of samples with common genotype**
1	1, 2, 3, 4, 5, 7 ,8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 23, 25, 26, 27, 28, 38, 40, 47, 48, 54, 56, 57, 58, 59, 62	34
2	31, 37	2

3	15	1
4	34, 39	2
5	22, 24, 30, 32	4
6	45	1
7	6, 61	2
8	51	1
9	52	1
10	53	1
11	29	1
12	55	1
13	42	1
14	36, 41	2
15	33	1
16	60	1
17	35	1
18	43	1

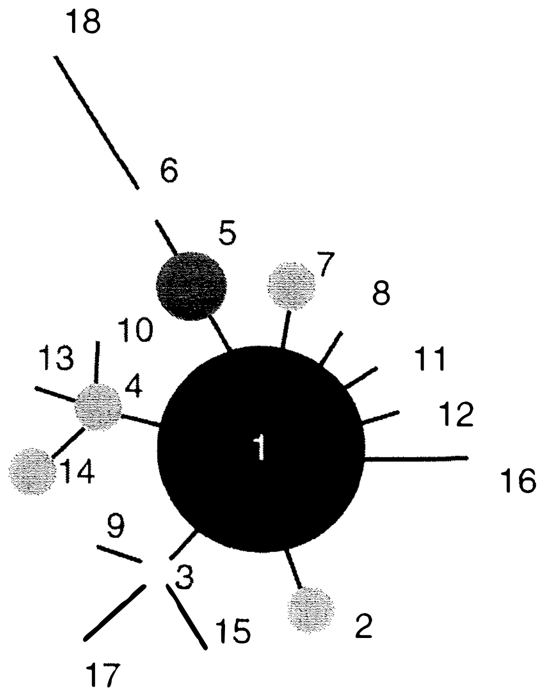


Figure 15. Minimum Spanning Tree representation of AFLP Fingerprinting genotypes. Circle sizes are proportional to the number of samples that contain that genotype. Branch lengths are proportional to the genetic distance in steps between each cluster. The shortest branch is a distance of 1.0 and the longest a distance of 3.0. Numbers next to circles refer to the genotype groups in Table 6.

3.4.4 Discussion

DNA fingerprinting of Black Jewfish in the present study has demonstrated that genetic identity can be determined using Amplified Fragment Length Polymorphisms. The Black Jewfish stock sampled in the NPA and Northern Territory in 1999 appear to comprise one homogeneous population (G_{ST} 0.046). This was consistent with the findings of Keenan (1997) who identified a Rogers (1972) genetic distance between sub-populations of Black Jewfish to be 0.049. Genetic analysis of a number of species inhabiting northern Australian waters has produced similar low levels of genetic diversity. This result is supported by additional evidence of high levels of genetic similarity in 2000 from the NPA.

In northern Australian waters extensive connections of fin fish populations over large distances have also been identified in: red emperor *Lutjanus sebae*, spangled emperor *Lethrinus nebulosus*, rankin cod *Epinephelus multinotatus*, sweetlip *Lethrinus choerorynchus* (Johnson *et al.* 1993), and the Spanish mackeral *Scomberomorus commerson* (Shaklee 1990). Homogenous populations of northern Australian stocks have also been identified in two shark species *Carcharhinus sorrah* and *C. tilstoni* (Lavery and Shaklee 1989), four species of squid of the genus *Photololigo* (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 have received universal acceptance (Yeatman and Benzie 1994). Among the most popularly accepted is the 'habitat specialist-generalist model' proposed by Smith and Fujio (1982), which is supported by several marine studies (Woodruff *et al.* 1983, 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 in 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 Section 3.2). The opportunistic feeding pattern has also been described by Rao (1963), Thomas and Kunja (1981), Dhawan (1971) and Bhatt *et al.* (1967).

(2) <u>The species occurs over a wide range of bottom substrates and wide depth range.</u> Black Jewfish have been caught in the NPA during the present study from a variety of habitats and depths ranging from sandy beaches and deepwater holes to rivers. In the Northern Territory Black Jewfish are reportedly caught offshore to depths of 100 m (Tracy Hay, DPIF, pers. comm.).

(3) <u>The species displays few morphological adaptations.</u> The Black Jewfish displays few morphological adaptations and Trewavas (1977) infers Black Jewfish would not be far

unlike the ancestral Nibeine in that it is both the least specialised of the tribe and has the widest distribution.

The maintenance of homogeneity in the Black Jewfish population may be attributable to the level of gene flow (>10 migrants per generation) observed in the present study. Migration rates in the order of one in ten individuals per generation are believed to be sufficient to keep gene frequencies similar (Kimura and Ohta 1971). Menzies (1981) calculated that as little as 1 in 10,000 to 1 in 100,000 immigrants per year would prevent genetic discreetness. Hence, several studies on tropical teleosts which demonstrate a high level of gene flow (≥5 migrants per generation) attribute this to the near-homogeneity of the study species (e.g. Lacson *et al.* 1989, 1992, Planes 1993, Doherty *et al.* 1995).

The close proximity of known aggregation sites in the NPA may act as stepping-stones that enhance the movement of Black Jewfish around the NPA. The aggregation sites of Muttee Head and Peak Point are separated by <30 km, and the tagging component of the present study detected the movement a specimen from Peak Point to Muttee Head during the period the aggregations (see Section 3.3.3). These observations also need to be placed in the context of the overall genetic variability of a species and the causes of that genetic variability. Additional causes of genetic uniformity may result from low population size at some point in recent history and a decrease in the effective breeding population. In this study, there may be evidence of a decrease in breeding population as seen in the minimum spanning tree from the 2000 sample.

The additional 2000 data supports the apparent uniformity of population structure in Black Jewfish from the NPA. There is no evidence of a major temporal changes in allele frequencies within regions in this study although this has been reported in several species (Smith 1979, Gauldie and Johnson 1980, Dempson *et al.* 1988, Gyllensten and Ryman 1988). The continued evidence of high degree of genetic uniformity within the NPA and that genetic diversity may in fact be decreasing, suggests that a genetic bottleneck may be being experienced by this species. Additional data from a wider range of sites and aggregations would be of particular value to determine the extent of genetic erosion that appears to be ongoing in this species.

The AFLP technique has proven itself in the present study as a robust technique of direct DNA analysis available to fisheries science. Additionally, the sampling regime of the AFLP technique is advantaged in the study of teleosts in that:

- Very little equipment and training is required from field collections. The only equipment needed are a pair of wire cutters and sample tubes filled with 70-80% ethanol. In the present study the upper sections of the first three dorsal spines (and connecting membrane) was removed and simply placed within the vial.

- Lack of transport restriction on necessary sampling equipment. Where transport regulations do restrict the transport of ethanol (e.g. Australia Post), dimethylsulfoxide (DMSO) solution may be used in substitution. During the present study an attempt to use samples for allozyme analysis became impossible because of the requirement for liquid nitrogen and its associated transport restrictions (imposed by the regional airlines and coastal barge services of the NPA) as well as the product's limited shelf life.

- Workable results can be generated from partly degraded tissue. No significant difference was identified from samples preserved immediately and those samples attained from specimens which had been frozen in household freezer for up to six weeks after initially being held on dinghies for up to six hours without ice.

- A lower number of specimens are required for sampling due to the greater number of informative points generated per sample. 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 will be of benefit to 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 DNA starting quantities (50 ng of DNA was sufficient in the present study). This presents the potential for the examination of juveniles and small teleosts.

- The AFLP technique allows the adoption of a minimally invasive tissue sampling regime for sampling teleosts. The sampling of fin-tips (1cm * 1cm sections used in present study) allows for the specimens to be released with minimal damage. Very high regeneration rates of previously fin-clipped fish has previously been recorded (see Morizot *et al.* 1990). The method does not necessitate the death of specimens (c.f. allozyme analysis which require liver and muscle tissue samples, e.g. Keenan 1997) presenting obvious advantages when examining endangered or heavily exploited stocks. Sampling may be also be conducted in conjunction with tag and release studies and/or cannular biopsy (used for sex determination).

These factors point to the conclusion that AFLP provides a cost-effective procedure to examine the genetic structure of Black Jewfish, and could be a useful tool in genetic resource and population studies in other teleosts. This study supports the need for additional information about the population biology of this species as it provides additional evidence of genetic erosion of the fisheries resource.

4. BENEFITS

An on-going consultation process throughout the lifetime of the project has ensured that the implications of the research have already been recognised by both management authorities and the communities of the NPA. In response to the research findings of the present project, the Injinoo Land Trust (representing the Traditional Land Owner Groups of the Anggamuthi, Atambaya, Gudang and Yadhaykenu Aboriginal people), in cooperation with the Injinoo Community Council, have self-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 8). The two-year ban was initiated on the 7th of August 2000 following a series of community meetings.

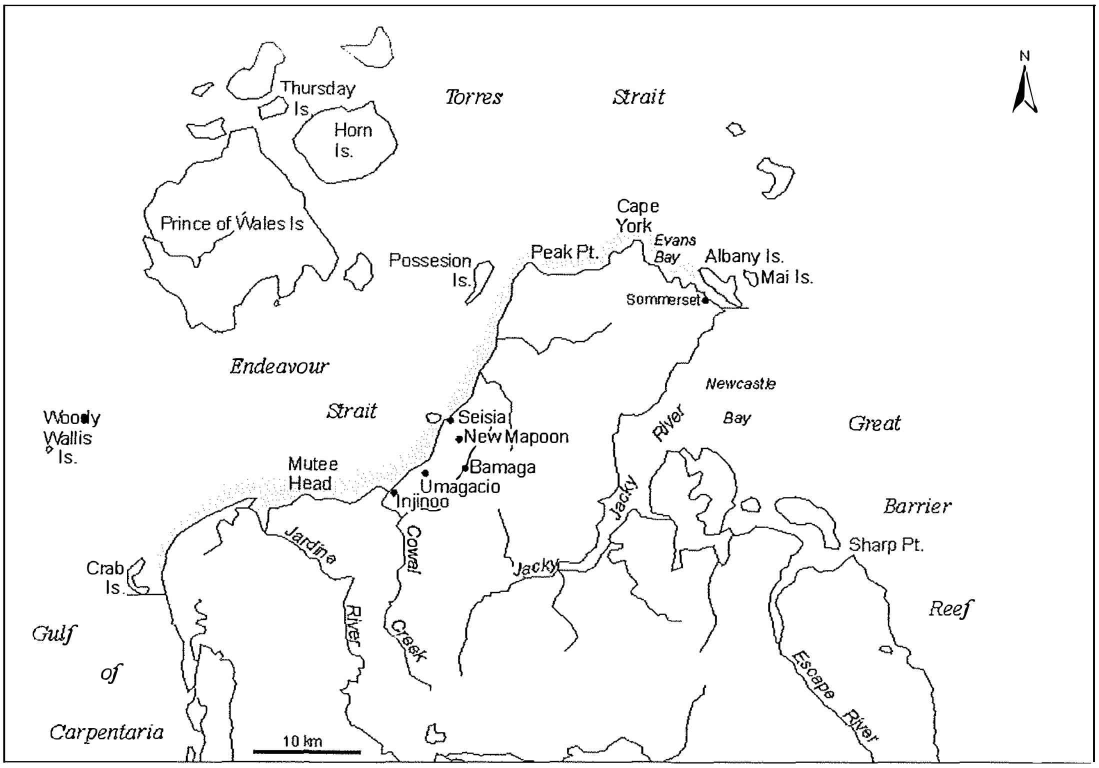


Figure 16. Location of area closed to the harvest of Black Jewfish.

Through appropriate consultation, the community-based management initiative has developed into a regional agreement with comprehensive support across the NPA. Representing each of the communities of the NPA, the Community Councils of Umagico, Bamaga, New Mapoon and Seisia have undertaken to participate in the two-year ban on the take of Black Jewfish. The Torres Shire Council and the Kaurareg Nation have also signed the agreement. Proprietors and operators of all tourist accommodation and fishing charter boats operating in the NPA region have pledged full cooperation with the initiative. All parties have signed their support.

The regional agreement is a response to the decline observed in the size of the Black Jewfish taken in the NPA in recent years. The catalyst for this action was the result of the present project that demonstrated an almost complete lack of adult Black Jewfish in the catch taken from the waters of the NPA. The aim of the two-year ban is to allow Black Jewfish in the local area to reach a mature size so that prospects for the replenishment of stocks are improved. Each of the parties involved recognises that the two-year ban may not provide adequate time for the complete recovery of the proportion of the adults in the population. The parties concerned 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 stocks.

All parties have advocated a review of the stock condition prior to the end of the two-year period, so that an informed decision can be made on future management needs. The exact nature of the review mechanism must be negotiated with all interested parties and the relevant resource management agencies. There exists a strong desire among the Indigenous and non-Indigenous community of the NPA to maintain local management input and decision-making. They believe that the high community involvement should be recognised by fisheries managers as highly beneficial to the acceptance of and compliance with the management solution.

Adding to the uniqueness of this community-developed and -imposed management arrangement, the Indigenous groups have asked for legislative backing for this species-specific ban. Each of the Indigenous communities have expressed a willingness to forfeit their statutory exemption from catch restrictions imposed on the species under the *Queensland Fisheries Act* 1994. Preliminary discussions with Cape York Land Council indicate that this might be possible without permanent impairment of native title. Indigenous community leaders are presently negotiating with Queensland Fisheries Service in relation to facilitating greater accountability of individuals.

Indigenous community leaders are advocating for the Queensland Fishing and Boating Patrol to enforce the ban over the two-year period. The majority of the Indigenous communities in the NPA have expressed a strong desire to see local community members involved in such patrols as community liaison officers. Similar Indigenous liaison programs are already employed by many organisations in Queensland; for example, the Great Barrier Reef Marine Park Authority, Australian Fisheries Management Authority, and the Queensland Police Force.

The State and Federal Institutions whose role it is to provide for the management and research needs of the states' fisheries have a clear responsibility to respond to the community demands presented by this regional agreement. Fulfilment of these responsibilities will require substantial investment by management agencies. Community members are prepared to make sacrifices by forfeiting their statutory right to an economically important resource.

5. RECOMMENDATIONS FOR FURTHER RESEARCH.

The implementation of the two-year closure presents new obligations for management and research agencies alike, to meet highly developed public expectations. The regional agreement developed in the NPA is a product of much public consultation and discussion, and has resulted in a set of clear resolutions. The research resolution requested by all parties to the regional agreement, calls for further stock assessment to be conducted in the NPA. Continued investigation on the local stock has been requested in order that decision-makers will be adequately informed to review management needs at the end of the two-year period for which the harvest of the species is banned (see Section 4).

Now that critical baseline information is available on the species (e.g. length at age, size at first maturity, etc), 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 suitable for extended resource monitoring programs, and are advantaged in being simplistic and cost-effective. Future monitoring of Black Jewfish in the NPA could be conducted by local community groups with a minimum of training. The value of length-frequency data is exemplified in the Fisheries (Gulf of Carpentaria Inshore Fin Fish) Management Plan 1999. The Plan aims to protect spawning target species, the achievement of which 'may be measured only by the abundance of juvenile target species'. The review event for the 'achievement of this objective is a significant decline in the abundance of juvenile target species'.

Such work, even conducted within the bounds of the no harvest rules of the agreement, provides the opportunity to further develop our knowledge of the species' biological traits. The collection of length-frequency data also provides the opportunity for minimally-intrusive sampling, such as genetic analysis using the AFLP technique, and reproductive analysis using cannular biopsy. This study identifies the need for further investigation of the observed genetic erosion and calls for further investigation of the reproductive status of Black Jewfish. Tag and release studies may also be continued, although a low rate of recapture especially within the closure period should be anticipated.

The two-year ban on the harvest of Black Jewfish presents many opportunities for scientific study. The initial responses of newly exploited fish stocks are commonly documented where previously unfished areas have became accessible, however, few opportunities have been gained to quantify the recovery of an over-exploited population granted a temporary relief from fishing pressure (Jennings and Lock 1996). Such a rare opportunity warrants further stock assessment. Comprehensive stock assessment would further develop our understanding of the dynamics of the resource in relation to fishing pressure and regulation. The efficiency of further investigations may be upheld by continuing to focus primarily on the aggregation events, as these present invaluable opportunities to capitalise on the spatial compression of the otherwise widespread animals.

The absolute effect of fishing aggregations will remain difficult to assess unless the relationship between the aggregating fish and the overall population can be developed. Determining the proportion of fish in the population that participate in each aggregation is therefore a necessary task. In several tropical species it has been observed that varying proportions of the adult population do not take part each year in aggregation events; e.g. the sea mullet *Mugil cephalus* (Thomas 1955), barramundi *Lates calcarifer* (Moore and Reynolds 1982), yellowfin bream *Acanthurus australis* (Pollock 1982, 1984). Accomplishing an equivalent understanding of the population necessitates further work outside of the temporal and spatial scale of the aggregation events focused on in this study. Such work may prove a formidable task in the NPA due to be the difficulty of attaining sufficient numbers of specimens outside of the scope of the aggregation.

The truncated population size and age structure of Black Jewfish in the waters of the NPA necessitates a degree of contingency to be incorporated into any plans to study the species in the region. The relatively unexploited aggregation that forms annually off Cullen Point may provide a more suitable basis for biological studies of Black Jewfish. Passive acoustics (hydrophone recordings) may be useful in locating the number and proximity of aggregations (e.g. Luczkovish *et al.* 1998). Hydroacoustics are also increasingly being adopted to describe cycles of abundance in soniferous fish, and have already been successfully applied to sciaenids (e.g. Saucier and Baltz 1993, Connaughton and Taylor 1995). Sound production has been observed in many sciaenids (Tavolga 1971, Guest and Lasswell 1978, Mok and Gilmore 1983), including the Black Jewfish (Grant 1997).

Zellar (1998) also provides that the effects of fishing pressure on spawning aggregations of a population of fish is strongly influenced by;

- the residence times of individual fish at aggregation sites, and,
- the catchment distances (how far do individuals move to specific aggregation sites).

Acoustic tags hold the potential to reveal such information. These external or internally fitted tags emit acoustic pulses that are recorded by receivers either temporarily or permanently in situ. The tags may also be equipped with temperature or pressure sensors to reveal further information on the movement patterns of the fish. Ultrasonic telemetry has successfully been adopted in many studies of teleosts (e.g. Szedlmayer 1997, Arendt *et al.* 2001).

Ultimately, the longterm objective of future research on the species must be to develop the means to rapidly assess stock abundance patterns as they change. The present study attests to this need. Within the period starting when concerns for the NPA stock were raised in 1995, and extending through to 2000 when management responses where rapidly implemented following the two years of stock assessment, the structure of the local Black Jewfish population changed dramatically. In 1995 full sized adult fish (<150 cm TL) where caught for the final time from Muttee Head, by 2000, catches at Muttee Head was based on one and two year old fish (~65 to 45 cm TL).

New analytical techniques and innovative technologies are constantly changing the way we evaluate aquatic life. Active acoustics (sonar) are an increasingly available for the cost-effective estimation of stock biomass and changes in abundance. Hydroacoustic techniques of determining the size distribution of the stock have become simpler and more effective (Jech and Luo 2000). Several studies provide evidence of the promising validity of size estimates derived from active acoustic surveys (e.g. Hartman *et al.* 2000, Yule 2000). If the presently unknown parameters characteristics of Black Jewfish aggregations can be determined (ie. the number of distinct spawning aggregation sites, catchment distances, participation rates, and residence times), active acoustic surveys may offer a viable option for the real time assessment of fish stocks.

6. CONCLUSIONS

This study delivered outcomes that enhanced the ability of resource users and managers alike to accomplish informed decision-making that contributes to the sustainable use of the resource. While the lack of adult fish in the harvested population hampered the realisation of some of the objectives of this study, the subsequent management outcomes have far surpassed original expectations.

Addressing the objectives:

I. To undertake a preliminary survey of the fishery for Black Jewfish in Injinoo Community waters, far northern Cape York Peninsula:
   - The vast majority of fish caught in 1999 and 2000 were one to two years short of breeding age.
   - CPUE figures were high but can be misleading where aggregations are concerned.
   - Total annual catch figures for Black Jewfish were established for the years 1999 and 2000.
   - Sexually mature fish constituted less than 1% of the catch in 1999 and 2000.
   - Evidence for a reduced age of first female sexual maturity was found.
   - Tagging results indicate potential for substantial movement not previously recorded in Queensland.
   - AFLP DNA analysis showed strong homogeneity between Northern Territory and NPA stocks.
   - For the first time jewfish did not follow the aggregation trends thought to be reliable, based on records from the previous decade.

II. To characterise the annual Jewfish aggregation event in terms of the time of formation and dispersal, species identification, reproductive status and population structure;
   - A new aggregation site was recorded.
   - The study found that aggregations were not as predictable as previously thought.
   - Limited dispersal information was gleaned from tagging studies
   - Two species of jewfish collected from the NPA waters were identified by the Queensland Museum.
   - Few specimens were found to be reproductively active.
   - The population structure was skewed towards juveniles.

III. To characterise the fishery in terms of catch and effort by the various user groups through on-ground surveys;
   - Indigenous peoples have a strong reliance on the local Black Jewfish fishery.
   - A separate document is provided which details the catch and effort of the Indigenous sector (Phelan 2002). The report demonstrates that Jewfish are an important component of the local subsistence fishery.

IV. To collate available historical data on the fishery to establish trends over time;
   - Historical record has been established.

5. To advise the Injinoo Community and the Queensland Fisheries Service on further investigations required for stock assessment, determination of resource condition, and the identification of possible sustainability indicators for long-term monitoring in the fishery:
    - Further stock assessment is required to ensure that opportunity for the recovery of the Black Jewfish stock is provided.
    - Further investigation of biological parameters might be more fruitfully carried out near Old Mapoon where the stock appears to be in better condition.

Management outcomes:

- A two-year ban on jewfish has been declared by relevant Indigenous parties.
- Proprietors and operators of all tourist accommodation and fishing charter boats in the region have undertaken to participate in the two-year ban.
- Dialogue has been entered into with the QFS relating to the legal expression of this agreement.

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9. APPENDIX 1: INTELLECTUAL PROPERTY.

As per the project agreement:

- 'Biological data in the form of species identification, population, age and length structure, gut contents, reproductive status and summary fisheries data in the form of total catch and aggregated catch rates will be made available to both the Injinoo Community and the FRDC/QFMA, but information of a personal and/or cultural nature will remain the property of the person or people concerned.'

10. APPENDIX 2: PROJECT STAFF.

The following staff from Balkanu Cape York Development Corporation, Queensland Department of Primary Industries, James Cook University, Injinoo Aboriginal Community, and members of the Project Steering Committee, contributed to project activities during the lifetime of the project:

Balkanu Cape York Development Corporation

Mr Chris Roberts	Principal Investigator
Mr Michael Phelan	Fisheries Biologist
Mr Deen Popoola	Financial Controller
Mr Tony Varnes	Financial Manager

Queensland Department of Primary Industries

Mr Rod Garrett	Co-Investigator
Dr Neil Gribble	Co-Investigator

James Cook University

Dr Michelle Waycot	Geneticist

Project Steering Committee

Mr John Charlton	Cape York Adventures
Mr John Clark	Balkanu Cape York Development Corporation
Mr Peter Finglis	Queensland Department of Primary Industries
Mr Laurie Gwyne	Queensland Fisheries Service
Mr Bill Kehoe	Queensland Seafood Industry Association
Dr Helene Marsh	James Cook University
Mr Robbie Sallee	Injinoo Community/ATSIC

11. APPENDIX 3: GENETIC RESULTS.

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.

Ht = total heterozygosity; Hs = Average heterozygosity; Gst = proportion of genetic diversity between populations; Nm = gene flow (Slatkin, 1987).

Selective amplification primer pair	Locus - Banding Position	Sample Size - Number of Individuals	Ht	Hs	Gst	Nm*
E-ACC, M-CAC	.1	50	0.0000	0.0000		
E-ACC, M-CAC	.2	50	0.0000	0.0000		
E-ACC, M-CAC	.3	50	0.2595	0.2577	0.0071	70.2506
E-ACC, M-CAC	.4	50	0.0000	0.0000		
E-ACC, M-CAC	.5	49	0.4505	0.4230	0.0611	7.6898
E-ACC, M-CAC	.6	50	0.1769	0.1577	0.1087	4.0990
E-ACC, M-CAC	.7	50	0.0000	0.0000		
E-ACC, M-CAC	.8	50	0.4677	0.4669	0.0016	312.1137
E-ACC, M-CAC	.9	50	0.0000	0.0000		
E-ACC, M-CAC	.10	50	0.0000	0.0000		
E-ACC, M-CAC	.11	49	0.4796	0.4747	0.0102	48.6629
E-ACC, M-CAC	.12	50	0.0601	0.0598	0.0045	111.5539
E-ACC, M-CAC	.13	50	0.0000	0.0000		
E-ACC, M-CAC	.14	50	0.0984	0.0981	0.0033	152.6105
E-ACC, M-CAC	.15	50	0.0000	0.0000		
E-ACC, M-CAC	.16	50	0.0000	0.0000		
E-ACC, M-CAC	.17	50	0.2259	0.2243	0.0072	68.8204
E-ACC, M-CAC	.18	50	0.0000	0.0000		
E-ACC, M-CAC	.19	50	0.0385	0.0377	0.0200	24.4900
E-ACC, M-CAC	.20	50	0.0000	0.0000		
E-ACC, M-CAC	.21	50	0.3689	0.2878	0.2198	1.7743
E-ACC, M-CAC	.22	50	0.4564	0.4493	0.0155	31.8573
E-ACC, M-CAC	.23	50	0.0000	0.0000		
E-ACC, M-CAC	.24	50	0.0000	0.0000		
E-ACC, M-CAC	.26	50	0.0000	0.0000		
E-ACC, M-CAC	.27	50	0.4962	0.4239	0.1457	2.9317
E-ACC, M-CAC	.28	50	0.0000	0.0000		
E-ACC, M-CAC	.29	50	0.0000	0.0000		
E-ACC, M-CAC	.30	50	0.0577	0.0559	0.0306	15.8180
E-ACC, M-CAC	.31	50	0.0984	0.0981	0.0033	152.6105
E-ACC, M-CAC	.32	50	0.4819	0.4434	0.0798	5.7641
E-ACC, M-CAC	.33	50	0.0000	0.0000		
E-ACC, M-CAC	.34	50	0.0000	0.0000		
E-ACC, M-CAC	.35	50	0.0000	0.0000		
E-ACC, M-CAC	.36	50	0.0000	0.0000		
E-ACC, M-CAC	.37	50	0.1521	0.1514	0.0044	112.4526
E-ACC, M-CAC	.38	50	0.0000	0.0000		
E-ACC, M-CAC	.39	50	0.1769	0.1577	0.1087	4.0990
E-ACC, M-CAC	.40	50	0.0000	0.0000		
E-ACC, M-CAC	.41	50	0.0000	0.0000		
E-ACC, M-CAC	.42	50	0.0000	0.0000		

E-ACC, M-CAC	.43	50	0.0000	0.0000		
E-ACA, M-CAG	.1	50	0.0000	0.0000		
E-ACA, M-CAG	.2	50	0.0000	0.0000		
E-ACA, M-CAG	.3	50	0.0000	0.0000		
E-ACA, M-CAG	.4	50	0.4464	0.4460	0.0008	632.3078
E-ACA, M-CAG	.5	50	0.0000	0.0000		
E-ACA, M-CAG	.6	50	0.0000	0.0000		
E-ACA, M-CAG	.7	51	0.0000	0.0000		
E-ACA, M-CAG	.8	49	0.3742	0.3633	0.0291	16.6716
E-ACA, M-CAG	.9	50	0.0000	0.0000		
E-ACA, M-CAG	.10	50	0.0000	0.0000		
E-ACA, M-CAG	.11	50	0.0000	0.0000		
E-ACA, M-CAG	.12	50	0.0000	0.0000		
E-ACA, M-CAG	.13	50	0.0000	0.0000		
E-ACA, M-CAG	.14	50	0.0000	0.0000		
E-ACA, M-CAG	.15	50	0.4839	0.4678	0.0332	14.5413
E-ACA, M-CAG	.16	50	0.0000	0.0000		
E-ACA, M-CAG	.17	50	0.0000	0.0000		
E-ACA, M-CAG	.18	50	0.0000	0.0000		
E-ACA, M-CAG	.19	50	0.4990	0.4903	0.0174	28.1763
E-ACA, M-CAG	.20	51	0.0000	0.0000		
E-ACA, M-CAG	.21	51	0.0000	0.0000		
E-ACA, M-CAG	.22	51	0.0000	0.0000		
E-ACA, M-CAG	.23	51	0.0000	0.0000		
E-ACA, M-CAG	.24	51	0.0000	0.0000		
E-ACA, M-CAG	.25	51	0.0000	0.0000		
E-ACA, M-CAG	.26	51	0.0000	0.0000		
E-ACA, M-CAG	.27	51	0.0000	0.0000		
E-ACA, M-CAG	.28	51	0.4773	0.4715	0.0121	40.7783
E-ACA, M-CAG	.29	51	0.4965	0.4962	0.0007	760.0472
E-ACA, M-CAG	.30	51	0.0000	0.0000		
E-ACA, M-CAG	.31	51	0.0000	0.0000		
E-ACA, M-CAG	.32	51	0.0000	0.0000		
E-ACA, M-CAG	.33	51	0.0000	0.0000		
E-ACA, M-CAG	.34	51	0.0000	0.0000		
E-ACA, M-CAG	.35	51	0.0000	0.0000		
E-ACA, M-CAG	.36	51	0.0000	0.0000		
E-ACA, M-CAG	.37	51	0.0000	0.0000		
E-ACA, M-CAG	.38	51	0.0000	0.0000		
E-ACA, M-CAG	.39	51	0.0000	0.0000		
E-ACA, M-CAG	.40	51	0.0000	0.0000		
E-ACA, M-CAG	.41	51	0.0000	0.0000		
E-AAT, M-CTA	.1	50	0.0000	0.0000		
E-AAT, M-CTA	.2	48	0.4059	0.4023	0.0090	55.2179
E-AAT, M-CTA	.3	46	0.0000	0.0000		
E-AAT, M-CTA	.5	50	0.0000	0.0000		
E-AAT, M-CTA	.6	48	0.0000	0.0000		
E-AAT, M-CTA	.8	50	0.0000	0.0000		
E-AAT, M-CTA	.9	50	0.0000	0.0000		
E-AAT, M-CTA	.10	50	0.0000	0.0000		
E-AAT, M-CTA	.11	50	0.0000	0.0000		
E-AAT, M-CTA	.12	50	0.0000	0.0000		
E-AAT, M-CTA	.13	49	0.0000	0.0000	****	****
E-AAT, M-CTA	.14	48	0.4519	0.4465	0.0120	41.2141
E-AAT, M-CTA	.15	48	0.4476	0.4285	0.0427	11.2145

E-AAT, M-CTA	.16	50	0.0000	0.0000	****	****
E-AAT, M-CTA	.17	50	0.3201	0.3201	0.00012	000.0000
E-AAT, M-CTA	.18	50	0.0192	0.0190	0.0098	50.4951
E-AAT, M-CTA	.19	50	0.0000	0.0000	****	****
E-AAT, M-CTA	.20	50	0.0000	0.0000	****	****
E-AAT, M-CTA	.23	48	0.3714	0.3678	0.0096	51.4486
E-AAT, M-CTA	.24	50	0.0000	0.0000	****	****
E-AAT, M-CTA	.25	49	0.4635	0.4325	0.0668	6.9871
E-AAT, M-CTA	.26	50	0.0000	0.0000	****	****
E-AAT, M-CTA	.27	50	0.0000	0.0000	****	****
E-AAT, M-CTA	.28	50	0.0000	0.0000	****	****
E-AAT, M-CTA	.29	50	0.0000	0.0000	****	****
E-AAT, M-CTA	.30	50	0.0000	0.0000	****	****
E-AAT, M-CTA	.31	48	0.4249	0.4085	0.0387	12.4074
E-AAT, M-CTA	.32	50	0.4785	0.4047	0.1543	2.7410
E-AAT, M-CTA	.33	50	0.4871	0.4743	0.0264	18.4541
E-AAT, M-CTA	.34	49	0.0795	0.0787	0.0105	47.1314
E-AAT, M-CTA	.35	48	0.4919	0.4768	0.0307	15.8015
E-AAT, M-CTA	.36	49	0.4902	0.4884	0.0037	135.9449
E-AAT, M-CTA	.37	50	0.0000	0.0000	****	****
E-AAT, M-CTA	.38	50	0.1769	0.1577	0.1087	4.0990
E-AAT, M-CTA	.39	50	0.2417	0.2411	0.0026	192.0551
E-AAT, M-CTA	.40	48	0.4761	0.4065	0.1463	2.9180
E-AAT, M-CTA	.41	50	0.0000	0.0000	****	****
E-AAT, M-CTA	.42	48	0.4716	0.4701	0.0032	157.1553
E-AAT, M-CTA	.44	50	0.4962	0.4594	0.0741	6.2500
E-AAT, M-CTA	.45	50	0.0000	0.0000	****	****
E-AAT, M-CTA	.46	49	0.4992	0.4486	0.1014	4.4298
E-AAT, M-CTA	.47	50	0.0000	0.0000	****	****
E-AAT, M-CTA	.48	50	0.0000	0.0000	****	****
Mean		**50**	**0.1160**	**0.1106**	**0.0467**	**10.2101**
St. Dev			**0.0360**	**0.0328**		

12. APPENDIX 4: POSTER PROMOTING THE CLOSURE.

Please see following page.

Traditional Owners

call for

Ban on catching Jewfish from Albany Island to Crab Island

JEWFISH

REQUEST FROM THE TRADITIONAL OWNERS and COMMUNITY LEADERS OF THE NORTHERN PENINSULA AREA and THURSDAY ISLAND

For a number of years the people of the NPA have been concerned by the number of jewfish caught in the NPA and the greed of some fishermen.

In 1998 the Injinoo community, with charter boat fishermen and other community members, joined forces with Balkanu Cape York Development Corporation, James Cook University and DPI Fisheries. The study found that over the last 2 years the fish caught were 1 to 2 years short of breeding age.

As soon as the traditional owners discovered this they called for a 2 year closure of the fishery so that the young fish can reach adult size.

We call on all people who live in and come to the Northern Peninsula Area, not to catch jewfish or fish in places where you are likely to catch them. This will save jewfish for our future and our children's future.

TRADITIONAL OWNERS and COMMUNITY CHAIRMEN
support a
2 YEAR BAN
on jewfish
starting January 1, 2001 to January 1, 2003 and to be reviewed at that time.

Signed:
TRADITIONAL OWNERS for the Injinoo Land Trust
Mary Eseli Deputy chair
George Ropeyarn [Injinoo Chairman]
Charles Woosup [Umagico Chairman]
Reg Williams [Bamaga Chairman]
Billy Daniel [New Mapoon Chairman]
Joseph Elu [Seisia Chairman]
Pedro Steven [Thursday Island, Mayor]

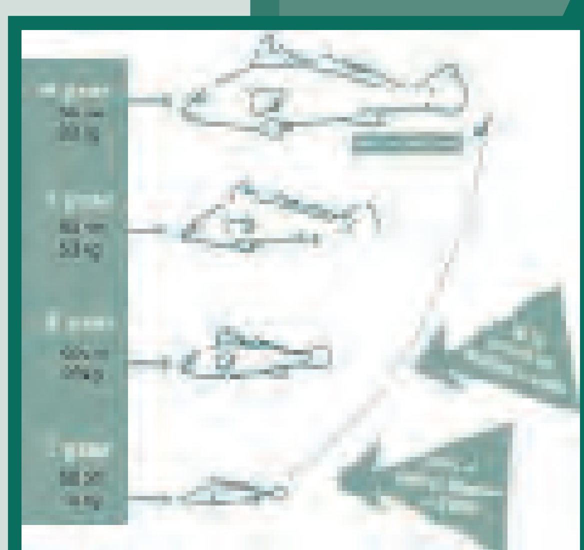
Research Results

Jewfish need to be four years old to breed. A four year old female black jewfish is about 1m or 3ft 3 ins long. Anything smaller is likely to be a young fish that has not yet had the chance to breed.

In 1998 about 80% of the catch was 3 years of age. In 1999, 90% of the catch was 2 years of age. Small breeder numbers mean less fish being hatched. The fish numbers that are breeding are also vulnerable to mishaps and attacks from other predators.

This serious situation has resulted in traditional owners requesting that everyone stop catching all Jewfish. Fish Tags in this area indicate that the fish are moving around a lot across the region. That is why, in order to protect them, a large area must be closed.

Traditional owners are requesting that this ban be maintained until the undersized Jewfish have a chance to grow to breeding size.



If you know a place where Jewfish are please don't fish there.

Balkanu
Cape York Development Corporation

Injinoo land Trust

FISHERY BIOLOGY AND MANAGEMENT OF BLACK JEWFISH *PROTONIBEA DIACANTHUS* (SCIAENIDAE) AGGREGATIONS NEAR INJINOO COMMUNITY, FAR NORTHERN CAPE YORK.

STAGE 2: STOCK MANAGEMENT NEEDS FOLLOWING THE TWO YEAR CLOSURE IMPLEMENTED UNDER A REGIONAL AGREEMENT.

July 2005

M.J. Phelan

FRDC PROJECT NUMBER 98/135

Balkanu
Cape York Development Corporation

Australian Government
Fisheries Research and Development Corporation

JCU
JAMES COOK UNIVERSITY

Queensland Government
Department of Primary Industries and Fisheries

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July 2005

FRDC Project Number 98/135

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FUNDING ORGANISATION

Fisheries Research Development Corporation

98/135 Fishery Biology and Management of Black Jewfish, *Protonibea diacanthus,* (Sciaenidae) Aggregations near Injinoo Community, Far Northern Cape York. Stage 2: Stock Management Needs following the Two Year Closure implemented under a Regional Agreement.

M.J. Phelan

Balkanu Cape York Development Corporation

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98/135 Fishery Biology and Management of Black Jewfish, *Protonibea diacanthus,* (Sciaenidae) Aggregations near Injinoo Community, Far Northern Cape York. Stage 2: Stock Management Needs following the Two Year Closure implemented under a Regional Agreement.

PRINCIPAL INVESTIGATOR: Mr M.J. Phelan

ADDRESS Black Jewfish Project
C/O Chris Roberts
Balkanu Cape York Development Corporation
PO Box 7573
32 Florence St
Cairns QLD 4870
Telephone: 07 4051 9089; Fax: 07 4051 9088

OBJECTIVES:

1. To undertake an ephemeral survey of the Black Jewfish stock in the waters near Injinoo Community waters, far northern Cape York. To assess the size/age structure of the Black Jewfish population to detect changes in the fish stock following the voluntary closure.

2. To advise the Injinoo Community and the Queensland Fisheries Service (QFS) on the current condition of the resource and options for its future management on a sustainable basis.

NON TECHNICAL SUMMARY:

OUTCOMES ACHIEVED TO DATE

Increasing recognition of the vulnerability of Black Jewfish aggregations has provided the catalyst for recent legislation changes in Queensland. In response to the findings of FRDC Project 98/135, the QFS has amended the *Fisheries Regulation* 1995 to include new closed waters provisions prohibiting the recreational and commercial harvest of Black Jewfish from a large area of Northern Peninsula subregion. The closed waters replicate the area in which the harvest of Black Jewfish was prohibited under the regional agreement which resulted from stage one of this project.

The outcomes of this project have the potential to continue to grow further. While the end result of current dialogue with the traditional land owner groups cannot be predicted, feedback from members of Injinoo Land Trust indicates that they are keen to ensure the sustainable future of the Black Jewfish resource. It is a credit to the people of the Northern Peninsula subregion that despite the remoteness of the aggregation sites, and the reliance of social pressures alone for the enforcement of the regional agreement, the closure has successfully alleviated the fishing pressure placed upon this fish stock.

It appears that the two year closure has facilitated the timely increase in the average length of the fish to a size where they may contribute to the replenishment of the stock. Black Jewfish harvested in 2003 were of a size large enough to be sexually mature (77 cm to 112 cm TL). However, despite the extensive experience of both the charter operator and the Indigenous fishers who conducted the sampling work, the ten dedicated sampling trips resulted in the harvest of only eleven black jewfish.

Significant extension of the project results has occurred to date. As provided for in the project funds, project staff presented at the 'World Congress on Aquatic Protected Areas' in Cairns. The presentation, titled 'The development, outcomes and future of an area closure implemented by the Indigenous Communities of northern Cape York', has been published in the conference proceedings. Further, a member of this project self-funded a presentation at the International Conference 'Putting Fishers' Knowledge to Work' in Vancouver. The presentation, titled 'Sciaenid aggregations in northern Australia: An example of successful outcomes through collaborative research' has also been published in the proceedings, and has been accepted for inclusion in a textbook to be published by Blackwell Science.

In 1997, the Fisheries Research and Development Corporation (FRDC) responded to the concerns of the Traditional Owners of the Northern Peninsula subregion by providing funding to investigate the effects of a perceived increase in fishing effort targeting aggregations of Black Jewfish (*Protonibea diacanthus*). Research commenced in late 1998 and concluded in late 2000. Within this period, approximately 15% of the 4031 individual fish recorded in the local fishery were sampled, and several aspects of the biology and harvest of the Black Jewfish were reported on (see Phelan 2002a). In 2002, the FRDC granted further funding to respond to the highly developed public expectations which resulted from this initial work.

In response to the findings of stage one, the Injinoo Elders and Land Trust immediately requested everyone cease harvesting Black Jewfish for a period of two-years. The area declared closed to the harvest of the species incorporates the inshore waters extending from Crab Island on the west coast and Albany Island on the east coast. The area closure incorporates three well-known aggregation sites and one migration corridor. At the request of Injinoo Community, negotiations were conducted with neighbouring communities. This resulted in a regional agreement with widespread support across the Northern Peninsula subregion and adjacent Torres Strait Islands.

Stage two of this project was initiated in response to the request of stakeholders to commence further stock assessment prior to the end of the two year period, so that an informed decision may be made on future management needs. Now that critical baseline information is available on the species (e.g. length at age, size at first maturity, etc), 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.

In 2002, the opportunity to fish the first half of the historical aggregation period (April to September) was lost due to the delay in gaining a research permit (a permit was not issued to this project until July). The dedicated sampling trips conducted in 2002 were each timed with the lunar, tidal and diurnal conditions most conducive to optimal catches, but did not result in any catches of Black Jewfish. Subsequently, project staff made the decision to conserve the limited funds of this project for more opportune moments. This decision created the need to extend activities beyond the project's original completion date.

Dedicated sampling trips conducted in 2003 revealed the waters of the Northern Peninsula subregion hosted Black Jewfish of a size likely to be sexually mature. However, in contrast to previous years, Black Jewfish were difficult to attain, and so there remain several unknown, such as the strength of the juvenile year classes. Each of the management options now available to the managers of the fishery, have been presented in this report in a manner that evaluates and ranks their suitability.

KEYWORDS: Aggregations, Area Closure, Black Jewfish, Cape York, *Protonibea diacanthus*.

TABLE OF CONTENTS

1. BACKGROUND

1.1 Background to FRDC project 98/135

In 1997, the FRDC responded to the concerns of the Traditional Owners of the Northern Peninsula subregion by providing funding to investigate the effects of a perceived increase in fishing effort targeting local Black Jewfish aggregations. Research commenced in late 1998 and concluded in late 2000. Within this period, approximately 15% of the 4031 individual fish recorded in the local fishery were sampled. Several aspects of the biology and harvest of the Black Jewfish were reported upon (see Phelan 2002a).

Project 98/135 also provided a quantitative analysis of the use of all aquatic resources by the Indigenous Community of Injinoo (see Phelan 2002b). Using the Indigenous Subsistence Fishing Survey Kit, this component of the project revealed the importance of Black Jewfish to the Indigenous fishers of the Northern Peninsula subregion. Monitoring surveys conducted in 1999 and 2000, revealed that Black Jewfish was among the five species most frequently harvested by the subsistence fishers of Injinoo Aboriginal Community.

In 2002, the FRDC granted further funding to respond to the highly developed public expectations which resulted from stage one of this project. The collaborative approach to the project has now resulted in over five years of close involvement with Injinoo Aboriginal Community. Injinoo is situated approximately 40 km from the northern-most point of the Australian continent. The population of Injinoo is presently less than 400 people, while the greater population of the Northern Peninsula subregion is now greater than 2500 people. In excess of 95% of the population in the region is of Aboriginal or Torres Strait Islander decent.

P. diacanthus is Australia's largest tropical Sciaenid (see Figure 1). These fish reportedly attain sizes of up to 180 cm in length and 45 kg in weight. They are highly regarded by all fishers and are colloquially known as 'Black Jewfish'. Aggregations of these fish form annually in the inshore waters of the Northern Peninsula subregion, and have also been reported at a number of locations extending across northern Australia from Central Queensland (Bowtell 1995) to northern Western Australia (Newman 1995). The research focused on the aggregations which form annually around Muttee Head (~15 km south-west of Injinoo).

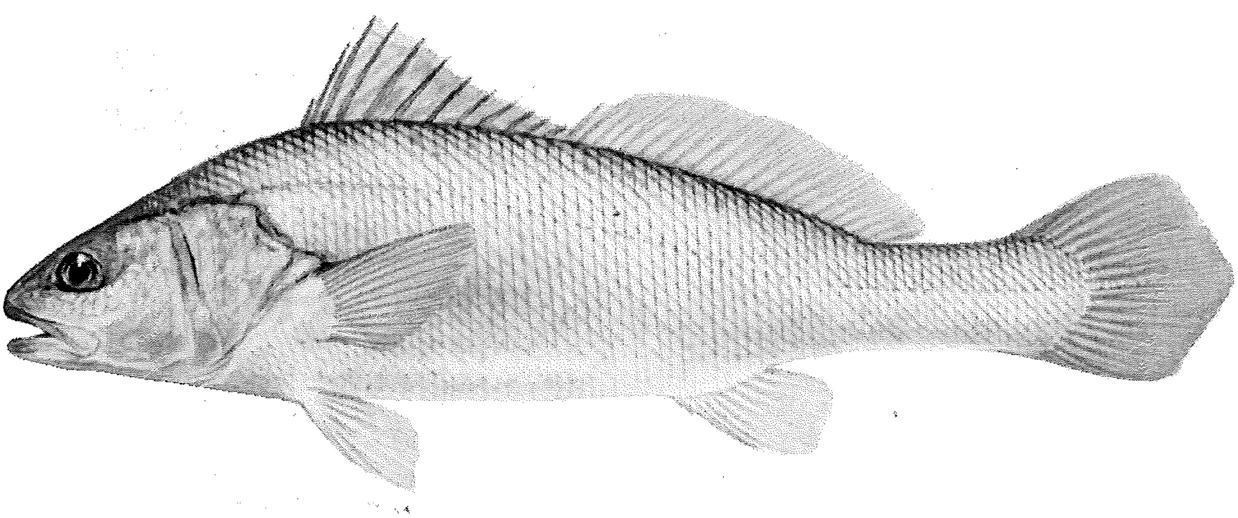

Figure 1: Illustration of an adult *Protonibea diacanthus*.

1.2 Summary of the key results from stage one

It appears that the tendency of Black Jewfish to aggregate in large numbers at well defined times and locations, may facilitate the increased catch of these fish and may render them susceptible to over-exploitation. In 1999, 88% of the recorded annual catch of Black Jewfish in the Northern Peninsula subregion (3.91 tonnes) occurred between April and September, the period in which Black Jewfish aggregate in the area. In 2000, 89% of the recorded annual catch (4.46 tonnes) occurred within the aggregation period. Catches in 1999 and 2000 commonly exceeded 50 Black Jewfish per boat per trip, and CPUE ranged up to 224.5 kg boat h^{-1}.

In 2000, Black Jewfish caught at Muttee Head were significantly (*P*<0.001) smaller than those caught at the site in 1999. Figure 2 illustrates that in 1999 the fishery was dominated by fish 700-800 mm TL (believed to be three-year-old fish), while in 2000, the dominant size class was 590-690 mm TL (believed to be two-year-old fish). Historical records revealed specimens close to the maximum size (>1500 mm TL) were being caught up until 1994. These data support the notion of a rapid change in the Northern Peninsula subregion Black Jewfish resource, and warrants concern for the state of the resource given that the fishery was previously based on adult stock.

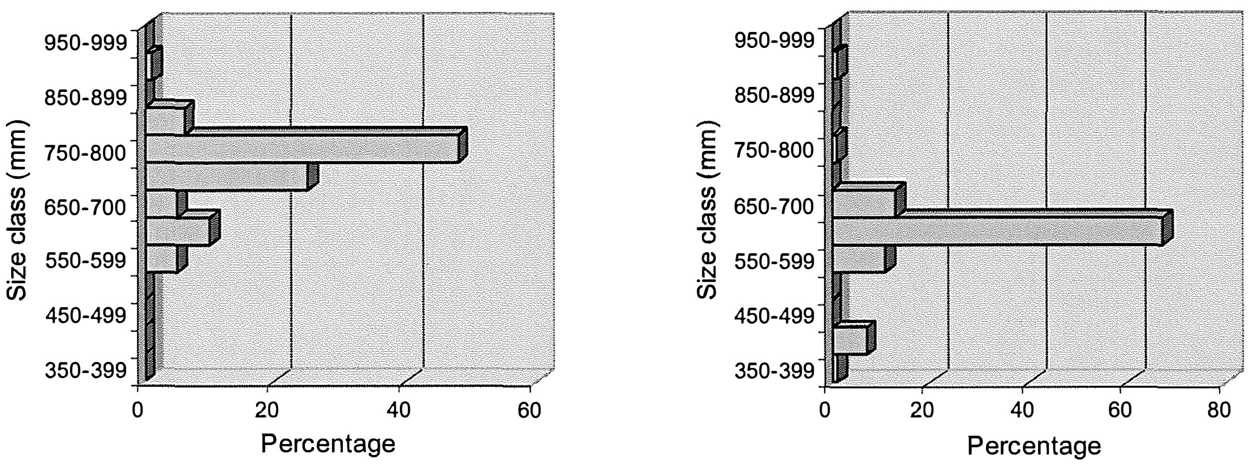

Figure 2. Composition of the size classes of *P. diacanthus* harvested from the aggregations that formed around Muttee Head in 1999 (left) and 2000 (right).

Sexually mature fish comprised less than one per cent of the catch examined in a sampling program biased towards the largest individuals available. This is quite concerning given that estimates of the critical stock threshold for tropical fish range between 20% and 40% (Turnbill and Samoilys 1997). Further, stage one of the present study found a minimum size at first maturity of 790 mm TL for female Black Jewfish. This represents a departure from the previous observed first length of maturity in Queensland waters of 920 mm TL, reported by McPherson (1997).

The tag and release component of stage I of this project provided limited data on the movement patterns of *P. diacanthus* in the Northern Peninsula subregion waters. Tag returns indicate that some of the fish remain at, or return to, the aggregation site at least into the following day. The recaptures also revealed the movement of an individual fish between two distinct aggregation sites. This was supported by DNA fingerprinting using the novel Amplified Fragment Length Polymorphism (AFLP) technique. Significant levels of homogeneity were found amongst fish sampled from the adjacent aggregation sites. As several aggregation sites are fished in the Northern Peninsula subregion, the participation of fish in multiple aggregations may increase their susceptibility to capture.

1.3 Outcomes of stage one

The comprehensive consultation process maintained throughout the lifetime of the project ensured that the implications of these research findings were rapidly acted upon by the communities of the Northern Peninsula subregion. In September 2000, the Injinoo Elders and Land Trust, requested their people cease to harvest *P. diacanthus* for a period of two years. The area declared closed to the harvest of the species incorporates the inshore waters extending from Crab Island on the west coast and Albany Island on the east coast (see Figure 3).

At the request of Injinoo Community, negotiations were conducted with neighbouring communities. Representing each of the communities of the subregion, the Umagico Aboriginal Community, Bamaga Islander Community, New Mapoon Aboriginal Community and Seisia Islander Community have undertaken to support the two year ban. Further, Torres Shire and the Kaurareg Nation of the adjacent Torres Strait region are also signatories to this community initiative. Proprietors and operators of all tourist accommodation and fishing charter boats operating in the subregion region, have also pledged their full cooperation.

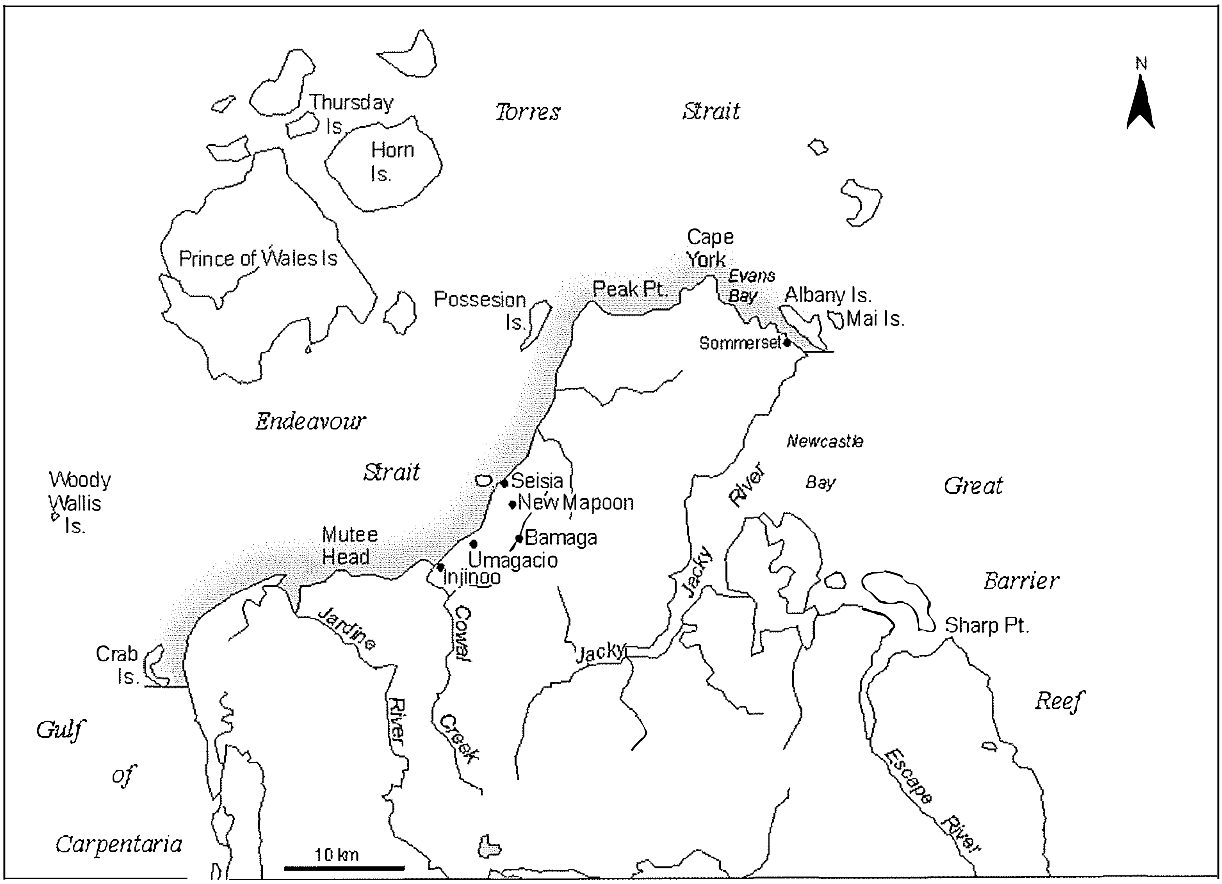

Figure 3. Location of the waters within the Northern Peninsula subregion that is closed to the harvest of *P. diacanthus* under the regional agreement.

Adding to the uniqueness of this self-imposed management arrangement, the elected Chairmen of these Indigenous Communities have formally requested legislative backing so that the Queensland Fishing and Boating Patrol would be able to enforce the management outcome over the two year period. In order to achieve this, community members indicated that they were prepared to forfeit their statutory exemption from the relevant catch restrictions for this species. In response to this project, the QFS initated regulatory changes for recreational and commercial fishers (see Section 8).

2. NEED FOR STAGE TWO

Stage one of this project was initiated because of concerns among the area's Traditional Owners of the impact of the increase in fishing activity targeting the aggregations of *P. diacanthus*. The annual aggregations that form off Muttee Head, approximately 15 km south-west of Injinoo, have been linefished by Indigenous subsistence fishers for over fifty years. *P. diacanthus* are also utilised in the Northern Peninsula subregion by local and transient recreational fishers, and by tourist anglers from all over Australia and the world. The findings of the initial work funded by FRDC warranted concern for the state of the fishery and resulted in a community-developed regional agreement.

The aim of the two-year area closure was to allow *P. diacanthus* inhabiting the Northern Peninsula subregion waters to reach a mature size so that prospects for the replenishment of the fish stock were improved. The stakeholders have acknowledged that the two-year period may not provide adequate time for the complete recovery of the proportion of the adults in the population. The parties concerned 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 review of the stock condition prior to the end of the two-year period, so that an informed decision can be made on future management needs.

The area closure that developed as a result of stage one presents many unique opportunities and obligations for research and management organisations alike. The two-year ban on the harvest of Black Jewfish presents a rare opportunity to quantify 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 opportunities have been available to quantify the opposite situation (Jennings and Lock 1996). Such an opportunity warrants further stock assessment. Further stock assessment would develop our understanding of the dynamics of the resource in relation to fishing pressure and regulation.

Now that critical baseline information is available on the species (e.g. length at age, size at first maturity, etc), 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 suitable for extended resource monitoring programs, and are advantaged in being simple and cost-effective. The value of length-frequency data is exemplified in the Fisheries (Gulf of Carpentaria Inshore Fin Fish) Management Plan 1999. The Plan aims to protect spawning target species, the achievement of which 'may be measured only by the abundance of juvenile target species'.

Such work provides the opportunity to further develop our knowledge of the species' biological traits. FRDC project 98-135 has identified the need for further study to investigate evidence of genetic erosion and changes in the reproductive status of Black Jewfish. In conducting further study on the biology of the stock we may fulfil outstanding needs (e.g. further investigation is required to ascertain whether the observed loss in genetic diversity represents real changes or is an artefact of increased sampling) together with current needs (e.g, continued AFLP analysis would allow us to identify if we are dealing with same Jewfish stock at the aggregation sites).

3. INTRODUCTION

In Australia, recognition of the importance of 'land' to Aboriginal cultures is a relatively new concept. It is only a little over a decade since the Australian High Court decision that acknowledged the native title rights of Indigenous Australians (*Mabo -v- Queensland, 1992*). The legal validity of Aboriginal 'sea estates' is even more recent, having been recognised only within the last five years (*Mary Yarmirr & Others -v- the Northern Territory of Australia and Others, 1999*). Following these High Court decisions, the inherent rights and responsibilities of Indigenous people under customary law, are now recognised under Australia's common law.

As a consequence, the rights of Indigenous peoples to access their traditional marine resources, and their role in the management of their customary estates, is of increasing relevance to coastal and marine resource administration in Australia. In all there are about 100 coastal communities, mostly in northern Australia, occupying land under some form of Aboriginal or Islander leasehold or title (Smyth 1993). Indigenous members of these communities in northern Australia are largely exempt from Commonwealth and State legislation in relation to the utilisation of marine resources when they are harvested for the purpose of traditional or subsistence use.

While the Indigenous population of Australia comprises only around 2% of the total population, this proportion is nonetheless growing rapidly. 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 2002). There exists a multitude of reasons behind this dramatic increase, a major contributor of which is a birth rate greater than the national average. Exemplifying this, at Injinoo 49% of the population is under eighteen years of age. 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). That the level of boat ownership far exceeds the state average reflects the continuing importance the Indigenous community places upon fishing and hunting.

The value of subsistence fishing is substantiated by the high participation rate in activities that utilise aquatic resources. At Injinoo Community, 95% of households participated in such activities, and of these 81% did so at least weekly (Phelan 2002b). In comparison, 33% of all Queensland households participate in fishing activities, and of these only 7% fished at least weekly (Roy Morgan Research 1999). While the Black Jewfish is only one of 75 aquatic taxa utilised by Injinoo Community for subsistence purposes, the community has forfeited their fifth most importance resource (see Phelan 2002b) in order to provide a sustainable future for the local stock.

Exemplifying the vulnerability of this species, commercial catches of Black Jewfish along the north-west coast of India, which once exceeded 5,000 t per annum, has recently been described as 'non-existent' (James 1992). Anecdotal evidence suggests intensive fishing has also severely impacted on several annual aggregations of Black Jewfish along the east coast of Queensland (Bowtell 1998, Bowtell 1994). This study has attempted to review the state of the Black Jewfish stock in the Northern Peninsula subregion waters following the community-initiated two year ban on the harvest of the species.

4. METHODS

The participatory approach adopted in stage one of this project has matured to a stage where the task of collecting biological and fishery data was coordinated and implemented by members of the Northern Peninsula subregion community. Minimal training was required for this step as many local fishers were heavily involved in stage one of the project, and hence were familiar with the protocols required.

A local charter boat charter operator, Mr Gary Wright, provided great assistance to this project by making available his experience and vessel. Mr Wright is widely renown among anglers from across the globe, and has fished the Northern Peninsula subregion waters 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. A General Fisheries Permit (No. PRM03162C) was issued to Mr Wright to conduct the necessary activities.

Indigenous fishers from Injinoo Community assisted on these expeditions in order 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 represent decades of experience fishing the local Black Jewfish aggregations.

Eleven dedicated sampling trips were conducted in 2002 and 2003 (see table 1, next page). Each sampling trip was timed with the lunar, tidal and diurnal conditions most conducive to optimal catches. A variety of line sizes and hooks were used, and both squid and bait fish were utilised. Fishing trips focused primarily on Muttee Head, but also included Crab Island and Peak Point. 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 research permit. However, two sampling trips were conducted in August, which was still within the period in which the fish have historically aggregated Muttee Head (April to September). Following the lack of success in these sampling trips, the decision was made to conserve the project's resources for a more opportune time. In 2003, sampling occurred through May to September.

During the course of this, members of this project attended the 'World Congress on Aquatic Protected Areas'. The Congress provided project staff exposure to the current issues of aquatic protected areas, and allowed the extension of information on this project. Mr Phelan presented a paper titled 'The development, outcomes and future of an area closure implemented by the Indigenous communities of northern Cape York' (see Appendix 1 for abstract). Mr Chris Roberts presented a paper titled 'Aboriginal cultural subregions as biodiversity conservation mosaics, Cape York, Australia - Towards reconciliation of management values and realities'.

Mr Phelan self-funded another presentation at the International Conference 'Putting Fishers' Knowledge to Work'. The article, titled 'Sciaenid aggregations in northern Australia: An example of successful outcomes through collaborative research', has also been published in the conference proceedings (see Appendix 2 for abstract), and has been accepted for inclusion in a textbook soon to be published by Blackwell Science (see Appendix 3 for abstract).

5. 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 1). However, from these limited catches, it appears that the average size of the black jewfish inhabiting the waters of the Northern Peninsula subregion has increased significantly. Black Jewfish harvested in 2003, were of a size large enough to be sexually mature (average 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 may be predominantly four to five years of age. These fish may be the same age cohort that dominated catches in 2000. Research conducted in stage one of this project revealed that one and two year old fish dominated catches of Black Jewfish in 2000. Juvenile Black Jewfish of an equivalent age have not been observed in recent catches, and so the strength of the age structure of the fish population is unclear.

Table 1: Details of the dedicated sampling trips conducted in 2002 and 2003.

Date	Moon phase	Location	No. jewfish	Size (cm TL)
18 August 2002	3 d. after 1st qtr.	Muttee Head	0	
20 August 2002	3 d. before full	Muttee Head	0	
1 May 2003	2 d. after 1st qtr.	Muttee Head	2	~113, ~107.
11 May 2003	5 d. before full	Muttee Head	1	112.
12 May 2003	4 d. before full	Muttee Head	5	111, 102, 103, 101, 77.
13 May 2003	3 d. before full	Muttee Head	2	~115, ~108.
14 May 2003	2 d before full	Muttee Head	0	
5 June 2003	3 d. before 1st qtr.	Muttee Head	1	90.
23 July 2003	2 d. after last qtr.	Crab Island	0	
18 Sept. 2003	1 d before last qtr.	Peak Point	0	

Also consistent with the findings of stage one, it appears that the 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 was observed suggesting the presence of Black Jewfish. These voluntarily conducted checks were continued beyond the period in which Black Jewfish continued to be caught in large numbers during previous years.

Personal communications with project staff has confirmed that some Black Jewfish were harvested during the period of the two year closure. However, the number of fish harvested during the closure could not be substantiated, as those fishers who harvested the species were not openly talking about catches. By all accounts, it appears that the social pressure applied by the vast majority of the people in the Northern Peninsula subregion, has limited the fishing effort targeting black jewfish to a small fraction of former levels.

6. DISCUSSION

6.1 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 of these fish was not examined, it is feasible that fish caught in 2003, may be from the same cohort identified as the dominant size class in 2000. Research conducted two years ago under stage one of the project 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 sexually mature fish be provided with the greatest level of protection. This is necessary to ensure the prospects of stock replenishment are realised.

The Injinoo Land Trust and Injinoo Elders 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 is not unlike the popular concept of 'ecological sustainable development', which has become increasingly fundamental to contemporary western natural resource management.

Central to this concept of 'ecological sustainable development' is the 'precautionary principle' that advocates the adoption of a risk averse 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.

The Injinoo Land Trust and Elders must ensure that the utilisation of the Black Jewfish by the people of Injinoo Community, and the neighbouring communities who also benefit from this resource, is governed by the needs of the fish stock. The custodians of this fishery must adopt which ever management option provides the maximum potential for the further enhancement of the Black Jewfish stock inhabiting the inshore waters of the Northern Peninsula subregion.

6.2 Examination of the management options

A number of management measures are available to manage the black jewfish in the waters of the Northern Peninsula subregion. Presented below is a series of options ranging from no protection through to maximum protection. Each of the options are discussed in brief and examples of each are provided where they exist locally or nationally. The advantages and disadvantages of these management tools are discussed in the context of the present situation. Recommendations have been presented as advice for the decision-makers whose role it is to provide for the sustainable future of the resource.

These management options have been grouped into four categories:

1. Unregulated fishing: Where no regulatory measures are applied.
2. Input controls: Measures that serve to limit fishing effort (e.g. the number of licences, seasonal closures and gear restrictions).
3. Output controls: Measures that directly limit the quantity of fish that may be harvested (e.g. quotas and permits).
4. Holistic controls: Permanently closed areas of varying levels of limitations.

6.2.1 Unregulated fishing

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 reexamination 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.

Capturing the turning point in resource management thinking is the renowned paper of Hardin (1968). Appropriately titled 'The Tragedy of the Commons', the logic of Hardin's view is straightforward. He argues that when the use of a resource in 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.

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 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.

Unregulated fishing: Black jewfish fishing in the Northern Peninsula subregion

Prior to 2000, when a temporary closure was introduced to control the harvest of Black Jewfish in the Northern Peninsula subregion, 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). 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.

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.

6.2.2 Input controls

Input controls serve to limit the efficiency of harvest rates while providing no limit on the total catch. Input controls limit such things as the type and amount of gear, and methods of fishing, or the number of participants in the fishery. They may also restrict the length of fishing seasons or close certain areas to fishing.

6.2.2.1 Gear restrictions

Gear restriction serve to limit the efficiency of harvest rates by determining the gear that may be utilised to harvest the species. For example, measures may be introduced to the use of a particular type of fishing 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.

Gear restrictions: Recreational fishing limits in Queensland

The 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).

The use of monofilament gill nets by recreational fishers in Queensland waters is not permitted. 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 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. This measure may be adopted to restrict the introduction of alternative fishing methods of greater efficiency.

6.2.2.2 Temporary closures

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 had occurred (Samoilys 1997).

Black jewfish have historically aggregated in the inshore waters of the Northern Peninsula subregion 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.

Temporary closures: 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. This option is advantaged primarily by the ease of public understanding, as well as simplified implementation and enforcement when compared with other options.

Disadvantages

Stage one of this project demonstrated that in 1999 and 2000 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 was not, and hence a seasonal closure may not provide sufficient protection.

Suitability

High

Recommendation

It is the view of project staff 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 Peninsula subregion waters. For ease of public understanding, any potential closure should aim to replicate the boundaries applied to the original two years.

6.2.3 Output controls

Output controls may limit the harvest of a species within a level determined to be sustainable. Economic inefficiency and other problems associated with managing fisheries through input controls, have led to the development of management systems based on output controls (Walters and Pearse 1996).

6.2.3.1 Size limits

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 legal size limits and maximum legal 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. Post-capture mortality has not been quantified for this species. Size limits are typically adopted in conjunction with a bag or boat limit.

Size limits: 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 2 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

For this species the survival rate of released fish is not known. Enforcement may be difficult.

Suitability

Medium to High.

Recommendation

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

6.2.3.2 Possession limits

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 limit 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 that 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 Peninsula subregion (given the high number of fishers who participate in most vessel-based fishing trip), boat limits do not encompass land based fishing; hence of combination of the two limits may be required (see Northern Territory example).

Possession limits: 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 5 with no more than 2 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 5, 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 4 combined with *Argyrosomus hololepidotus*, plus a general mixed bag limit of 8 '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 Peninsula subregion 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).

6.2.3.3 Access rights

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).

Quotas: Dugong hunting permits in the Great Barrier Reef Marine Park

Within the Great Barrier Reef Marine Park permits have been required to conduct traditional hunting activities. Along the east coast of Queensland 'Councils of Elders' were established by the Great Barrier Reef Marine Park Authority (GBRMPA) to address traditional hunting issues. Permits to hunt dugongs were issued to these Councils, who then handled individual permits for traditional hunting. Hunters were required to submit to the GBRMPA details of their hunting trips through the Councils.

In response to documented declines in the abundance of dugongs along the urban coast of Queensland most Councils voluntarily agreed not to harvest the species. Following this, the Queensland and Commonwealth Governments both decided not to issue permits for traditional hunting in the Great Barrier Reef Marine Park south of Cooktown (Marsh et al. 1999). Though successful in many areas, the introduction of the permitting system presented a number of negative responses.

Sources: Marsh and Cockeron 1997; Smith and Marsh 1990

Advantages

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

Disadvantages

Devising fair methods of ensuring the equitable use of the resources through a permit 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. Given the limited resources currently available, this approach is considered the least suitable option for this fishery.

6.2.4 Holistic management

Increasingly, holistic management are being recognised as the way forward for managing fisheries. There is now a growing body of evidence documenting the deficiencies of conventional management approaches that focus on single species management. Ecosystem-based management presents an alternative approach that recognises the complexity of marine environments and the need for precaution in the face of uncertainty.

6.2.4.1 Marine Protected Areas

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 within Marine Protected Areas 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 such Protected Areas is typically achieved through the establishment of a Board of Management. Under the *Environment Protection and Biodiversity Conservation Act* 1999 (Cth) through which 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 dugong and turtles).

Marine Protected Areas: 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 under the control of an eight person Board made of up to four traditional owners and four Northern Territory Government representatives. One of the traditional owners chairs the Board and has the casting vote.

Advantages

There are many potential advantages of Marine Protected Areas including:

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

Disadvantages

Transfer of some management rights 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. We suggest interim measures will be required.

6.2.4.2 Indigenous Protected Areas

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. In the past three years, 15 Indigenous Protected Areas have been declared, encompassing over 3.6 million hectares of customary estates.

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.

Indigenous Protected Areas: Deliverance Island.

Deliverance Island Indigenous Protected Area was declared in February 2001. Deliverance Island 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 is available for the creation of Indigenous Protected Areas and provides 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

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 Land Trust may wish to consider this tool in the development of a longer-term solution.

As with all of the above mentioned management approaches, the Cape York Land Council is prepared to oversee potential arrangements to ensure that traditional owner rights are protected.

6.3 Summary of the management options

Prior to 2000 when a temporary closure was introduced to control the harvest of Black Jewfish in the Northern Peninsula subregion, the fishery based on this species was unregulated in respect to Indigenous subsistence fishers. However, in the decade prior to the management action of 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 current 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 may be retained may protect particular size cohorts so that they may contribute to the replenishment of the stock. Presently, the strength of size cohorts 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 Peninsula subregion 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 to be 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 the least practical tool available for this fishery given the limited resources available.

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 the view of project staff and collaborators that a temporary closure replicating that initiated by the Northern Peninsula subregion community in 2000, presently 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 Peninsula subregion waters.

7. CONCLUSION

There is an extensive body of evidence derived from fish stocks around the globe that indicate target fishing of aggregations can rapidly undermine fishery production. Chronic effects of aggregation fishing include the truncation of size and age structure (e.g. Beets and Friedlander 1992), deterioration of the stock's reproductive capacity (e.g. Elkland et al. 2000), and altered genetic composition (e.g. Hauser et al. 2002). Acute effects include the total loss of aggregations (e.g. Sadovy 1994). Aggregations of fish stocks are now widely renown as vulnerable fishery targets.

Domeier and Colin (1997) state that comprehensive stock assessment and monitoring of annual fish aggregations has been limited globally because such work is seldom easy. They explain that this is because such aggregations are often ephemeral events occurring in remote locations, and where accessible have often been eliminated or reduced by fishing pressure. The aggregations that form annually off Muttee Head, have themselves changed dramatically over the last decade, greatly increasing the difficulty of examining this stock.

Despite the difficulties in catching Black Jewfish in 2002 and 2003, there has come positive news from this project. Black Jewfish measured in 2003 are now of a size in which they may now contribute to the replenishment of the fish stock (average size equals 103 cm TL). Although it appears that the two year closure has facilitated the timely increase in the average length of the fish, the apparent limited abundance of these fish warrants continued attention from the custodians of this fishery.

Inshore subsistence fisheries remain essential to the health, culture and economic welfare of Indigenous people across most the Indo-Pacific region (Zann and Vuki 1998), yet reports of declines in fishery landings have been widespread (Jackson et al. 2001). Contemporary management of subsistence fisheries is currently in its infancy, and requires a completely new approach to that of commercial and recreational fisheries management (Zann and Vuki 1998). Fisheries managers are increasingly recognising that resource conflicts can be diminished, and resources better managed, when stakeholders are more involved in the management process (Pomeroy 1995).

King and Fassili (1999) highlight the successful outcomes that can be achieved through collaborative management approaches. They describe a program in Samoa that encouraged coastal communities to define key problems, propose solutions and take appropriate actions. Within the first 2 years, the extension process commenced in 65 villages, of which 44 have produced Village Fisheries Management Plans. A large number (38) of these villages chose to establish community-owned Marine Protected Areas.

The implementation of the community-developed jewfish closure is believed to be a product of the communities' understanding, participation and ownership of this research project. It is hoped that this approach will continue to drive future actions that will serve to enhance the sustainable use of the Black Jewfish stock. Despite the successes achieved to date, there remains a long road in front of us in 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.

8. BENEFITS

In September 2002, the QFS 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 were subsequently amended to incorporate the new closed waters provision that prohibits the harvest of Black Jewfish from a large area of Northern Peninsula subregion. The boundaries of the area closed under Schedule 2 (Section 46a) and Schedule 3 (Section 44a) are described in Appendix 4. The closed waters replicate the area closed to the harvest of Black Jewfish under the regional agreement that resulted from stage one of this project, and applies to recreational and commercial fishing.

The changes do not apply to Indigenous subsistence fishers, however the Indigenous people of the Northern Peninsula subregion have expressed a strong desire to continue an active role in the management of this fish stock. The outcomes of this project have the potential to continue to grow further. While the end result of current dialogue with the traditional land owner groups cannot be predicted, feedback from members of Injinoo Land Trust indicates that they are keen to ensure the sustainable future of the Black Jewfish resource.

That aggregations of Black Jewfish are susceptible to overexploitation was demonstrated by this project and has been acknowledged as one catalyst for proposed possession limits changes in the Northern Territory. The range of benefits developed to date from this project are diverse. For example, the methods adopted by this project to profile the Indigenous subsistence fishery of Injinoo Community have been drawn upon by the QDPI project 'Assessment of fish stocks in coastal streams of central and north Queensland', headed by Rod Garrett. In order to overcome a lack of Indigenous fishing data from Trinity Inlet, the approach was replicated with the assistance of the Giangurra Community (www.dpi.gld.gov.au/fishweb).

The extension of project's progress has occurred at a number of levels. As provided for in the project funding, Mr Phelan presented an oral presentation at the 'World Congress on Aquatic Protected Areas', held in Cairns during August 2002. The presentation, titled 'The development, outcomes and future of an area closure implemented by the Indigenous Communities of northern Cape York' generated much positive feedback. The article has been published in the conference proceedings, the abstract of which is provided in Appendix 1.

Mr Phelan self-funded a presentation at the International conference 'Putting Fishers' Knowledge to Work' held in Vancouver in August 2001. The presentation, titled 'Sciaenid aggregations in northern Australia: An example of successful outcomes through collaborative research' was also well received. An article, already published the proceedings (see Appendix 2 for abstract), has also been accepted for publication in a forthcoming book on 'Putting Fishers' Knowledge to Work' (see Appendix 3 for abstract).

9. FURTHER DEVELOPMENT

The future of the Black Jewfish inhabiting the waters of the Northern Peninsula subregion remains uncertain and warrants further assessment on a regular basis. Given the truncated state of the black jewfish stock in the Northern Peninsula subregion, local assessments should occur on a yearly or bi-yearly basis. As a minimum, future studies may continue to operate in the manner adopted by the present study. That is, relying on members of the local community to gain information on the size/age structure of the local stock.

Ultimately, the long-term objective of future research on Black Jewfish must focus on developing the means to rapidly assess change in stock abundance. The present study attests to this need. Within the period starting from when concerns for the Northern Peninsula subregion stock were first publicly raised in 1994, and extending through to 2000 when management responses where rapidly implemented following stage one of this project, the structure of the local stock changed dramatically. In 1995, full sized adult fish (<150 cm TL) where caught for the final time from Muttee Head, by 2000, catches at Muttee Head was based on one and two-year-old fish (~42 cm and ~65 cm respectively during the mid- year period).

New analytical techniques and innovative technologies are constantly changing the way we can evaluate aquatic life. Several recent studies have produced results suggesting that active acoustics (sonar) may be used to estimate the size of fish in the water (e.g. Hartman *et al.* 2000, Yule 2000). Potentially active acoustics may allow us to determine the proportion of juvenile fish verse the adult fish in a minimally intrusive manner, and in real time.

Black jewfish appear the perfect candidates for this type of work; not only is the location of the fish spatially and temporally predictable, the large growth increments of juveniles exceeds the size estimate error margins of current studies. Studies such as Hartman et al. 2000 and Yule 2000, have refined errors to within 5 cm. Before Black Jewfish reach sexual maturity, these fish grow between 10 cm to 15 cm a year.

Active acoustics (acoustic tags) hold the potential to reveal information such as; the residence times of individual fish at aggregation sites, catchment distances, and participation rates. These external or internally fitted tags emit acoustic pulses that are recorded by receivers either temporarily or permanently *in situ*. The tags may also be equipped with temperature or pressure sensors to reveal further information on the movement patterns of the fish. Ultrasonic telemetry has successfully been adopted in many studies of teleosts (e.g. Szedlmayer 1997, Arendt *et al.* 2001).

Passive acoustics (hydrophone recordings) may be useful in locating the number and proximity of aggregations (e.g. Luczkovish *et al.* 1998). Sound production has been observed in many sciaenids (Tavolga 1971, Guest and Lasswell 1978, Mok and Gilmore 1983), including the *P. diacanthus* (Grant 1997). Hydroacoustics are also increasingly being adopted to describe cycles of abundance in soniferous fish, and have already been successfully applied to sciaenids (e.g. Saucier and Baltz 1993, Connaughton and Taylor 1995).

Given the demonstrated vulnerability of Black Jewfish to overfishing, the further development of our understanding of these fish is critically important.

10. PLANNED OUTCOMES

Given what we do know of the Black Jewfish stock in the Northern Peninsula subregion waters, and with due consideration to those uncertainties which still exist, each of the options available to the managers of the fishery have been presented in this report. This information forms the basis of current dialogue with the Injinoo Land Trust. While it is not possible to prempt the outcomes of this effort, feedback generated to date provides that the Injinoo Land Trust is keen to ensure the viable future of this important natural resource.

In May 2004, the Principal Investigator met with the Chair of the Injinoo Land Trust, Mr Robbie Sallee, to discuss the results of stage two of this project. Copies of the report were presented to the Chair of the Injinoo Land Trust, and permission to publish this document was provided. Mr Sallee has provided that the future management options presented in this report will be discussed at a special meeting of the Injinoo Land Trust to be held prior to the annual general meeting.

While this project examined the status and needs of the Black Jewfish in the waters of the Northern Peninsula subregion, the results may have much wider application. As highlighted within the introduction of this report, Indigenous subsistence fishing sector is of increasing importance to contemporary aquatic resource management. Contemporary management of subsistence fisheries is still in its infancy, yet the contributions of this project serve as a template for similar works.

Further, many fisheries are based on species that form annual aggregations and so the outcomes of this project will be of widespread relevance. The tendency of many fish species to form spatially and temporally discrete aggregations, be it for the purpose of feeding, migration or spawning, greatly increases the stock's vulnerability to overfishing. The risk associated with sustained fishing pressure targeting aggregations has been demonstrated in this project, with the truncation of the size/age structure of the aggregating fish stock.

This project has contributed to our understanding of the dynamics of aggregating fish stocks to greatly varying levels of fishing pressure. The two year closure that resulted from stage one of this project provided a rare insight into the response of a fish stock granted a temporary relief from sustained utilisation. The results of stage two indicate larger fish now inhabit the waters of the Northern Peninsula subregion coast, but the reduced abundance of Black Jewfish exemplifies the need for adequate and timely protection.

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12. APPENDIX 1: ABSTRACT FROM THE WORLD CONGRESS ON AQUATIC PROTECTED AREAS

The development, outcomes and future of an area closure implemented by the Indigenous Communities of northern Cape York.

Aggregations of *Protonibea diacanthus* form annually in the inshore waters of northern Cape York (Queensland), and have been exploited by indigenous subsistence fishers for over fifty years. The management of aquatic resources utilised by indigenous fishers is a relatively new concept to many natural resource management agencies in Australia, and presents many unique opportunities and obligations.

Participatory stock assessment of *P. diacanthus* in the Northern Peninsula subregion revealed that sexually mature fish comprised less than one percent of the subsistence harvests in 1999 and 2000 (see Phelan 2002a). The findings support the notion of a rapid change in the fish stock, and warrant concern for the state of the resource given that the fishery was previously based on mature adult fish.

In response to the findings of this stock assessment, the traditional land owner groups of the Northern Peninsula subregion (the Anggamuthi, Atambaya, Gudang and Yadhaykenu Aboriginal people) self-imposed a two year ban on the harvest of *P. diacanthus*. With much consultation, this initiative has developed into a regional agreement, with comprehensive support across all communities of the Northern Peninsula subregion and the adjacent Torres Strait Islands.

The area of closure incorporates the inshore waters of the Northern Peninsula subregion north of Crab Island (on the west coast) and Albany Island (on the east coast). The principal aim of this community-developed management response is to allow local stocks of *P. diacanthus* to reach a mature size so that prospects for replenishment are improved. This paper reviews the development, outcomes, and future of the two year closure that commenced in September 2000.

13. APPENDIX 2: ABSTRACT FROM THE FISHERS' KNOWLEDGE CONGRESS

Sciaenid Aggregations in Northern Australia: an Example of Successful Outcomes through Collaborative Research.

Anecdotal evidence suggests intensive fishing effort has severely impacted on several annual aggregations of Black Jewfish (*Protonibea diacanthus*) along the East Coast of Queensland (Bowtell 1994, Bowtell 1998). The apparent recent increase in effort targeting Black Jewfish in far northern Cape York Peninsula (CYP), has prompted concerns from the Injinoo community, which has custodial responsibilities for that stock, and for the Queensland Fisheries Service, who must provide for managing fisheries in Queensland on a sustainable basis. Aggregations of Black Jewfish which form annually off Muttee Head in CYP's Northern Peninsula subregion, have been exploited by Indigenous subsistence fishers for over fifty years.

In response to the research findings of the present project, the Injinoo Land Trust (representing the Traditional Land Owner Groups of the Anggamuthi, Atambaya, Gudang and Yadhaykenu Aboriginal people), in cooperation with the Injinoo Community Council, have self-imposed a two-year ban on the taking of Black Jewfish. The area of closure incorporates the inshore waters of the Northern Peninsula subregion north of the southern boundaries of Crab Island (on the West Coast) and Albany Island (on the East Coast). The aim of the two-year ban is to allow local Black Jewfish stocks to reach a mature size so that prospects for the replenishment of stocks are improved.

With much consultation, this initiative has developed into a regional agreement with comprehensive support across the Northern Peninsula subregion. Representing each of the communities of the Northern Peninsula subregion, the Community Councils of Umagico, Bamaga, New Mapoon and Seisia, have undertaken to participate in the two-year ban on the take of Black Jewfish. Further Torres Shire and the Kaurareg Nation based on Horn Island are also signatories to the ban. Proprietors and operators of all tourist accommodation and fishing charter boats operating in the Northern Peninsula subregion region have also pledged full cooperation with the initiative. The implementation of the two-year closure presents new opportunities and obligations for research and management agencies alike, to meet highly developed public expectations.

14. APPENDIX 3: ABSTRACT FROM THE BLACKWELL SCIENCE TEXTBOOK

Tropical Fish Aggregations in an Indigenous Environment in Northern Australia: An Example of Successful Outcomes through Collaborative Research

Aggregations of the Sciaenid *Protonibea diacanthus*, have been harvested in Australia's Cape York Peninsula (CYP) by Indigenous subsistence fishers for over fifty years. The relative ease of catching *P. diacanthus* when aggregating may render them susceptible to over-exploitation. Oral, biological and catch data gained through a collaborative research project conducted with the assistance of Injinoo Community, provided evidence of a rapid change in the local fish stock resource.

In response to the research findings of the present project, the Injinoo community self-imposed a two-year ban on the taking of *P. diacanthus*. With much consultation, this initiative has developed into a regional agreement with comprehensive support across the region. The outcome appears unique among Australian fisheries, being the only example in the modern context in which indigenous communities have initiated the long-term ban on harvest of a fish species.

15. APPENDIX 4: AMENDMENTS TO THE *FISHERIES REGULATION* 1995

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

(1) Waters within the following boundary -

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

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

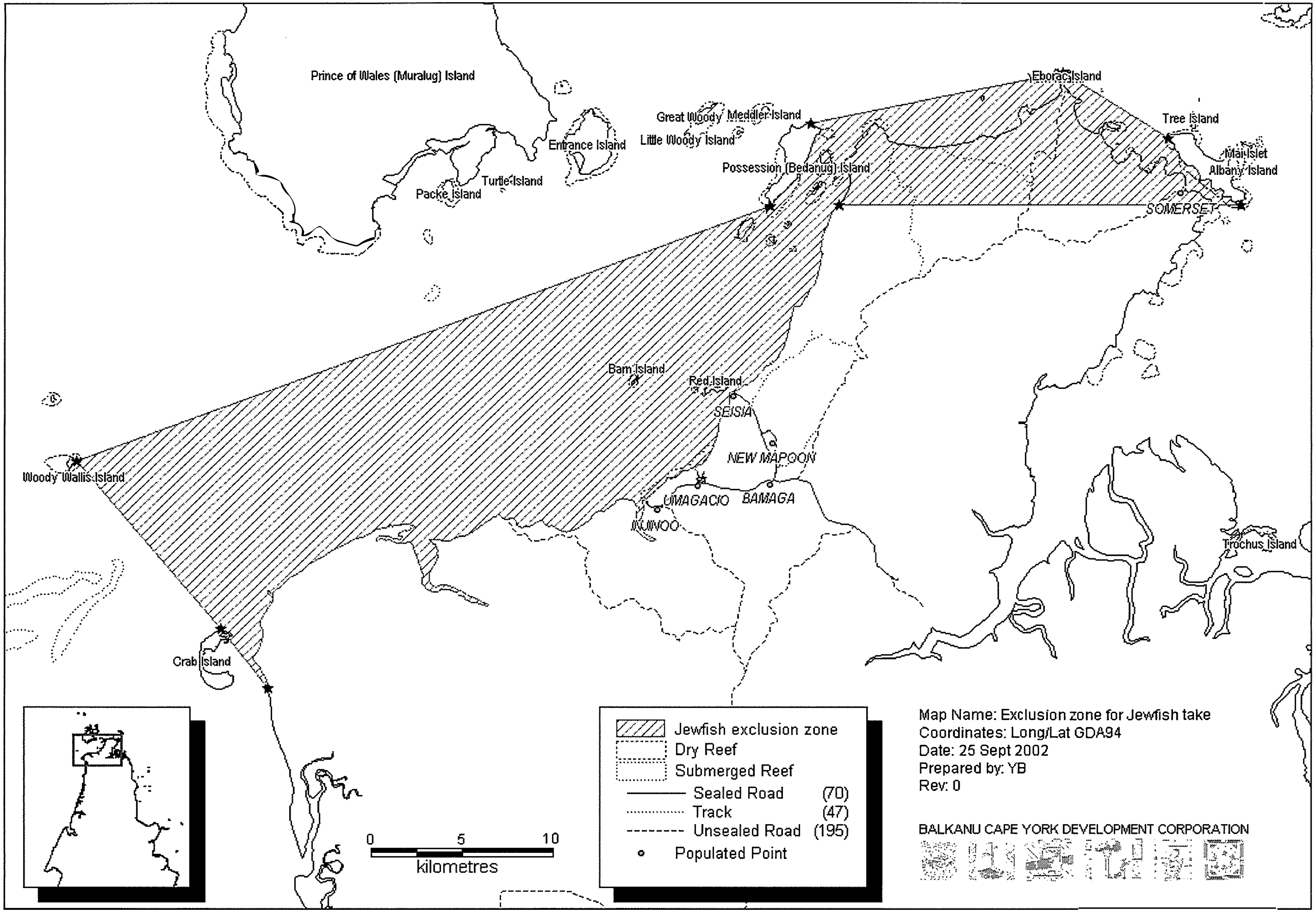
Schedule 3, Section 44A: Waters adjacent to north Cape York

(3) Waters within the following boundary -

- from where latitude 10°44.97' south intersects the mainland shore at Fly Point to where longitude 142°37.26' east intersects the southern tip of Albany Island
- along the southern and western shore of Albany Island to where latitude 10°42.96' south intersects the shore at the Island's north-western tip
- to the navigational light on Eborac Island, approximately at latitude 10°40.95' south and longitude 142°31.96' east
- to where longitude 142°24.40' east intersects the northern tip of Possession Island
- along the northern and eastern shores of Possession Island to where longitude 142°23.16' east intersects the shore at the Island's southern tip
- to the intersection of latitude 10°52.87' south with the eastern shore of Woody Wallis Island
- to where longitude 142°06.56' east intersects the northern shore of Crab Island along the western shore of Crab Island to where longitude 142°06.46' east intersects the shore at the Island's southern tip
- to where latitude 10°59.84' south intersects the mainland shore south of Slade Point along the mainland shore in a northerly and easterly direction to where latitude 10°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
Woody Wallis Island
Crab Island
Trochus Island
Jewfish exclusion zone
Dry Reef
Submerged Reef
Sealed Road (70)
Track (47)
Unsealed Road (195)
Populated Point
0
5
10
kilometres
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

16. APPENDIX 5: INTELLECTUAL PROPERTY

As stated in the original project agreement for project 98/135: Biological data in the form of species identification and length structure, and summary fisheries data in the form of total catch and aggregated catch rates will be made available to both the Injinoo Community and FRDC, but information of a personal and/or cultural nature will remain the property of the person or people concerned.

17. APPENDIX 6: PROJECT STAFF

The following staff from Balkanu Cape York Development Corporation, Queensland Department of Primary Industries, James Cook University, Injinoo Aboriginal Community, and members of the Project Steering Committee, contributed to project activities during the lifetime of the project:

Balkanu Cape York Development Corporation

Mr Chris Roberts	Project Coordinator
Mr Michael Phelan*	Principal Investigator
Mr Deen Popoola	Financial Controller

* Presently employed by the Department of Business, Industry and Resource Development, Northern Territory

Queensland Department of Primary Industries

Mr Rod Garrett	Co-Investigator
Dr Neil Gribble	Co-Investigator

Injinoo Aboriginal Community

Mr Shorty Lifu	Casual Staff – Black Jewfish Sampling
Mr Steven Ropeyarn	" "

James Cook University

Dr Michelle Waycot	Geneticist

Project Steering Committee

Mr John Charlton	Cape York Adventures
Mr John Clark	Balkanu Cape York Development Corporation
Mr Peter Finglis	Queensland Department of Primary Industries
Mr Laurie Gwyne	Queensland Fisheries Service
Mr Bill Kehoe	Queensland Seafood Industry Association
Dr Helene Marsh	James Cook University
Mr Robbie Sallee	Injinoo Community/ATSIC

18. APPENDIX 7: ACKNOWLEDGMENTS

Special thanks to all the people of Injinoo Aboriginal Community and the Northern Peninsula subregion who assisted with this work, especially the Ropeyarn family (who made available their home to the project biologist) and Mr Gary Wright (who contributed greatly in organising the sampling trips of stage 2).