DEPARTMENT OF
PRIMARY INDUSTRY AND RESOURCES

MANAGEMENT FRAMEWORK FOR THE NORTHERN TERRITORY MUD CRAB FISHERY

JUNE 2017

www.nt.gov.au

NORTHERN TERRITORY GOVERNMENT

1. Table of Contents

LIST OF FIGURES

LIST OF TABLES

2. FISHERY TO WHICH THIS MANAGEMENT FRAMEWORK APPLIES

This Management Framework applies to the Northern Territory (NT) Mud Crab Fishery declared under section 22 of the *Fisheries Act* 1988 to be a managed fishery by notice published in *Gazette* G12 dated 28 March 1990. This Framework is the result of a comprehensive review of the Mud Crab Fishery, and is a guiding document for the *Mud Crab Fishery Management Plan*.

3. TERM OF FRAMEWORK

This Framework applies from 1 July 2017. A comprehensive review for the purpose of determining whether the Framework should be amended, replaced, or reinstated without amendment, will be undertaken after 5 years.

4. DESCRIPTION OF THE FISHERY

The NT Mud Crab Fishery is primarily based on the capture of the Giant Mud Crab (*Scylla serrata*), and to a far lesser extent (<1% of catch) the Orange Mud Crab (*Scylla olivacea*). The Giant Mud Crab is a highly prized and iconic species that forms the basis of one of the NT's key wild harvest fisheries, is a popular recreational target species, and is an important resource to indigenous Territorians for customary harvest and cultural practices.

Mud crab fishing activity is carried out in coastal waters and estuaries, and the requirement for boat ramps to access fishing areas has resulted in areas of operation overlapping between sectors, necessitating the need for joint management and agreement on management arrangements.

The 2008 High Court's Blue Mud Bay decision confirmed that tidal waters overlying aboriginal land are recognised under the *Aboriginal Land Rights (Northern Territory) Act 1976*. The High Court decision clarified that the water overlying Aboriginal land should not be treated differently from the land itself, meaning that permission from Traditional Owners was required for access. The decision also confirmed that the Fisheries Act applied in these waters, meaning it was important that Traditional Owners and Government worked together to manage fishing in affected waters. The NT Government has worked with Aboriginal Land Councils to negotiate agreements that allow permit free access and provide benefits back to Traditional Owners. There are currently seven agreements in place and the NT government is consulting with Land Councils to negotiated agreements for access to other areas utilised by other fishing stakeholders.

Mud crab fishing can occur to the edge of the Australian Fishing Zone, however crabbers generally operate in coastal and estuarine areas, predominantly on mud flats or creeks and rivers. The most productive commercial fishing grounds are in the Gulf of Carpentaria (GoC) and the Darwin area, and the majority of

recreational effort occurs around Darwin. Only limited commercial or recreational effort occurs off the Arnhem Land coast and far west coast due to access and logistic issues.

Traditional harvest of mud crabs can occur in all waters, and the recreational take of mud crabs is allowed in all waters except areas of the Cobourg Marine Park and the rivers of Kakadu National Park. Additional restrictions apply to the commercial sector, with no commercial harvest allowed from Darwin Harbour, Leaders Creek, and most creeks leading into Shoal Bay.

The commercial fishery has accreditation to export product, with most product sold on the domestic market through the Sydney and Melbourne fish markets. The fishery currently generates an average Gross Value of Production (GVP) in the order of $4-5 million per annum, however GVP has reached levels of over $10 million. Export sales are supply driven in a global market; when supply is low in Australia, prices are high and the domestic market readily utilises all product as imports of live mud crab into Australia are prohibited due to biosecurity concerns. When the Australian supply increases, the export market is an essential component of the industry marketing strategy.

4.1. Historical overview

Subsistence fishing has been undertaken along the NT coast since the first occupation of the region by Aboriginal tribes over 40,000 years ago. During their occupation of the land and seas, Aboriginal people carried out their custodial rights, hunting and collecting marine resources in a sustainable manner.

Prior to 1980 mud crabs were harvested for commercial purposes under a general fishery licence. In 1980 the first commercial mud crab fishing licences were issued. There was no cap on the number of licences at the time, and in 1982 the number of licences peaked at 112, rising from the 61 that were first issued.

In response to increased commercial activity in the Darwin region, in 1984 a fee of $5.00 per commercial pot was imposed on operators together with a requirement to submit monthly logbook returns detailing specific mud crabbing activities. Despite these measures, the potential for a significant increase in effort remained a concern due to a lack of restriction on licence and pot numbers.

The recreational harvest of mud crabs was unregulated until 1972, when a gear limit of three pots or dillies and a $5.00 pot registration fee was introduced. This requirement was removed in 1985, and during that time (between 1972 - 1985) up to 2,295 recreational crabbers per year had applied to register recreational pots.

A substantial increase in commercial landings was observed in 1985, and in response a moratorium was placed on the issuing of any new mud crab licences. Following a review of the fishery, additional management measures were introduced including a cap of 55 fully transferable commercial licences, with an entitlement of 60 pots per licence. A minimum legal size (MLS) limit of 130mm across the widest part of the carapace was introduced for both sectors, and commercial closures were introduced in Darwin Harbour, Leaders Creek, and most creeks leading into Shoal Bay.

In 1988 the maximum number of commercial licences was reduced to 49. With the introduction of the first legislated *Mud Crab Fishery Management Plan* in 1991, recreational bag vessel limits were introduced along with a range of additional commercial regulations.

The first management plan underwent numerous amendments including the introduction in 1993 of a ban on taking berried female crabs, and a 10 mm increase in the MLS of female crabs for both sectors in 1996. A prohibition on the take of commercially unsuitable crabs (CUCs) was introduced for the commercial sector in 2001, as was a further 10mm increase in the MLS of both male and female crabs in 2006, and the unitisation of licences in 2010.

The first comprehensive survey of recreational catch and effort in the NT, which included mud crabs was conducted between November 1994 and February 1996 (Coleman, 1998). At that time the estimated annual recreational harvest of mud crabs was 52,225 retained individuals (approximately 42t). Annual mud crabbing effort was estimated at 256,832 hours, accounting for 12% of the total recreational fishing effort (Coleman, 1998).

A second survey conducted in 2000 estimated the annual recreational mud crab harvest to be 82,371 individuals (approximately 66t). Mud crabbing effort was estimated at 303,033 hours, accounting for 17% of all recreational fishing effort (Coleman, 2004).

In 2009, a third recreational fishing survey estimated that recreational crabbing harvested 30,382 individuals annually (approximately 24t), and that pot fishing (which included fresh water cherabin pots) accounted for 130,945 hours of recreational fishing effort (West *et al.* 2012).

The traditional harvesting of mud crabs is important to coastal Aboriginal communities, helping to retain independence and connection to country, reinforcing social networks through sharing of gathered food, and maintaining traditional knowledge. Fishing is also an important educational tool, with customary fishing practices being passed on to successive generations. The Indigenous harvest of mud crab in the NT over a 12 month period in 2000-01 was estimated at approximately 86,000 crabs or about 69 t (Henry and Lyle 2003).

Fishing for mud crabs by Fishing Tour Operator (FTO) clients is considered a secondary activity, generally accounting for 2 to 3% of the total time spent fishing with less than 1t harvest annually. FTOs must submit mandatory catch logbooks, and clients employ the same harvest methods and are subject to the same catch and gear controls as recreational fishers.

Table 1. Chronology of management for the NT Mud Crab Fishery

Year	Management milestone
1972	• Recreational crabbers limited to 3 pots or dillies per person • $5.00 registration fee introduced for recreational pots
<1980	• Commercial crabbing carried out under a General Fishing Licence and general log books submitted
1980	• Commercial licences specific to mud crab fishing introduced (61)
1984	• $5.00 commercial pot registration fee introduced • Commercial operators required to submit specific mud crab fishery logbook returns
1985	• Moratorium on the issue of new commercial licences • Number of commercial licences capped at 55 fully transferable licences • Commercial pots limited to 60 per licence • $5.00 pot registration fee removed (both sectors) • Introduction of a 130mm carapace width MLS • Closure of Darwin Harbour, Leaders Creek, and most Shoal Bay creeks to commercial crabbing
1988	• Number of commercial licences reduced to 49
1990	• Commercial crabbing banned in Kakadu National Park as part of general provisions relating to prohibiting trapping
1991	• Mud Crab Fishery Management Plan introduced • Recreational possession limit of 10 mud crabs per person, or 30 per vessel introduced • Recreational pot or dilly limit changed to 5 per person, or 10 per vessel
1993	• Ban on the take of berried female mud crabs imposed
1996	• 10mm increase in MLS for female mud crabs to 140mm carapace width
2000	• Recreational crabbing using traps and other equipment banned in Kakadu National Park with the introduction of the EPBC Act
2001	• Industry initiative to introduce Commercially Unsuitable Crab (CUC) rule for the commercial sector
2006	• 10mm MLS increase for the commercial sector: - Male crabs 140mm carapace width - Female crabs 150mm carapace width
2010	• Unitisation of the licences (30 pots per unit)
2015	• Industry voluntarily closes the Roper, Towns, and Limmen Bight Rivers to commercial crabbing for a period of three years
2017	• Introduction of a Harvest Strategy

4.2. Ecosystem and habitat

Across the NT, tidal types change between semi-diurnal (two high and two low tides per day), and diurnal (one high and one low per day) that occurs in both the north of the Arafura Sea and in the south of the GoC (Webb, 1981).

The semi-diurnal and diurnal tidal waves for both the North West mud crab fishery region, and the Western Gulf of Carpentaria mud crab fishery region enter from the Indian Ocean. Considerable variation in tidal range is experienced along the NT's coast, with ranges exceeding 7 meters in the western areas during the spring tide, to less than 2 metres in areas of the GoC (Figure 1).

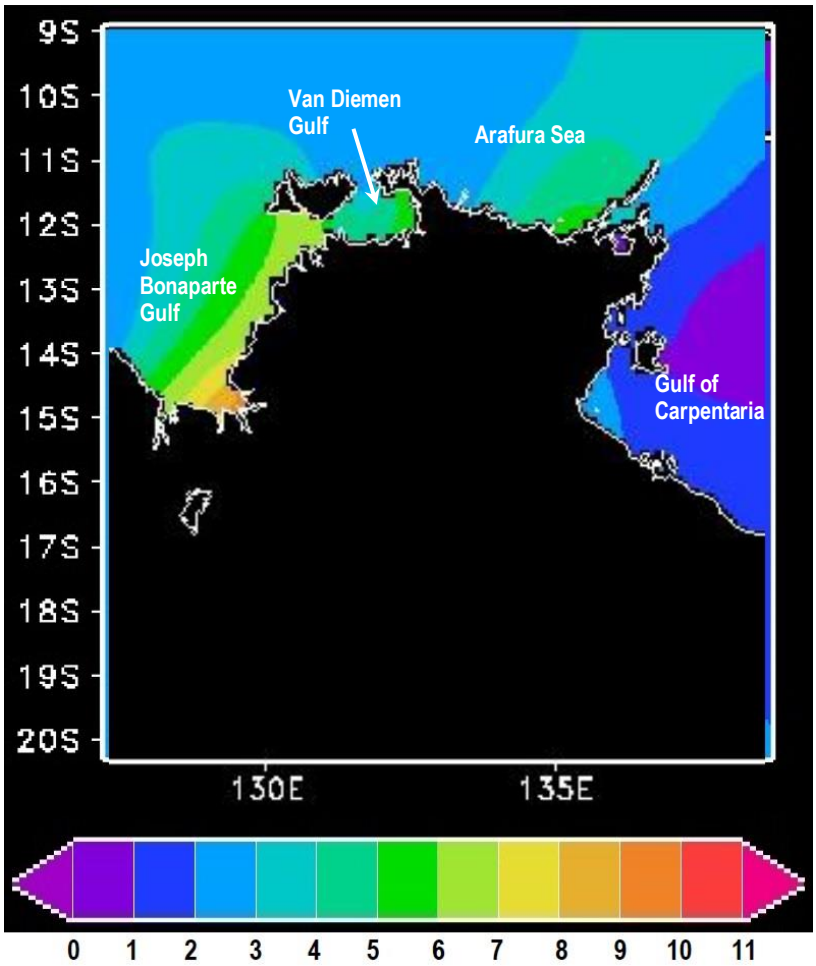


Figure 1.Tidal range in metres Source: (Modified from) Commonwealth of Australia 2004, Bureau of Meteorology, National Tidal Centre; Hay et al. 2005.

The Joseph Bonaparte Gulf, west of Darwin, is an extensive, shallow basin that receives significant loads of sediment from the numerous rivers in the region (Lees, 1992). It is dominated by tidal and wind-driven currents according to the season, with the area being comprised of soft substrate expanses with localised rocky outcrops, and strong tidal currents, high turbidity (particularly during the wet season), and substantial sediment mobility (Przeslawski *et al*. 2011).

The area immediately east of Darwin – Van Diemen Gulf, is a large almost fully enclosed body of water. Mainland landforms along the coast in this area are dominated by extensive low, flat, estuarine, coastal plains fringed at the coast by

mud flats/banks often associated with a narrow band of mangroves. The rivers and creeks are typically tide dominated with intertidal flats, mangroves and saline flats/salt marshes with a naturally high turbidity (Roelofs *et al.* 2005).

The Arnhem Land region has a diverse coastline. The dominant landforms in western Arnhem Land are undulating sand and lateritic plains with sandy beaches and low rocky headlands with mangrove lined saline mudflats in the more protected bays and estuaries. In eastern Arnhem Land, coastal landforms are dominated by floodplains and mangroves with extensive tidal mud and sand flats (Roelofs *et al.* 2005).

The major rivers of this region all have a moderate freshwater output, and wave energy is generally low except during short periods during storm and cyclonic activity during the wet season (Davies, 1986). Water clarity varies within the region, the estuaries and protected bays in the west, and the near coastal waters in the east are naturally turbid, whereas the rocky platform and sandy areas in the west have low turbidity.

The GoC is a large, shallow, muddy marine bay that has marked seasonality in temperature, rainfall, salinity and wind regimes. The region has a diversity of land forms including offshore islands, fringing coral reefs, sandy, muddy and cliff-lined coastal topographies as well as extensive tidal mud/sand flats. The western GoC coast is a complex coastline with few river inputs, and is less muddy than the southern Gulf, where extensive open coastline seagrass communities have been reported to exist (Poiner et al 1989).

Sediments throughout the Gulf are predominantly fine muds, and these are easily resuspended due to the shallow bathymetry resulting in increased turbidity. Cyclones and storms also readily disturb and shift sediments in this shallow environment (Roelofs *et al.* 2005).

4.3. Biology

The Giant Mud Crab is found in tropical and sub-tropical coastal regions in the Indo-West Pacific. It is the most widespread *Scylla* species ranging from South Africa to Tahiti. In Australia it has been recorded from Shark Bay in Western Australia to Port Hacking, south of Sydney (Keenan *et al.* 1998). The Orange Mud Crab is centred around the equator, most commonly found in the South China Sea and specific locations across the Indo-West Pacific (Keenan *et al.* 1998). In the NT it is most common in the west, between the Western Australia border and Bynoe Harbour, with only occasional captures north or east of that location.

The Orange Mud Crab does not grow as large as the Giant Mud Crab. Other distinguishing features include the different shape of the lobes between the eyes, and the spines on the elbows and claws (Figure 2).

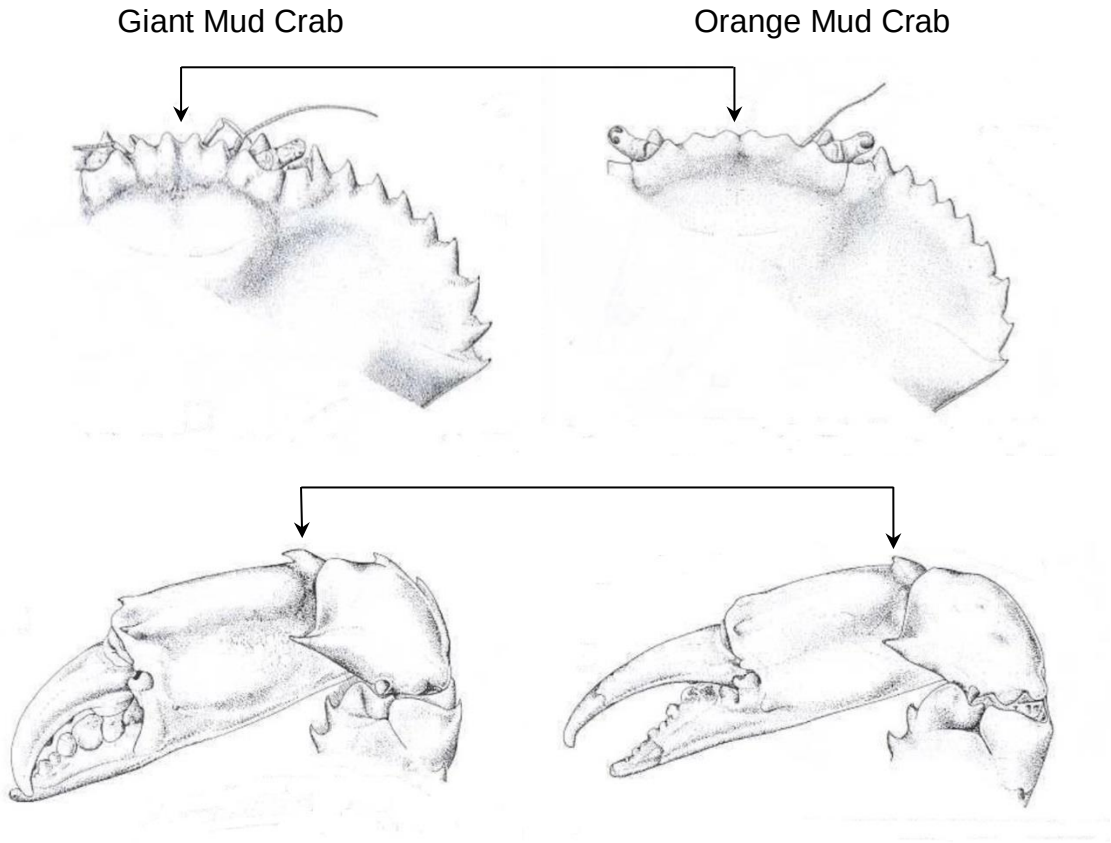


Figure 2. (a) Images of the carapace of the Giant Mud Crab and the Orange Mud Crab showing diagnostic taxonomic features. (b) Images of the claw of the Giant Mud Crab and the Orange Mud Crab showing diagnostic taxonomic features. Source: Keenan *et al.* 1998.

Mud crabs are top benthic predators, feeding on sessile or slow-moving benthic macroinvertebrates, mainly gastropods, crustaceans, and molluscs (Hill, 1976). There is no detected periodicity in feeding activity over a day's cycle (Alberts-Hubatsch *et al.* 2016), however feeding rates drop with decreasing temperatures, and ceases 2-14 days before moulting. Feeding resumes 2-4 days after moulting when the mouthparts harden (Du Plesis, 1971).

Moulting is closely related to the lunar and tidal cycles, with crabs most often moulting during the neap high tide during the night (Mirera & Mtile, 2009). The growth rates of males and females is similar, however adult male mud crabs are generally heavier than females of the same size due to their bigger claws (Schenk & Wainwright, 2001).

Mud crabs have a high natural mortality rate and relatively short life-span (<4 yrs), which results in large variations in annual catch primarily due to varying annual recruitment levels (Knuckey, 1999). Both sexes reach maturity within 12 months, however even under ideal conditions around 70% of mud crabs die within their first 12 months, and less than 3% surpass three years of age. Figure 3 represents the life expectancy and mortality curve for mud crabs under normal conditions.

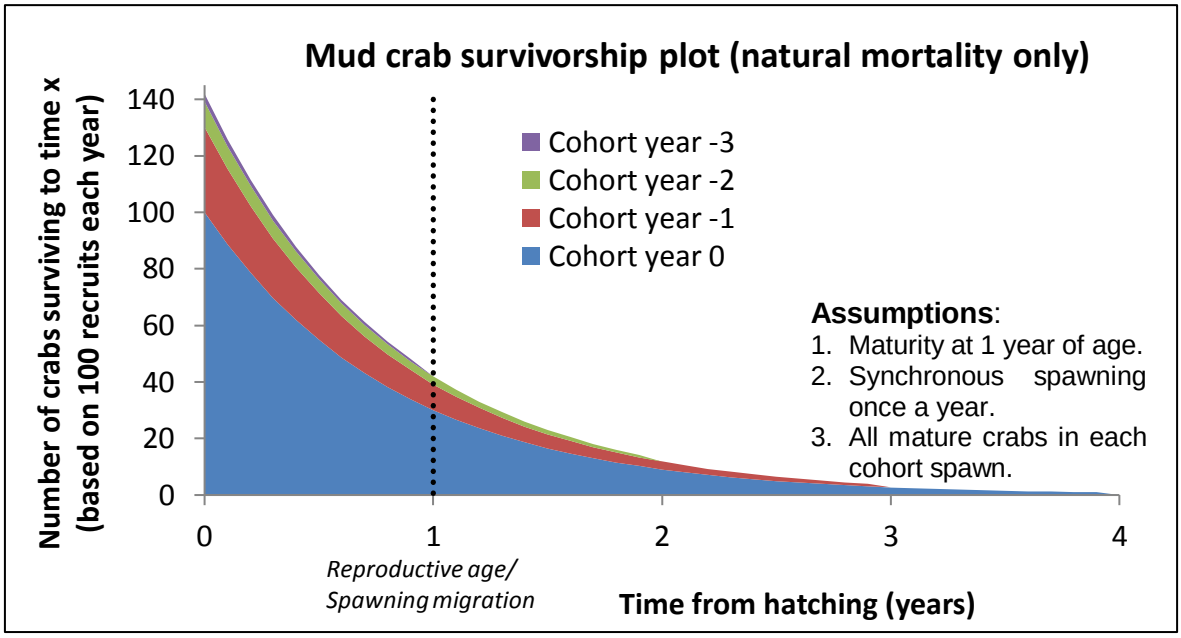


Figure 3. Mud Crab annual mortality curve[1].

Large scale climate patterns influence mud crab populations. A high Southern Oscillation Index (La Niña) can increase productivity in coastal areas and estuaries brought on by cooler temperatures and rainfall, and positively affect the occurrence and reproduction of mud crabs (Meynecke *et al.* 2012). Mud crabs are highly fecund and depending on whether the environmental conditions are favourable, populations can vary markedly even when there is no fishing pressure.

Spawning in the NT typically occurs from September – November (Hill, 1994), and females release around 5 million eggs per individual (Davis *et al.* 2004). The larvae of Giant Mud Crab undergo five developmental stages, with survival and developmental time dependent on water temperature and salinity. Larvae are planktonic and require stable salinity and temperature that is within their optimal range to successfully metamorphose into the megalopa stage (Figure 4). At this stage they begin to show an increase in tolerance towards lower salinities and temperature (Baylon, 2010).

Metamorphosis into the first crab stage occurs in waters with intermediate to high salinities, and early juveniles express a strong preference for seagrass habitat (Webley *et al.* 2009). Juvenile mud crabs have an increased tolerance for changing salinity (5 - 40‰) and temperature (Ruscoe *et al.* 2004), which facilitates movement into estuarine habitats where these factors vary substantially (Alberts-Hubatsch *et al.* 2016).

Adult mud crabs generally inhabit muddy estuaries and enclosures in mangrove ecosystems and tidal flats that are influenced by tidal waters, juveniles (3-99cm carapace width) reside in the upper intertidal and remain there during low tide (Hill *et al.* 1982). Movement of larger mud crabs (>100mm carapace width) seems related to the habitat they live in. Crabs inhabiting narrow mangrove-fringed creeks normally do not move more than 1 km, crabs found in open environments

[1] Note: the assumptions are used for the purpose of modelling and uncertainty needs to be taken into account.

like intertidal flats or open bays show greater movement (Hyland *et al.* 1984). It is suggested that movement may be dependent on the availability of alternative feeding grounds at high tide.

Female mud crabs leave their usual habitat for spawning, and have been recorded moving large distances (up to >95 km) offshore to release their eggs (Hill, 1994). It is assumed that to maximise the survival rate of larvae, female mud crabs seek stable conditions with high salinity and temperature for hatching the larvae (Alberts-Hubatsch *et al.* 2016).

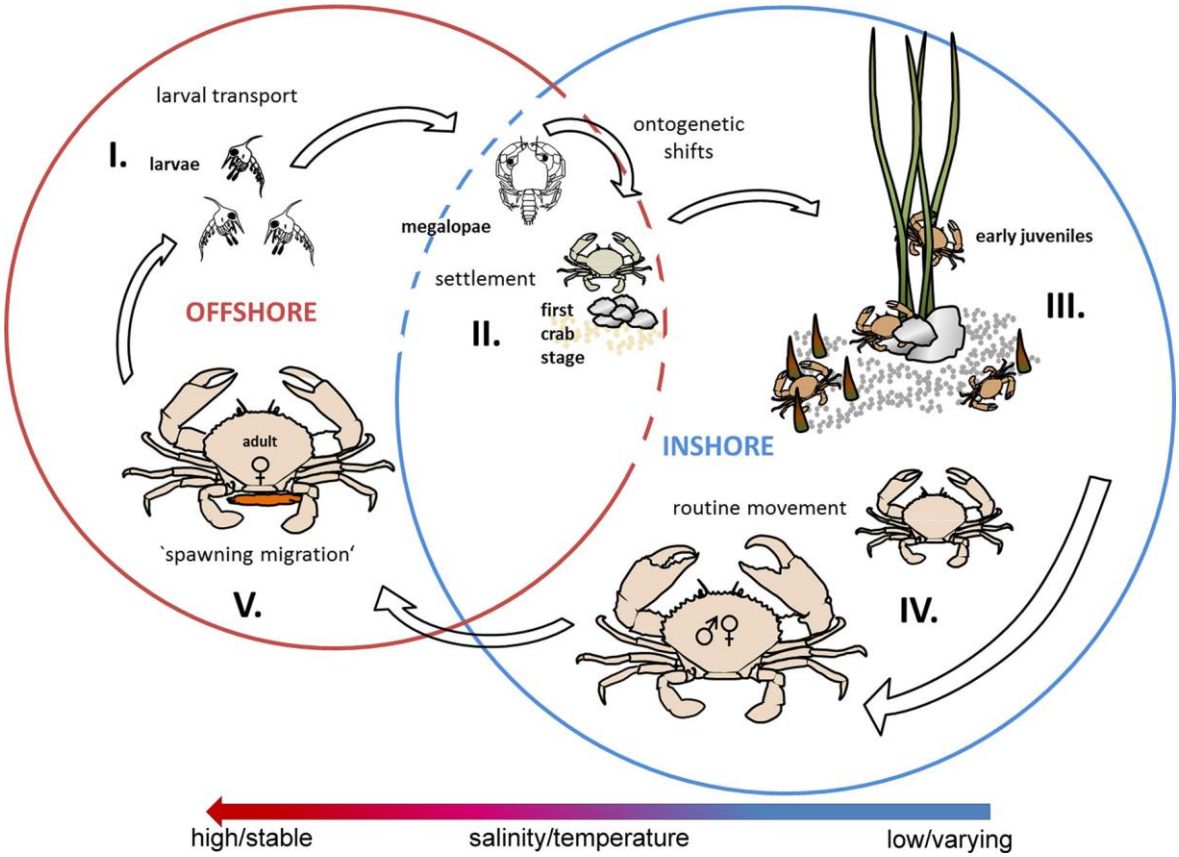


Figure 4. Mud Crab life cycle, the arrow indicating the gradient for salinity and temperature. Source Alberts-Hubatsch *et al.* 2016.

4.4. Current Biological Status

The Giant Mud Crab (*Scylla serrata*) constitutes around 99% of the commercial mud crab harvest in the NT (Calogeras and Hay, 2000). Genetic evidence suggests that there are at least two biological stocks of Giant Mud Crabs in Australian waters: one to the west and another to the south-east of Torres Strait (Gopurenko and Hughes, 2002) commonly referred to as the Northern Australian and East Coast Biological Stocks, respectively. It is expected that should evidence of finer genetic structure be revealed through future studies, it will be adequately accommodated for within this Management Framework or upon its

review.

The 2015 Status of Australian Fish Stocks reported the mud crab stock in the Arafura-West to be sustainable, and the Western-GoC stock to be transitional-depleting. The careful management to recover the mud crab stock in the GoC is being addressed through the implementation of the Harvest Strategy in this Management Framework for the fishery.

The Australian Government Department of Environment re-assessed the NT Mud Crab Fishery against the *Guidelines for the Ecologically Sustainable Management of Fisheries,* in 2016 and concluded the fishery was being managed in an ecologically sustainable way. As a result, the fishery was declared an approved Wildlife Trade Operation, allowing it to export mud crabs for 10 years.

For the purposes of this Framework, Giant Mud Crabs in the NT are treated as two separate stocks: a Arafura-West stock, and a Western GoC stock (Figure 5). The Western GoC stock encompasses waters to the east of 135°E and to the south of 13°S (within the NT), whereas the Arafura-West stock extends westward along the coast from 13°S into Western Australia.

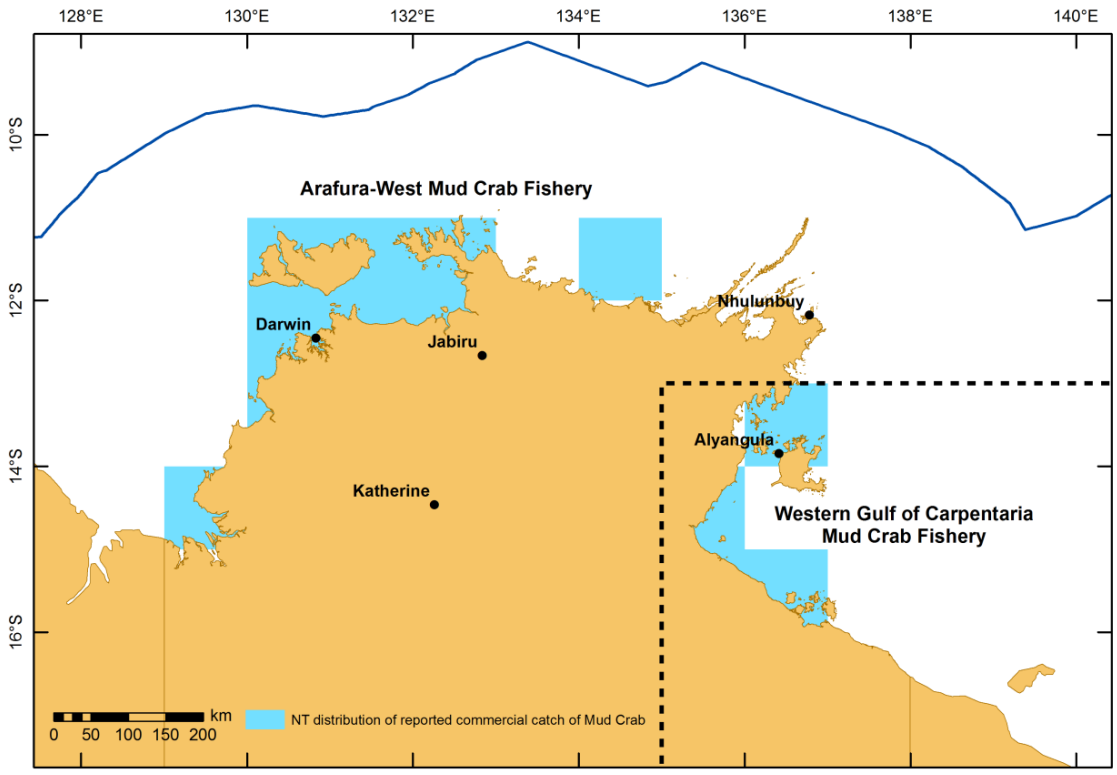


Figure 5. Map showing the areas of operation of the Northern Territory Mud Crab Fishery (2015). The dotted line represents the delineation between the stocks being assessed.

Arafura-West Australian Giant Mud Crab stock

Commercial catches from the Arafura-West Australian Giant Mud Crab Stock have averaged 124t over the previous 10 years, and ranged between 67t and 149t during this period (Figure 6). The relatively small catches from the Arafura-West Australian Giant Mud Crab stock, combined with an east-flowing, wet season current that may disperse mud crab larvae over long distances, suggests that this stock is unlikely to be overfished and that overfishing is unlikely to be occurring.

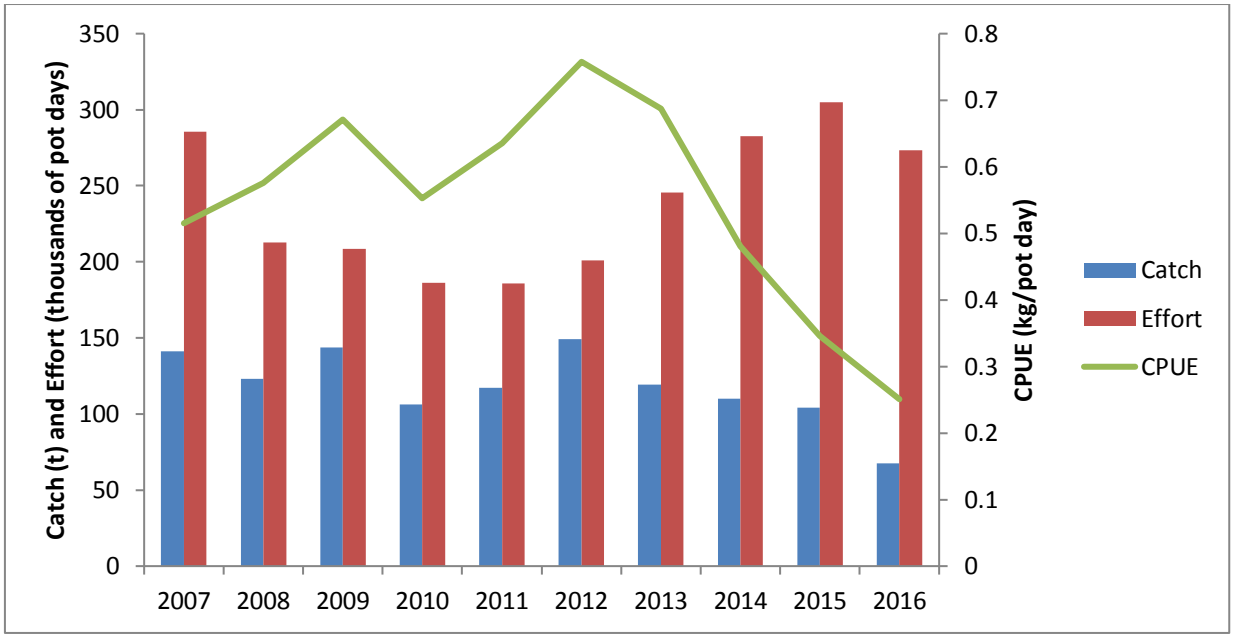


Figure 6. Catch (t), Effort (thousands of pot-days) and Catch per Unit Effort (CPUE; kg/pot-day) for the Arafura-West Australian Giant Mud Crab stock, 2007 to 2016.

Western Gulf of Carpentaria Giant Mud Crab Stock

Commercial catches from the Western GoC Giant Mud Crab Stock have averaged 215t over the previous 10 years, and ranged between 46t and 419t during this period (Figure 7). A recent assessment (2016) of recruitment overfishing risk for the mud crab fishery in the western (NT section) of the GoC (Walters, unpublished) suggests that overfishing is not currently occurring. However, the report also warns that the modelling approach is highly sensitive to changes in the catchability of mud crabs (through changes in fishing practices) and that there is some risk that overfishing may occur if unfavourable environmental conditions persist and constrain recruitment.

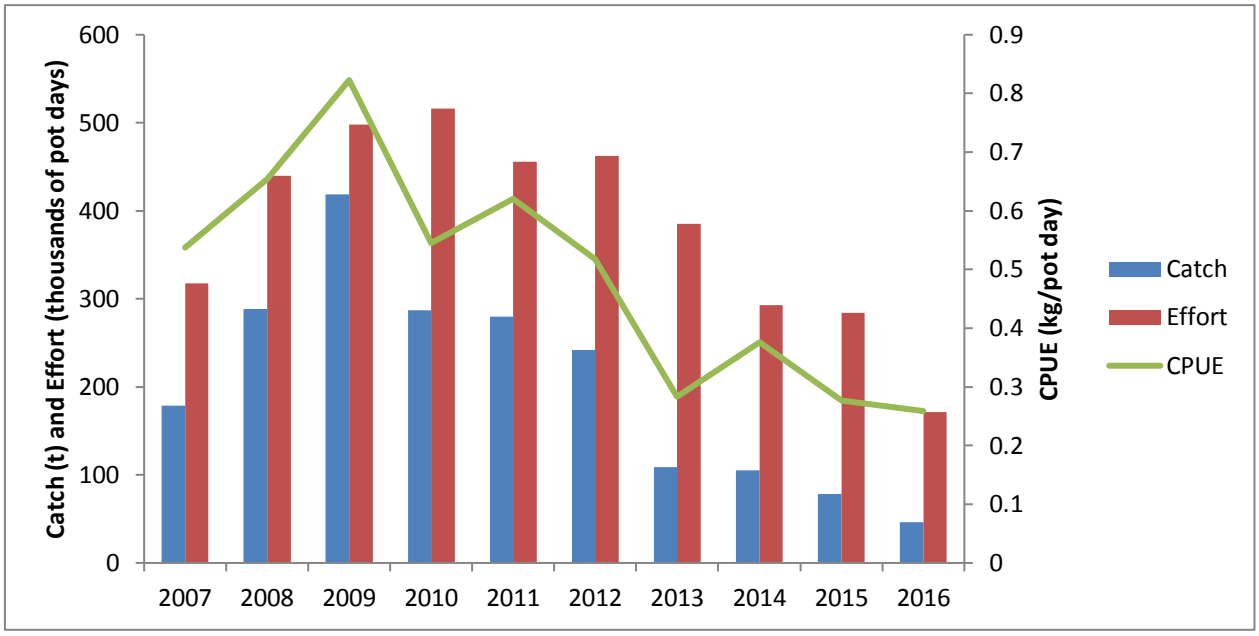


Figure 7. Catch (t), Effort (thousands of pot-days) and Catch per Unit Effort (CPUE; kg/pot-day) for the Western Gulf of Carpentaria Giant Mud Crab stock, 2007 to 2016.

4.5. Economic characteristics

The total catch of mud crabs has varied significantly over the last decade, with catches increasing from 2006 to 2009 and then declining. The catch data presented in Figure 8 varies from published calendar year data due to the requirement for comparative purposes to capture the information for the financial year.

Limited data is available for an accurate GVP analysis specific to the NT Mud Crab Fishery, consequently annual average price data from the Sydney Fish Market (SFM) was used for the assessment. This data, published in the SFM annual reports (http://www.sydneyfishmarket.com.au/our-company/annual-report), is based on all mud crabs sold through the Market and does not factor in higher prices that may be achieved for NT mud crabs which include female crabs and crabs which are subject to quality regulations (i.e. the CUC rule) not in place in other jurisdictions.

Based on these figures, in the last decade the GVP peaked in 2008/09 at nearly $12M, but has since dropped to $4.5M in 2015/16 despite on average receiving higher prices per kilo (Figure 9).

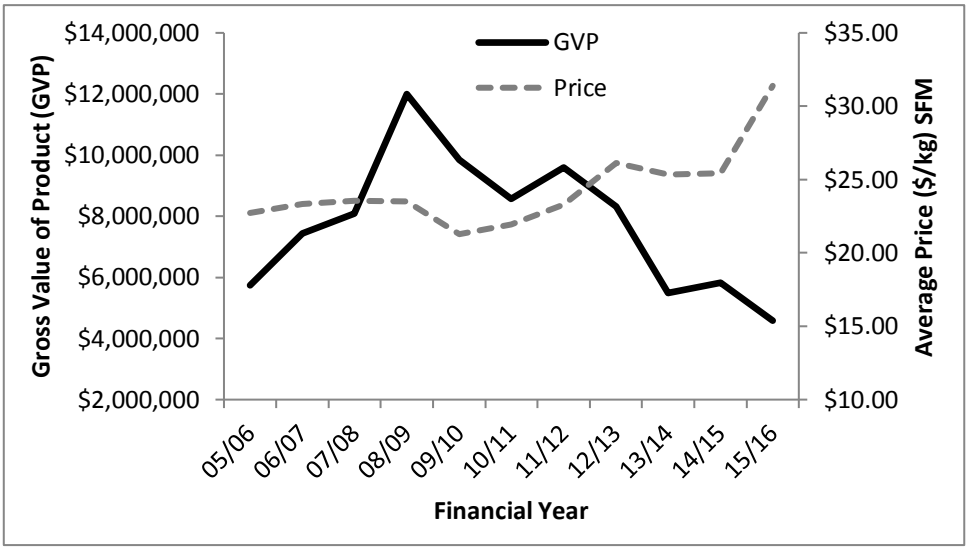


Figure 8. Annual mud crab fishery GVP based on average SFM prices, and the SFM reported annual average price received for mud crab from 2005/06 to 2015/16.

The price per kilo has increased by over 30% since 2009/10, mostly made up by an increase of nearly 20% between 2014/15 – 2015/16. Licence fees as a percentage of GVP hovered around 1% until 2013/14 when a sharp increase was observed. The figure of 2.3% observed for 2015/16 could be a reflection of the reducing catch and GVP for the fishery (Table 2).

Table 2. Fishery GVP and licencing costs in the Mud Crab Fishery between 2005/06 and 2015/16.

Year	Price ($/kg) SFM	Catch (t)	GVP ($,000)	Fees / levy's (per licence)	No. Licences	Total fees	Fees/GVP (%)	Fees/Catch ($/kg)
05/06	$22.72	252.8	$5,745	$1380	49	$67,620	1.2%	$0.27
06/07	$23.35	318.3	$7,432	$1595	49	$78,155	1.1%	$0.25
07/08	$23.56	343.6	$8,096	$1635	49	$80,115	1.0%	$0.23
08/09	$23.49	510.7	$11,997	$1730	49	$84,770	0.7%	$0.17
09/10	$21.28	463.1	$9,855	$1770	49	$86,730	0.9%	$0.19
10/11	$21.94	391.0	$8,578	$1855	49	$90,895	1.1%	$0.23
11/12	$23.31	412.1	$9,605	$1915	49	$93,835	1.0%	$0.23
12/13	$26.11	318.2	$8,309	$1970	49	$96,530	1.2%	$0.30
13/14	$25.34	216.4	$5,484	$2020	49	$98,980	1.8%	$0.46
14/15	$25.44	228.9	$5,823	$2090	49	$102,410	1.8%	$0.45
15/16	$31.39	146.0	$4,584	$2150	49	$105,350	2.3%	$0.72

Operator profitability and economic value to the community were both identified as moderate risks through a social and economic risk assessment conducted for the fishery. The use of GVP was proposed as an indicator to monitor profitability, but due to the variability in operating expenses based on region of activity and operating platform this is still to be adopted.

Limited data is available to describe the economic characteristics of the recreational, FTO, and indigenous sectors. The Territory-wide recreational fishing surveys carried out in 2001 and 2009 captured expenditure information including items and categories of expenditure, however this could not be broken down to reflect expenditure specifically related to mud crabbing with any accuracy.

4.6. Social characteristics

The evaluation of social characteristics of the NT Mud Crab Fishery for all sectors is difficult to undertake, as at this stage there are no recognised and easily measured indicators of social performance. Social value may be considered to be derived from various economic indicators such as employment, profit, and lifestyle contribution which can deliver flow-on benefits, and indicators to assist in understanding the complete benefit of the fishery should be considered for future monitoring.

There is a value to the community for having access to the resource. The public has the ability to purchase local fresh seafood, or harvest mud crab as a recreational pastime that is also often undertaken as a low-cost family activity. The commercial Fishery is predominantly utilised by land-based operators in remote and regional areas. Through this there is an element of social engagement and contribution by living and operating in these areas. The resource provides an important lifestyle contribution to the health and wellbeing of indigenous Territorians through cultural and social practices and lore, promoting family bonding, and maintaining traditional fishing knowledge.

5. ALLOCATION OF ACCESS BETWEEN SECTORS

A key element of Fishery Management Framework development is to identify the utilisation of the resource and access arrangements between sectors. This may progress to the fishery undergoing a formal allocation process, in which case this process would be guided by the '*Northern Territory Fisheries Allocation Policy*'. The Policy was developed by the Department of Primary Industry and Resources to address the issues related to the allocation of access between extractive user groups.

5.1. Current use of the resource

Current use of the resource is based on ratios of the reported figures published in the Status of Key Northern Territory Fish Stocks reports. Utilising the recreational fishing, and traditional harvest information that is available, as a proportion of the total harvest, on average these sectors account for around 6% and 5% respectively. The Fishing Tour Operator sector accounts for less than 1% (Table 3).

As a guide Table 3 represents the available information regarding sector use (allocation) of the resource for the purpose of this management framework document.

Table 3. Historical use of the Fishery between sectors.

Species	Commercial	Indigenous	Recreational	Fishing Tour Operator
Mud Crab	88%	5%	6%	1%*[2]

Significant spatial variation exists across the Fishery between sectors, the recreational component of the fishery can operate across the entire Territory coastline, however 70% of the recreational catch is from the Darwin region, extending from Darwin Harbour to Cape Hotham (West *et al* 2012). Additionally, information gaps exist, in particular for traditional harvest rates. There is potential for a significant lag in determining if traditional harvest rights have been diminished due to the limited information that is available, and the difficulty in capturing that information. Through investigating a catch share system, further work may be required regarding harvest rates from the traditional sector to ensure the information available is current and accurate.

[2] **FTO annual catch around 1 t (rounded up to 1%)*

5.2. Catch shares

The use of catch shares is a proposed method to facilitate the equitable distribution of access to the resource. Catch shares may be allocated to a whole fishery, or defined regions within a fishery. Several conditions exist if determining a catch share allocation between sectors for the Mud Crab Fishery, including that:

- appropriate data must be available,
- the data is recent and reliable, and,
- the information should be collected, reviewed, and prepared in a way that is verifiable.

5.3. Sectors of the Fishery

Commercial Fishing Sector

Commercial access to the resource is restricted to licence holders and people who are nominated by those licence holders to fish those rights and is managed through a complex range of controls including MLS limits, area restrictions, prescriptive gear, and catch and handling methods. Mud crab licences are currently limited to 49 and were unitised in 2010, with the previous gear allocation of 60 pots per licence being divided into two units of entitlement, each valued at 30 pots. Under the current management regime, units of entitlement can be leased to other licence operators but not sold individually. Licensees must also hold at least two units of entitlement (60 pots) before they can operate.

For catch reporting purposes, through mandatory logbooks commercial operators provide area information that includes the 'grid' number (Appendix I) the catch came from, and the local area name along with details on days fished, number of pots used, and how many times gear was retrieved.

Licence holders are permitted to take other species, and are only restricted against the take of other managed species (refer Appendix 2). Given the nature of the gear allowed in the fishery, the capture (and retained) rates of other species by the commercial sector is consistently less than 0.5% of the harvest, subsequently at this stage allocation for these species are not considered necessary.

The Aboriginal Coastal licence does allow for the sale of mud crab that has been caught as byproduct, however the intent of the licence is not to intentionally target mud crabs and sales are generally limited to no more than five per month. This however does not preclude the possibility of changes to future harvest arrangements under this licence pending the outcome of future negotiations and consultation.

The Recreational sector

Recreational access to the Mud Crab resource is primarily managed using gear limits, minimum legal size limits, personal possession limits, and vessel limits. Recreational crabbers cannot sell or barter their catch.

There is currently no recreational fishing licence. Improved region specific catch

data in the greater Darwin area is becoming available through ongoing recreational fishing surveys. Additionally, it is hoped the introduction of the 'Recreational Mud Crabbing Diary' - a voluntary catch reporting system for recreational fishers harvesting mud crab, and the catch reporting function on the 'NT Fishing Mate' app will also improve recreational harvest information. Recreational fishers are restricted by size limits, possession limits, and gear that includes the use of complying pot or dilly, hand-spear, hand-held hook, hook and line, cast net, or amateur drag net.

The Indigenous sector (traditional harvest)

Under the *Fisheries Act*, the Indigenous sector is entitled to use the resources of an area of land or water in a traditional manner, and that regulation under the Fisheries Act will not diminish this right. This does not include the ability to use this entitlement to engage in commercial activity. Commercial engagement by the indigenous sector is encouraged through the purchase of a commercial licence, or potentially to explore the management arrangements of the Aboriginal Coastal licence.

Fishing Tour Operator sector

Fishing tour operator access to the Mud Crab Fishery is restricted to licence holders. The fishing tour operator sector is managed under the same regulations as recreational fishing and there is no cap on the number of licences that are issued, however operators are required to submit monthly logbook returns. FTOs and their clients cannot sell or barter their catch.

5.4. Information used to allocate shares

The process for determining sector allocations outlined in the '*Northern Territory Fisheries Allocation Policy*' states that:

- Shares of an aquatic resource should be expressed as the proportional share of each fishing sector to the total use of the resource.
- Where possible, shares should be further defined in terms of the Total Allowable Catch available for the species of interest.
- The preferred unit of measurement to estimate catch shares of fish and aquatic resources will be catch by weight

An allocation of any given resource must take into account the existing level of proportional use by all sectors within a fishery and ensure that there are processes to maintain these levels during an allocation of shares. Calculation of shares is based on the best available information on the current level of use by all fishing sectors, and the information is to be based on data that is:

- Real, that is collected and published,
- Recent, and where possible no more than five years old, and;
- Reliable - data that is scientifically verifiable.

Data to inform the resource use of commercial and fishing tourism sectors is taken

from compulsory catch and effort logbooks, while data to inform the resource use of recreational and Indigenous fishing sectors is taken from scientific surveys.

The information to be used to guide the allocation of shares in this fishery should consider information from the following sources:

- *The National Recreational and Indigenous Fishing Survey* (Henry & Lyle, 2003)
- *The National Recreational Fishing Survey: The Northern Territory* (Coleman, 2004)
- *Survey of Recreational Fishing in the Northern Territory, 2009–10* (West *et al.* 2012)
- *Status of Australian Fish Stocks* (Grubert *et al*, 2016)

5.5. Review of allocations

A review of resource use between sectors in the Mud Crab Fishery is to be undertaken every four years, or periodically in accordance with Government process and policy using an agreed market mechanism to undertake any reallocation under the following scenarios:

- There is a review of the Mud Crab Fishery Management Plan, which will reassess the appropriateness of the shares that acknowledges longer term data sets.
- There is a proposed significant change in the management of mud crabs that results in the shift of allocation to or from a sector.

5.6. Review process

Any review of sector allocations will follow the process outlined in the '*Northern Territory Fisheries Allocation Policy*'.

In the event that an adjustment of shares is required the process will follow the the *Northern Territory Fisheries Resource Sharing Framework*, which can be located at https://dpif.nt.gov.au/strategies-and-projects/fisheries-resource-sharing-framework.

6. ECOSYSTEM IMPACTS

The NT *Fisheries Act* clearly states that aquatic resources are to be managed in accordance with the principles of ecologically sustainable development (ESD).

In consultation with stakeholders an ESD risk assessment was conducted following the revised *National ESD Reporting Framework for Australian Fisheries* (Fletcher, 2015). All the ecological, economic and social factors that affect the management of the Mud Crab Fishery were identified and prioritised by

stakeholders at workshops held on 15th August, and 2nd November 2016.

The ecological impacts associated with the Mud Crab Fishery were rated from negligible to high, and a total of 16 risks were identified with a rating of 'Moderate' or 'High'. Most moderate to high risks were associated with governance, economic, or social issues, however four risks identified were ecological in nature:

- Sustainability of the target species in the GoC
- Terrestrial impact from construction and use of temporary land-based camps by commercial fisherman
- Environmental conditions that impact recruitment to the fishery
- The potential for runoff from development to impact water quality.

In accessing the fishery it is also acknowledged that there are other collateral impacts from other users of the resource that should be taken into account (e.g. camping, litter).

7. GOALS AND OBJECTIVES

This Management Framework provides a set of goals for the Mud Crab Fishery that align with agreed national guidelines for development of fishery harvest strategies and that are in accord with the objectives outlined in section 2A of the NT *Fisheries Act*. Concise and defined specific fishery related operational objectives have been introduced through the development of the harvest strategy decision rules.

7.1. Goal 1

Ensure the mud crab resource is harvested within determined limits that are ecologically sustainable

This goal relates to the sustainability of the target stocks. The operational objectives apply to both the Arafura-West region and the Western GoC region and are to ensure the Mud Crab resource is harvested within sustainable limits as defined by the reference points in the Harvest Strategy for each region.

The operational objectives of this Management Framework to guide the Harvest Strategy decision rules are:

- Maintain the mud crab stock above sustainable levels within natural variations
- Ensure sufficient information is available to inform the Harvest Strategy decision rules.

7.2. Goal 2

Maintain responsible planning and management of the mud crab stock to promote equity and access to the resource by all relevant stakeholder groups including:

- ***Aboriginal people;***
- ***Commercial operators;***
- ***Fishing Tour Operators***
- ***Recreational fishers' and***
- ***Others with an interest in the mud crab resource in the NT.***

This goal relates to the planning of management activities for the fishery, and to ensure the fishery is managed in an equitable way. This Management Framework identifies shares of the mud crab resource to commercial, recreational, traditional and FTO fishing sectors. The methodology behind any allocation process and the mechanisms for managing and adjusting shares are outlined in Section 5.

The key objectives are to ensure that stakeholders have involvement in the decision-making processes for developing and recommending management

arrangements for the fishery, and ensure that management arrangements are complied with. The objectives for this goal are to:

1. Ensure the management arrangements reflect relevant and legitimate concerns and interests of the wider community
2. Support for representative bodies to participate and function to assist the management advisory process for the fishery
3. Promote understanding and compliance of management arrangements
4. Explicitly allocate the shares of access to the mud crab resource between the commercial, recreational, traditional, and FTO sectors.

7.3. Goal 3

Promote optimum utilisation of the Mud Crab resource in line with agreed allocations through a simple and adaptive approach to the management of the resource

This goal relates to the social and economic benefits derived from the fishery and aims to optimise the utilisation of the fishery in a sustainable way that benefits the community. The objectives of this Framework in relation to these benefits are:

1. Manage allocated shares to deliver optimum utilisation of the resource in line with allocations.
2. Seek to minimise external impacts on the ESD of the Mud Crab Fishery.
3. The Mud Crab Fishery is well supported by the community.

8. RESEARCH

8.1. Stock assessment

8.1.1 Data collection and analysis

A range of data is collected to assist in the monitoring of the Mud Crab Fishery. Information collected is primarily fishery-dependent data derived from commercial and FTO catch and effort logbook data, and wildlife interaction logbook data.

Recreational and Indigenous harvest information is collected through surveys. Boat ramp surveys for recreational effort in the Darwin area are ongoing with the most recent Territory-wide recreational survey conducted in 2009 (West *et al.* 2012). The most recent Indigenous harvest survey was conducted in 2001 (Henry & Lyle, 2003). Further work may be required to monitor traditional harvest levels and ensure traditional harvest rights are not impacted.

8.1.2 Commercial data

8.1.2.1 Logbooks

A compulsory requirement for commercial fishers is to record information on catch and effort levels and other details on fishing operations. Logbook returns are submitted to NT Fisheries monthly and entered into the database. Current details recorded in the logbooks include:

- Operator details
- Month of operation
- Number of days in the month fished
- The Fishing Grid(s) fishing activity occurred in (Appendix 1)
- The area location of the fishing activity
- The number of pots set
- The number of times the pots were pulled twice
- The landed weight of mud crab
- The species and landed weight of byproduct
- The number and species of bycatch caught
- The trader product was sold to
- Any direct interactions with Threatened, Endangered and Protected Species (TEPS)

Catch per unit effort (CPUE) of legal sized retained mud crab is the primary biological performance indicator for the fishery, used to underpin all stock assessments and the Harvest Strategy decision rules. Trends in CPUE are summarised and published in the annual Status of Key Northern Territory Fish Stocks report. Industry and Government are working together to revise logbooks so that they best meet the needs of industry and researchers. It is proposed to move to an ELog system for catch reporting at the earliest opportunity.

8.1.2.2 Fishery independent data

Historically there is almost 30 years of data on the species, fishery and environmental variables through a range of research projects and programs. This information has provided critical data for analysis and modelling of the fishery.

Little fishery independent data is currently collected. NT Fisheries is trialling the use of fine mesh pots for potential development of a pre-recruit survey index, however this work requires further refinement.

8.1.2.3 Fishery dependent data

Market monitoring of crabs sold is conducted at wholesalers premises in Darwin. Data is collected monthly as live crabs are being packed for sale from four areas of the Fishery:

- Roper River
- McArthur/Wearyan Rivers
- Bynoe Harbour
- Adelaide River

The information recorded includes carapace width, sex, weight, shell hardness, growth phase, right claw height (males), mating success (males), presence of parasites and any limb damage. Each month this data is collected from 100 crabs for each area of the Fishery.

It is proposed to introduce a Vessel Monitoring System (VMS) to help inform refined spatial data collection and fishing patterns.

8.1.3 Recreational fishing data

Improved region specific catch data in the greater Darwin area is becoming available through ongoing recreational fishing surveys. Additionally, it is hoped the introduction of the 'Recreational Mud Crabbing Diary' - a voluntary catch reporting system for recreational fishers harvesting mud crab, and the catch reporting function on the 'NT Fishing Mate' app will also improve recreational harvest information. In addition, it is anticipated that repetition of the regular recreational fishing survey will continue.

8.1.4 Fishing Tour Operators

A compulsory requirement for Fishing Tour Operators is to record information on catch and effort levels and other details on fishing operations. Logbook returns are submitted to NT Fisheries monthly and entered into the database. Current details recorded in the logbooks include:

- Operator details
- Month of operation

- Number of days in the month fished
- The Fishing Grid(s) fishing activity occurred in (Appendix 1)
- The area location of the fishing activity (optional)
- The number of pots set and soak time
- The number of times the pots were checked
- The number of mud crab kept and released
- The number and species of bycatch caught
- The number and origin of clients
- Any direct interactions with Threatened, Endangered and Protected Species (TEPS)

8.1.5 Customary fishing data

Further work with traditional owners is required to identify methods to capture the customary harvest of mud crabs. Options include further development of the NT Fishing Mate app.

8.1.6 Reporting

The *Status of Key Northern Territory Fish Stocks* report is prepared annually, providing a document that formally interprets and analyses catch and effort data. This report also provides information, including CPUE, relevant to the Harvest Strategy decision rules.

8.2. Economic

Limited economic data is collected for the Mud Crab Fishery. To address this the Northern Territory Seafood Council has contracted EconSearch Pty Ltd to advise on what economic analysis can be undertaken with the data available, and to undertake a gap analysis in relation to what data could be collected to enhance such analysis. The report (in prep) will provide information on:

- Potential economic indicators
- Available fishery data
- Data gaps
- Economic contributions

8.3. Social

Limited social research has been undertaken for the Mud Crab Fishery. To address this, the NT Seafood Council has commissioned research through Territory Natural Resource Management to capture the communities' broader values and understandings of the industry. The project is stage one of a process aimed at engaging the diverse range of licence holders, wholesalers, researchers,

professional, cultural and recreational fishers in the NT Mud Crab fishery. It is anticipated this project will be completed by 2018, and is aiming to:

- Capture the knowledge and skills, record the needs, aspirations and visions of industry and document what they believe the fishery could sustainably achieve; and,
- Identify skills development opportunities within the fishery, resources needed for successful strategic planning, help industry understand the need for change, incorporate their ideas on change, improve industry engagement in management decisions and assist in the development of a formal sustainable harvest strategy.

A number of Fisheries Research and Development Corporation (FRDC) projects are underway that include components that may assist understanding and designing future social research relating to the traditional harvest of mud crabs in the NT.

It is anticipated that the regular recreational fishing survey will provide updated social information relating to the recreational fishing sector.

9. HARVEST STRATEGY

9.1. Introduction

This Harvest Strategy provides a structured framework for decision making to ensure that ESD objectives can be achieved, and has been developed in line with the 'NT Harvest Strategy Policy'. The decision making framework involves two key steps to be undertaken annually following the process set out in section 9.5 (The decision making process and timelines).

- The first step uses biological performance indicators to assess the current status of the mud crab resource. This includes an opportunity for industry to provide input on external factors that may have contributed to biological status;
- The second step utilises decision rules to guide the management action process that ensures the mud crab resource is harvested within ecologically sustainable limits.

The decision rules are designed to assist to manage the fishery in a way that promotes stock sustainability, maximises the opportunities for harvesting mud crabs, and provides certainty and stability for stakeholders.

Given the variable nature of mud crab populations (see section 4.3) and hence their availability, of primary concern for the management of the fishery is the ability to determine when populations are low and avoid the possibility of overfishing at these times. In the event of a concern to the sustainability of the stock through fishing pressure, management actions will be centred on the protection of stock during the major spawning period (October to December).

Management actions will be linked to fishery performance that is monitored by the performance indicators. If the fishery is performing poorly based on agreed indicators, further management actions may be introduced, if the fishery performs well i.e. during a highly productive season, the Harvest Strategy can enable the fishery to utilise the opportunity to increase returns but not have an adverse effect on sustainability.

The Harvest Strategy applies to the commercial, FTO and recreational sectors and all must contribute to improved performance if a management action is required.

At the 2016 assessment the Mud Crab stock in the Arnhem–West region was defined as 'sustainable' and the Western GoC defined as 'transitional-depleting' (Grubert *et al*, 2016). Prior to the latest assessment both stocks were defined as 'sustainable'.

This Harvest Strategy is aimed to firstly have the ability to introduce management actions if required that promote stock recovery, and secondly to focus on improving Mud Crabbing for all stakeholders in the Western GoC.

9.2. Biological performance indicators

A goal of the Management Framework is to ensure the mud crab resource is

harvested within ecologically sustainable limits. To achieve this goal, it is imperative that the present performance of the fishery is routinely assessed.

Assessment of the performance of the fishery will be done using the primary performance indicator, secondary performance indicator, and structured stakeholder feedback. The following four reference points are used to assess the performance of the biological performance indicators in the Mud Crab Fishery.

Target level	Is the desired annual level of performance expected from the Mud Crab Fishery that achieves the goals of the management Framework.
Upper trigger point	Is an indication that higher exploitation of the resource will not impact the sustainability of the stock.
Lower trigger point	Is the level of performance that indicates the fishery has declined and there may be a risk to the sustainability of the stock, i.e. there is a concern that the spawning stock biomass may become impacted through fishing, and a reduction in harvest is required.
Limit reference point	Is the point at which the spawning stock biomass has declined through catch to a point that recruitment levels are significantly reduced, and harvest must be substantially reduced to rebuild the spawning stock biomass.

For the purpose of this Harvest Strategy, and in line with the stock assessment reporting, the Mud Crab Fishery is separated into two regions; the Arafura-West region, and the Western GoC region (Figure 5). This ensures that the spatial variability in catches that has historically been observed in the fishery (see section 4.4) does not invoke decision rules that impact a region when it is not at risk, or in a position to sustain higher catches.

The following performance indicators acknowledge that the model used will be continually refined and improved; in addition the primary biological performance indicator (CPUE), will be assesses as to its effectiveness and appropriateness as practical experience with the Harvest Strategy occurs.

9.2.1 Primary biological performance indicator

This Harvest Strategy will utilise the commercial retained CPUE (kg/pot day) of legal sized mud crab as the primary biological performance indicator for the fishery. High CPUE is generally indicative of a large mud crab biomass and successful recruitment the previous year, and low CPUE is indicative of a small biomass. Commercial CPUE of legal sized crabs is measured using catch and effort data submitted in the mandatory logbooks.

CPUE reported as kg/pot day has been accepted as the best available indicator at this stage that is representative of mud crab abundance. This information is also summarised and published in the annual ‘Status of Key Northern Territory Fish Stocks’ report published in the last quarter of a calendar year.

Due to the uncertainty of using CPUE as the only indicator, an additional secondary indicator will be used to assist the decision rules.

The commercial fishery is responsible for approximately 88% of the harvest (Table 3), and is the only sector that provides adequate volumes of data for assessment of the fishery's performance. Decisions that impact other sectors will be based on information obtained through the commercial logbook reporting. Additionally, the location reporting component of the mandatory logbooks provides the ability for CPUE to independently assess the fishery's performance in the different regions of the fishery.

Calculation of CPUE for the assessment of the primary biological performance indicator uses the gross catch and effort for the period.

9.2.2 Secondary biological performance indicator

The 'Delay-difference' model developed with independent support specifically for the NT Mud Crab Fishery provides estimates for:

- The harvestable biomass of mud crabs at the start of the dry season,
- The recruitment of legal-sized crabs at the start of the wet season.

Outputs from this model can assist with predictions about the future performance of this fishery by providing an indication on the health of the stock in relation to spawning biomass, and consequently the capacity for the population to increase rapidly and take advantage of favourable environmental conditions.

The 'Delay-difference' model provides supporting information regarding the Female Stock Spawning Biomass (FSSB) in each region, and can assist in gauging whether:

1. The population can support additional exploitation, and;
2. There will be enough spawning females remaining to ensure successful recruitment to the fishery.

This secondary biological indicator will only be used to determine the magnitude of reduction in harvest that is required when lower trigger or limit reference points are breached. Additionally, the model will be used in times of high mud crab catch rates, to determine the magnitude of any potential increase in harvest.

9.2.3 Additional performance measures

Fine mesh research pots are being used to assess the abundance of pre-recruits in the fishery. Pre-recruit indexes have been shown to work well in other pot-based fisheries (i.e. SA Rock Lobster Fishery) to estimate the future biomass in the fishery. A time-series of data is required to develop this as a potential performance measure, however initially the fine mesh research pots will provide supplementary data to assist the CPUE figures.

After several years of collecting research pot data, the information can be used to assess the usefulness of this as an indicator to measure fishery performance and potentially assist the decision making process.

The commercial sector has also agreed to assist by using and checking these pots and providing regular data to Fisheries. In addition, it is proposed that industry will also provide information from a sample of pots on mud crabs that are caught but released, this will include CUC, undersized and other crabs not retained for sale. It is anticipated this will give a much better overview of the status of the resource and recruitment to the fishery.

9.2.4 Industry input

External factors not related to stock abundance can also influence CPUE. To ensure CPUE is providing an accurate as possible measure of fishery performance, industry will provide factual and credible evidence to interpret the impacts these external factors may be having. The external factors that may be considered by the management advisory committee include:

- Fluctuations in prices (e.g. impact of QLD product on market);
- Environmental influences;
- Operator expertise/regional experience;
- Logistical costs;
- Fluctuations in fuel prices.

The risk assessment identified gear interference and black market sales as 'high risks' for the fishery. Both these risks have the potential to impact the performance of the fishery for all sectors.

9.3. Reference points for biological performance indicators

Reference points are established in this Harvest Strategy for the primary biological performance indicator and secondary biological indicator. The primary biological indicator has a target level, two trigger reference points, and a limit reference point. The secondary biological indicator has a target level, and provides additional guidance for the decision rules.

Lower trigger point and Limit Reference

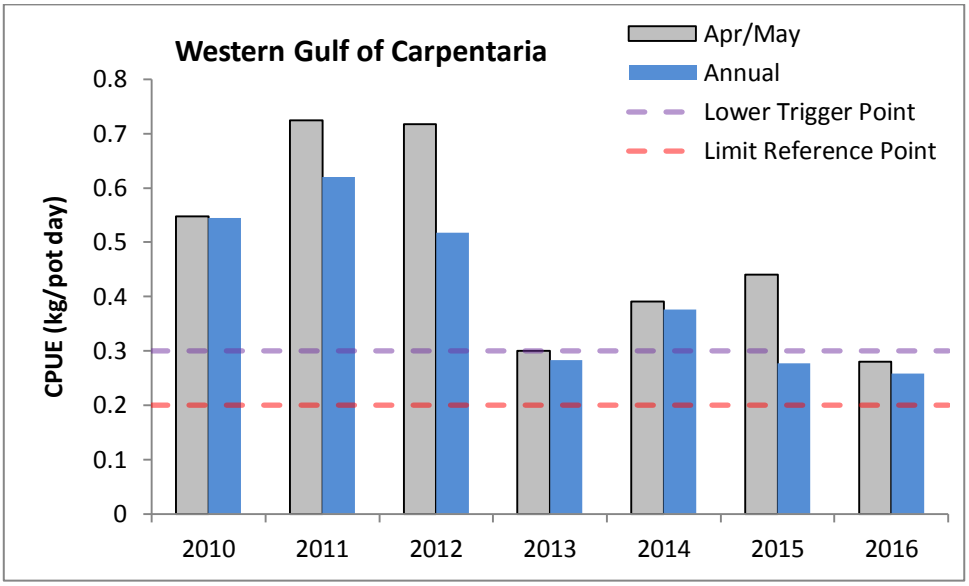
Catch rates can vary markedly month by month throughout each year in the Mud Crab Fishery. However, since unitisation of the fishery the average catch rates in April and May each year have provided an indication of the performance of the fishery for the remainder of the year in both regions.

The April-May average CPUE in each region is used to assess the performance of the fishery against the lower trigger point of 0.3 kg/pot day and the limit reference point of 0.2 kg/pot day. This will enable management actions (if required) to be implemented in time to afford protection to spawning stocks when spawning occurs later in the year, or consider other adjustments.

If a trigger level is breached the secondary biological indicator will provide additional information to guide the extent of the management action. Figure 9

(below) compares a retrospective assessment of the catch rates from April to May in each region from 2010 to 2016, against the annual average for each year.

(a)



(b)

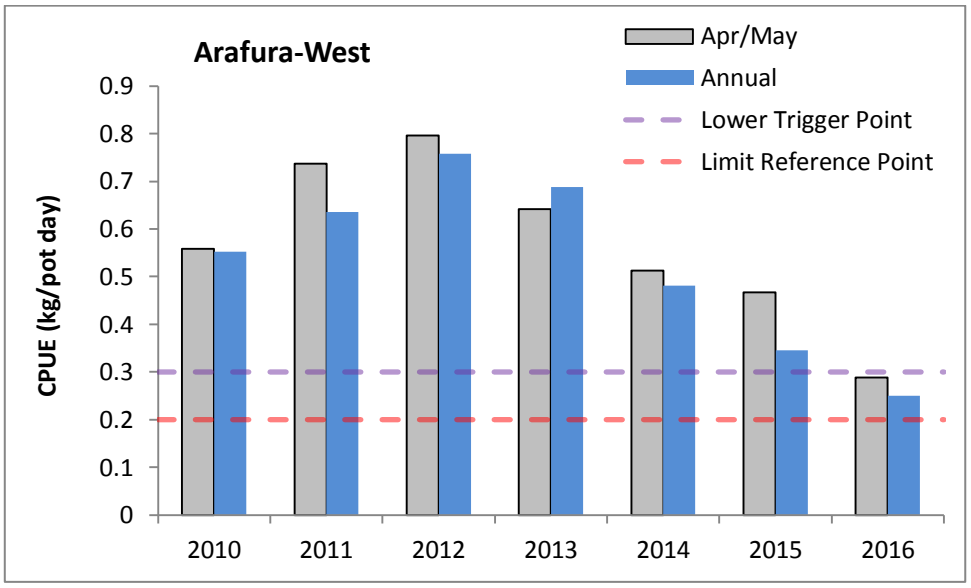


Figure 9. Average CPUE for April-May and the annual observed between 2010 and 2016 including the proposed lower trigger point and limit reference.

Target Level and Upper trigger point

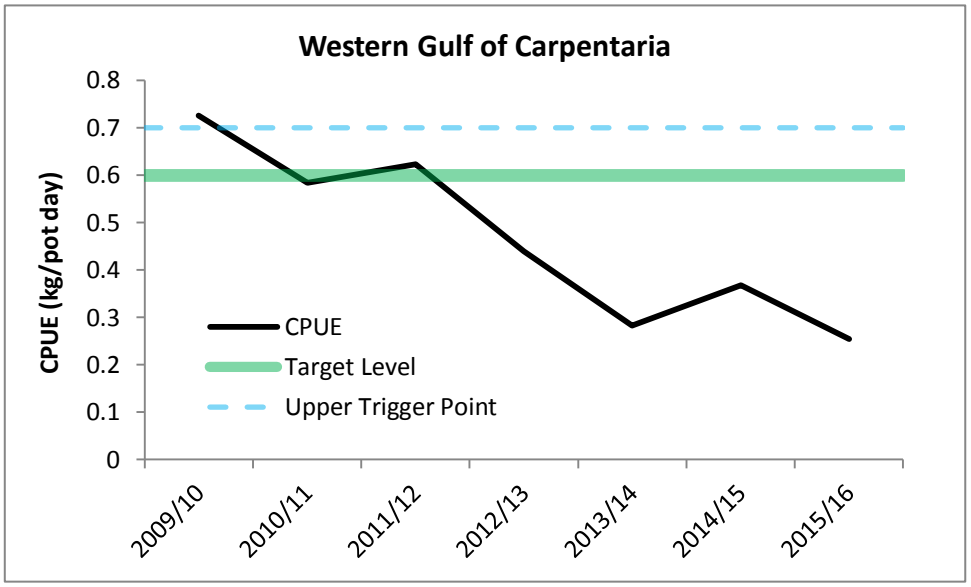
The target level for the fishery in both regions is based on recent catch history and uses the average CPUE of 0.6 kg/pot day for a 12 month period, with the aim being to achieve that catch rate for the year as a whole. The upper trigger point is also based on catch history, and is also assessed against the average CPUE over a 12 month period.

The upper trigger point is set at 0.7 kg/pot day for both regions, and requires additional assessment with the secondary biological indicator before making

additional harvest available in exceptional seasons.

Figure 10 shows the retrospective assessment of the Target Level and Upper Trigger Point for both regions.

(a)



(b)

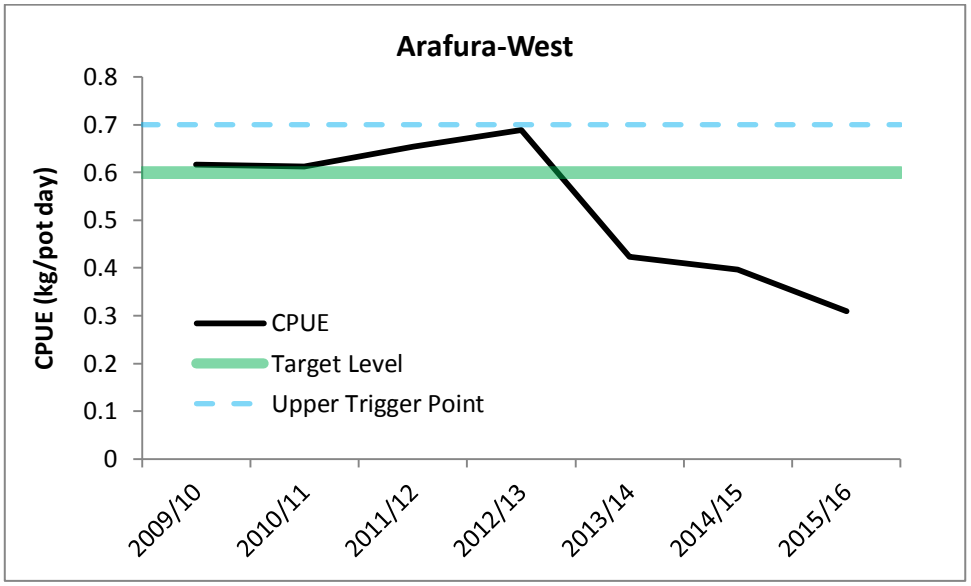


Figure 10. Annual CPUE (1 June – 31 May) observed in each region between 2010 and 2016 including proposed target level and upper trigger point.

9.3.1 Catch per unit effort (CPUE) reference points

Reference points for the primary biological performance indicator for both the Arafura-West region, and the Western GoC are set out in Table 4.

Table 4. Primary biological indicator reference points for each region.

	Limit	Lower trigger	*Target*	Upper trigger
West-GoC	0.2	0.3	*0.6*	0.7
Arafura-West	0.2	0.3	*0.6*	0.7

9.3.2 Basic delay-difference model target levels

Target levels for the secondary biological performance indicator for both the Arafura-West region, and the Western GoC are set out in Table 6 below. These estimates are based on the average FSSB in each region for the last 20 years.

Table 5. Female Stock Spawning Biomass target levels for each region.

	Target (female stock spawning biomass)
West-GoC	70 tonnes
Arafura-West	70 tonnes

9.4. Decision Rules

The decision rules in this harvest strategy have been designed to provide clear guidance for setting the level of effort, and how it is managed in the fishery. The rules for both the Arafura-West and the Western GoC regions are structured around CPUE (kg/pot day), and in this Harvest Strategy are the same for both regions. However acknowledging the differences in sector resource use between the regions (see section 4.4), there is scope for the management action options to differ.

The limit reference point of 0.2 kg/pot day is set at a point where harvest levels are too high and recruitment will be impaired if fishing continues, the target levels reflect the fishery's historical productivity and are set at what is considered achievable and sustainable. The trigger points indicate that some action is taken to either conserve stocks or for crabbers to capitalise and maximise their harvesting opportunities when conditions are favourable and it is sustainable to do so.

Under section 53 of the NT *Fisheries Act*, no regulation within or subordinate will limit the right for Aboriginals to harvest resources in a traditional manner, as such traditional harvest is not legally impacted by the decision rules in this Harvest Strategy.

9.4.1 Management actions

All performance indicators are assessed following submission of the May commercial logbooks. The CPUE observed between 1 April and 31 May each year is assessed against the lower trigger and Limit Reference points, and these measures determine if a management action is to be introduced on 1 October each year.

The CPUE observed between 1 June the previous year and 31 May is assessed against the upper trigger. The upper trigger determines if a management action is to be introduced on 1 January until 30 September the next year.

If the CPUE breaches either the lower trigger or Limit Reference point a low, medium, or high management action will be activated. The diagrammatic thresholds shown in Figure 11 demonstrate how the secondary biological indicator (FSSB) will be used to guide the extent of the management action if the CPUE breaches 0.3 kg/pot day or 0.2 kg/pot day between April and May.

If no other management actions are in place, the annual CPUE exceeds 0.7 kg/pot day and the FSSB is estimated at ≥70 tonnes, then there is an option for additional effort from 1 January until 30 September the next year.

- Low level action:
  Commercial Fishery - 3 weeks of closure in the period 1 October – 31 December, constituting a 25% reduction in commercial effort over the main spawning period.

Recreational anglers – Implement appropriate management options, including assessment of the impact of recreational fishing in specific areas

- Medium level action:
  Commercial Fishery - 6 weeks of closure in the period 1 October – 31 December, constituting a 50% reduction in commercial effort over the main spawning period.

  Recreational anglers – Implement appropriate management options, including assessment of the impact of recreational fishing in specific areas.

- High level action:
  Commercial Fishery - 3 month closure (1 October – 31 December), protection of stocks from commercial effort during the spawning period (100% reduction in commercial effort).

  Recreational anglers:

  GoC - 50% reduction in possession limit (5 per person, 15 per vessel).

  Arafura-West – Implement appropriate management options, including assessment of the impact of recreational fishing in specific areas.

- Upper trigger action:
  Commercial Fishery – Consider possible increase in unit entitlements.

  Recreational anglers – assess appropriate management options.

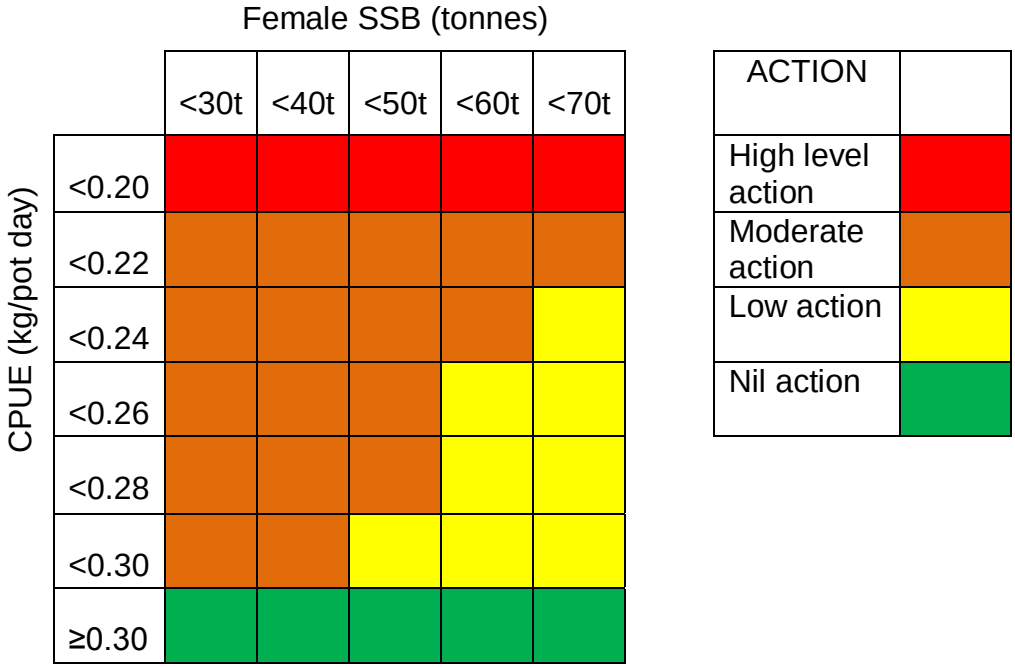


Figure 11. Catch per unit effort (CPUE) and Female Stock Spawning Biomass (FSSB) thresholds and coresponding management action.

As an example, if CPUE is 0.24 kg/pot day and the FSSB is estimated at 65t, the corresponding management action would be low level. Alternatively if the CPUE is 0.28 kg/pot day and the FSSB is estimated at 35t, the corresponding management action would be medium level. At any time if the CPUE is below 0.2 kg/pot day, the high level management is triggered.

Table 6 represents the CPUE assessment and management action periods, and in Table 7 the decision rules for the fishery are summarised.

Table 6. Timing of CPUE assessments and periods of management actions.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lower trigger				← - - -	- - - →							
Limit reference				← - - -	- - - →							
Upper trigger						←						

Assessment of CPUE

Effort Increase

Protection of stock

Possible management action

Table 7. Decision rules for the Mud Crab fishery.

DECISION RULES
Target level maintained No restriction to management arrangements if: • The average CPUE in April/May is above 0.3 kg/pot day in the Western GoC • The average CPUE in April/May is above 0.3 kg/pot day in the Arafura-West
Lower trigger point - Decrease in Effort **WGoC** • CPUE is between 0.2 and 0.3 kg/pot day for April-May Management Actions for the commercial fishery starting 1 October will be either: - 3 week closure in the period 1 October – 31 December (low action. - 6 week closure in the period 1 October – 31 December (medium action. Recreational Fishery – Implement appropriate management options, including assessment of the impact of recreational fishing in specific areas. **Arafura-West** • CPUE is between 0.2 and 0.3 kg/pot day for April-May Management Actions starting 1 October will be either: - 3 week closure in the period 1 October – 31 December (low action.. - 6 week closure in the period 1 October – 31 December (medium action Recreational Fishery – Implement appropriate management options, including assessment of the impact of recreational fishing in specific areas.
Limit reference point – Protection of stocks **WGoC** Commercial Fishery - Protection of stocks in the GoC from 1 October until 31 December (high action). Recreational Fishery – 50% reduction in possession limit from 1 October until 31 December. **Arafura-West** Commercial Fishery - Protection of stocks in Arafura-West from 1 October until 31 December (high action). Recreational Fishery – Implement appropriate management options, including assessment of the impact of recreational fishing in specific areas.
Upper trigger point – Increase Effort Management Actions (starting 1 January until 30 September): **WGoC** • The average CPUE (12 months) is 0.7 kg/pot day or higher • Estimated Female SSB is greater than 70 tonnes Commercial Fishery – Consider possible increase in unit entitlements. Recreational Fishery - Implement appropriate management options, including assessment of the impact of recreational fishing in specific areas. **Arafura-West** • The annual average CPUE (12 months) is 0.7 kg/pot day or higher • The Estimated Female SSB is greater than 70 tonnes Commercial Fishery - Consider possible increase in unit entitlements. Recreational Fishery - Assess appropriate recreational management options.

9.5. Decision making process and timelines

This process will be undertaken throughout each year following submission, data entry, and analysis of the commercial logbooks. Logbooks are required to be submitted within 28 days of the end of the month and for the purpose of this Harvest Strategy, entry of the Mud Crab Fishery logbook returns will be prioritised for at this time to meet the timeframe.

Following circulation of the catch data information, the Mud Crab Licensee Committee on behalf of industry, will provide industry input to the Mud Crab Fishery Management Advisory Committee (MCFMAC) regarding the current catch rate. If a trigger point (upper or lower) is breached, industry has the opportunity to provide supporting information.

The MCFMAC will consider the information and if agreement is reached provide a recommendation to the Director regarding management arrangements for the fishery from 1 October until 30 September the next year. If agreement from the MCFMAC is not reached, the Director will consider all the information provided.

It is proposed the delivery of CPUE information, and management recommendations if required, are scheduled to be conducted annually within the following timeframes:

28 June	-	All logbook data submitted by commercial operators.
6-10 July	-	All logbook data entered into FISHDAT.
12-16 July	-	CPUE information analysed and circulated, including details of any decision requirements (i.e. lower trigger point) or management actions. The Delay-Difference model will be run to estimate spawning biomass levels
20-24 July	-	Receive stakeholder input.
4-8 August	-	MCFMAC meet and agree on recommendations to submit to the Director for the fishery.
16-20 August	-	Director makes determination on MCFMAC recommendation, stakeholders formally notified of management requirements from 1 October until 30 September for the fishery.
24-28 August	-	Public notice released for Mud Crab fishery management arrangements
1 October	-	Implementation of fishery management arrangements for the appropriate period.

To enact the Harvest Strategy decision rules, flexibility provisions will be built in to the *Mud Crab Fishery Management Plan*, which will enable the Minister (or a delegate) to impose temporal or spatial amendments at any time to enact Harvest Strategy decision rules through public notice.

An initial comprehensive review of this harvest strategy will be undertaken after 12 months by the MCFMAC to determine the appropriateness of performance indicators and their reference points set out in the harvest strategy.

10. COMPLIANCE AND MONITORING

An objective of the compliance program is to maximise voluntary compliance through education to ensure fishers are aware of, and understand the rules that apply to their fishing activities. Both the Department of Primary Industry and Resources and the NT Police are responsible for delivering education regarding fisheries regulations, with the role of enforcement primarily undertaken by the NT Water Police section. Peak stakeholder groups such as the NT Seafood Council, the Amateur Fishermen's Association of the NT, and the Land Councils also have a key role in ensuring their constituents are aware of the rules associated with the fishery and seeking to work cooperatively in a shared management role to optimise outcomes in line with the fisheries objectives.

The NT Police are the responsible agency for enforcing provisions of the NT *Fisheries Act*, and its subordinate legislation including the NT *Fisheries Regulations,* and the *Mud Crab Fishery Management Plan*.

Effective compliance is created through the presence of Water Police officers and authorised and accredited Marine Rangers, as well as through detection and prosecution of illegal activity. Compliance activities include routine patrols and planned responses to risks identified in the fishery, with an emphasis on serious risks.

Compliance status reports can be requested from the NT Water Police, and will include:

- A description of the program for the previous year including an overview of activities and relevant statistics.
- An overview of the compliance status of the fishery, and any changes to the risk profile that have been observed.
- Suggestions for future compliance planning.

11. REGULATORY ARRANGEMENTS

The regulatory arrangements for the Mud Crab Fishery are contained within the NT *Fisheries Regulations 2015*, and the *Mud Crab Fishery Management Plan*.

11.1. Commercial Licensing

Commercial access to the Mud Crab Fishery is limited to 49 commercial licences, each licence is endorsed with two units that comprise of 30 pots each. Units are

able to be leased but not sold individually, and a commercial fisher must hold a minimum of two units before they can operate.

Under the *NT Fisheries Act* a commercial fishing licence can be granted for a period of up to five years.

Conditions can be imposed relating to areas, species, quantities, methods, the use or non-use of vessels and the specific vessel or types of vessels that may be used, types and amounts of fishing gear, harvesting, handling, specific ports or places where fish or aquatic life may be landed, and periods of time as the Director considers appropriate.

11.1.1 Approved Operator

Every person in charge of a commercial fishing operation (including licensees if they operate their own licence) need to have Approved Operator status. Approved Operator authorisations are obtained by applying in writing to the Director of Fisheries.

A commercial fishing licensee must appoint an Approved Operator to undertake fishing operations. Once an Approved Operator is appointed, details of the appointment must be forwarded to the Fisheries Licensing Office on the appropriate form within 24 hours.

11.1.2 Vessels

A licensee is permitted to use one vessel to catch, take or harvest mud crabs. Licensees can apply to the Director to use more than one vessel, for example to use as a live-aboard vessel, these applications are considered on a case-by-case basis.

Operators who have been approved to use a second vessel as a live-aboard vessel by the Director, can carry up to 15 spare pots on the live-aboard vessel under the following conditions:

- The pots are only stored on the live-aboard vessel,
- The pots do not have entrance funnels installed; and,
- The pots do not have floats attached

A Fishing Infringement Notice can be issued if up to 5 of the spare pots on a live-aboard vessel breach any of the configuration conditions. If over 5 of the spare pots on a live-aboard vessel breach the condition it may be viewed as a more serious over-potting offence.

11.1.3 Complying Marine Pot

The only method permitted for the commercial targeting of Mud Crab is a complying marine pot (Figure 13). Regulations for a complying pot include:

- Is designed to take mud crabs.
- Does not exceed a volume of 0.5m^3

- Does not exceed 1m in length, height or width
- Does not have inside or attached to it material that is likely to entangle fish or aquatic life
- Has not more than four openings (excluding any openings for emptying crabs from the pot or placing bait in the pot).
    a) Wire pots must be equipped with an escape vent with the configuration of either: one escape vent, not less than 46 mm high and 240 mm wide, or
    b) two escape vents, both of which are not less than 46 mm high and 120 mm wide.

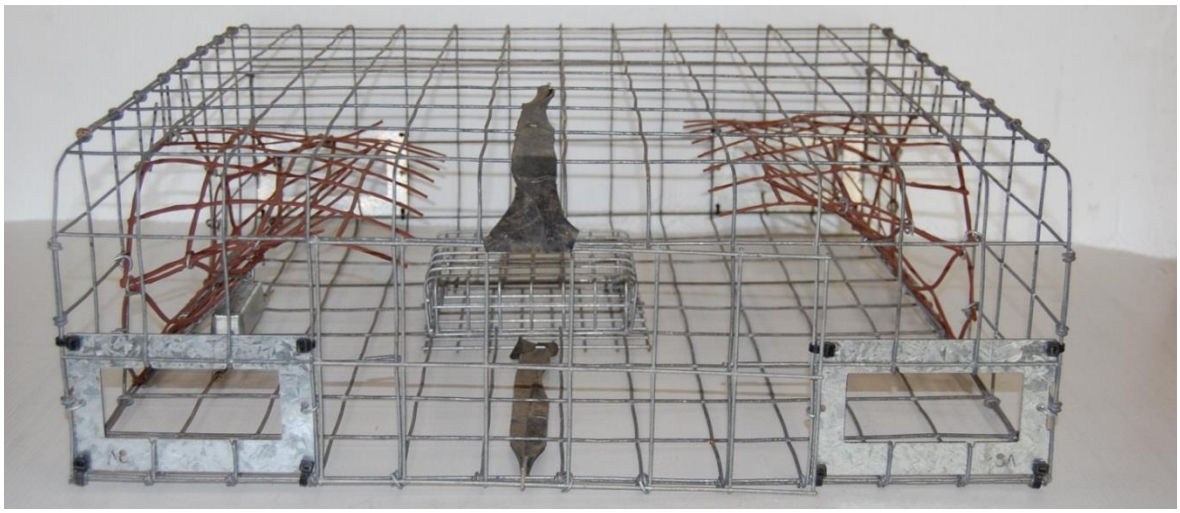


Figure 12. A rigid wire mesh pot typical of that used by commercial mud crab fishers in the Northern Territory showing escape vents fitted. Several variations on this basic design exist.

Recreational pots have the same dimension requirements but differ from the commercial pots by not requiring an escape vent, however pots must have a minimum mesh stretch of 50mm (Figure 13).

Figure 13. Two styles of collapsible polyethylene mesh pots which are commonly (but not exclusively) used by recreational mud crabbers in the Northern Territory.

Recreational crabbers and FTO clients can also use dilly pots to target mud crabs. Regulations for recreational use of dilly pots include:

- It is made of flexible net
- Has metal hoops that do not exceed 1 m in diameter
- Has a mesh size of not less than 15 mm
- Is constructed so that, when set, the sides collapse and the net lies flat on the ground and is not capable of entangling fish or aquatic life;

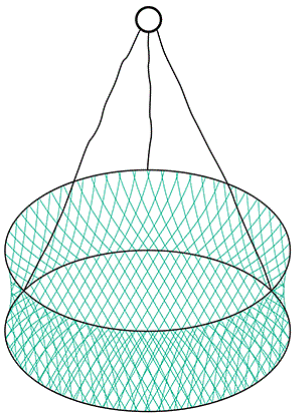


Figure 14. Line drawing of a dilly pot.

11.2. Current management arrangements

11.2.1 Commercial Fishery

The commercial fishery is managed through a range of input and output controls. All holders of a licence must nominate one place as the Licensees 'nominated place'. The nominated place cannot be a vessel that is used to fish for mud crabs. The nominated place, or permanent residence is where licensees can store up to 30 'spare pots'.

Table 8. Management arrangements for the commercial sector of the Mud Crab fishery.

Management tool	Requirement
Limited entry	49 licences.
Total number of pots	2,940 **not including spare pots*
Minimum size	Male – 140mm carapace width. Female – 150mm carapace width.
Minimum number pots / licence	60

Berried females	No retention – released immediately.
Commercially Unsuitable Crab (CUC)	No retention at camps.
Escape vent(s)	Mandatory in wire pots.
Closed areas	Darwin Harbour, Kakadu National Park, Leaders Creek, most creeks leading into Shoal Bay, aquatic reserves. Non tidal waters.
Pot specifications	Does not exceed a volume of $0.5m^3$, does not exceed 1m in length, height or width, does not have inside or attached to it material that is likely to entangle fish or aquatic life. Has not more than four openings (excluding any openings for emptying crabs from the pot or placing bait in the pot).
Complying float	Specifically designed marker buoy a minimum of 100mm in diameter. Is attached to a pot with line of minimum 6mm in diameter. Is marked legibly and indelibly in a way that can be easily read at all times with the commercial vessel identification number in Arabic numerals and no other number.
Restraining crabs	A licensee must: ▪ Not have un restrained crabs at their camp. ▪ Not release undersize or CUC crabs within 200 m of their camp.
Crabs to remain intact	A licensee must ensure mud crabs in possession remain intact until it is sold.
Processing crabs	Under a mud crab licence a licensee must not process mud crabs for sale other than by cooking, freezing or chilling.
Abandoned gear	Pots are deemed abandoned if left in the water unattended for more than 48 hours, unless the operator notifies the Director.
Monitoring tool	**Requirement**
Catch and effort data	Mandatory logbooks submitted monthly.

11.2.2 Recreational Fishery, and Fishing Tour Operators

Recreational fishers and Fishing Tour Operator clients are permitted to take mud crab with a complying marine pot that complies with recreational requirements, by hand, hand-spear, hand-held hook, hook and line, scoop-net, cast-net or amateur drag net.

The recreational and fishing tour operator sectors are managed through a range of input controls.

Table 9. Management arrangements for the recreational and FTO sector of the Mud Crab fishery.

Management tool	Requirement
Minimum size	Male – 130mm carapace width. Female – 140mm carapace width.
Maximum number of pots / dilly's	5 per person. 10 per vessel (with 2 or more people on board).
Berried females	No retention.
Possession limit	10 per person. 30 per vessel (with 3 or more people on board).
Escape vents	Optional.
Closed areas	Non tidal waters. Kakadu National Park, Port Essington, aquatic reserves.
Pot specifications	Does not exceed a volume of 0.5m^3, does not exceed 1m in length, height or width, does not have inside or attached to it material that is likely to entangle fish or aquatic life, has not more than four openings (excluding any openings for emptying crabs from the pot or placing bait in the pot). Minimum stretched mesh size of 50mm.
Dilly specifications	It is made of flexible net, has metal hoops that do not exceed 1 m in diameter, has a mesh size of not less than 15 mm, is constructed so that, when set, the sides collapse and the net lies flat on the ground and is not capable of entangling fish or aquatic life.
Complying float	Specifically designed marker buoy a minimum of 100mm in diameter, and is

	attached to a pot with line of minimum 6mm in diameter. Is marked legibly and indelibly in a way that can be easily read at all times with the first and last name of the person using the gear, and an active phone number for the person using the gear.
Crabs to remain intact	Crabs must remain intact unless being used for immediate consumption or at the persons permanent place of residence.

11.2.3 Indigenous sector (traditional harvest)

No provision under the NT *Fisheries Act* shall limit the right of Aboriginals who have traditionally used the resources of an area in a traditional manner from continuing to do so.

12. REVIEW OF MANAGEMENT FRAMEWORK

The management Framework will be reviewed after 5 years. Changes to the management Framework, and subsequently the Management Plan, must be approved by the Minister responsible for Fisheries. The Director can submit proposed amendments to the Minister for consideration, and to assist the Director to give advice in relation to the management plan, under section 24 of the *NT Fisheries Act* the Minister may establish a Management Advisory Committee (MAC). The Minister can appoint members to the committee that provides expertise from all stakeholder groups.

If exceptional circumstances arise, amendments to the management plan can be made at any time, if after consulting the MAC, the Minister is of the opinion there is sufficient threat endangering stocks, or aquatic life in any area or managed fishery.

13. REFERENCES

Alberts-Hubatsch, H., Lee, S. Y., Meynecke, J-O., Diele, K., Nordhuas, I., and Wolff, M. (2016). Life-history, movement, and habitat use of *Scylla serrata* (Decapoda, Portunidae): current knowledge and future challenges. *Hydrobiologia,* vol 763: 5–21

Baylon, J. C., (2010). Effects of salinity and temperature on survival and development of larvae and juveniles of the mud crab, Scylla serrata (Crustacea: Decapoda: Portunidae). *Journal of the World Aquaculture Society,* vol 41: 858–873.

Calogeras, C. and Hay, T. (2000). *Fishery Status Reports 1999.* Fishery Report 55, Northern Territory Department of Primary Industry and Fisheries, http://www.nt.gov.au/d/Content/File/p/Fish_Rep/FR55.pdf

Coleman, A. P. M. (1998). *Fishcount*: A Survey of recreational fishing in the Northern Territory. NT Department of Primary Industry and Fisheries. *Fishery Report 43.*

Coleman, A. P. M. (2004). The National Recreational Fishing Survey: The Northern Territory. NT Department of Business, Industry and Resource Development. *Fishery Report 72.*

Davies, LJ (1986). The coast. In: Deans, DN (Ed.) *Australia - a geography (Vol 1)*. Sydney University Press, Sydney, Australia.

Davis, J. A., Churchill, G, J. Hecht, T, and Sorgeloos, P. (2004). Spawning characteristics of the South African mud crab *Scylla serrata* (Forskål) in captivity. *Journal of the World Aquaculture Society*, **35:** 121–133.

Du Plessis, A. (1971). A preliminary investigation into the morphological characteristics, feeding, growth, reproduction and larval rearing of *Scylla serrata* Forskal (Decapoda: Portunidae), held in captivity. Fisheries Development Corporation of South Africa, unpublished report. pp. 78.

Fletcher, W.J. 2015. Review and refinement of an existing qualitative risk assessment method for application within an ecosystem-based management framework. – *ICES Journal of Marine Science*, **72**: 1043–1056.

Gopurenko, D. and Hughes, J. M. (2002). Regional patterns of genetic structure among Australian populations of the mud crab, *Scylla serrata* (Crustacea: Decapoda): evidence from mitochondrial DNA. *Marine and Freshwater Research*, **53:** 849–857.

Grubert, M., Johnson, D., Johnstone, D. and Leslie, M. (2016). Mud Crabs. *In*: Status of Australian Fish Stocks Reports, Fisheries Research and Development Corporation, Canberra, http://www.fish.gov.au/report/41-MUD-CRABS-2016.

Hay, T., Gribble, N., de Vries, C., Danaher, K., Dunning, M., Hearnden, M., Caley, P., Wright, C., Brown, I., Bailey, S. and Phelan, M. *Methods for Monitoring the Abundance and Habitat of the Northern Australian Mud Crab* Scylla serrata. Final Report FRDC Project 2000/142. Fishery Report No. 80.

Henry, G. W. and Lyle, J. M. (eds.) (2003). *The National Recreational and Indigenous Fishing Survey.* FRDC Project 99/158, Australian Government Department of Agriculture, Fisheries and Forestry, Canberra, **http://eprints.utas.edu.au/2526/1/Henry_Lyle_Nationalsurvey.pdf**.

Hill, B. J. (1976). Natural food, foregut clearance-rate and activity of the crab *Scylla serrata. Marine Biology,* vol 34: 109–116.

Hill, B. J., Williams, M. J., Dutton, P. and Valley, F. (1982). Distribution of juvenile, subadult and adult Scylla serrata (Crustacea: Portunidae) on tidal flats in Australia. *Marine Biology,* vol 120: 117–120.

Hill, B. J. (1994). Offshore spawning by the portunid crab *Scylla serrata* (Crustacea: Decapoda). *Marine Biology,* vol 120: 379–384.

Hyland, S. J., B. J. Hill & C. P. Lee, 1984. Movement within and between different habitats by the portunid crab *Scylla serrata*. *Marine Biology*, vol 80: 57–61.

Keenan, C. P., Davie, P. J. F. and Mann, D. L. (1998). A revision of the genus *Scylla* De Haan, 1833 (Crustacea: Decapoda: Brachyura: Portunidae). *The Raffles Bulletin of Zoology,* vol 46(1): 217-245.

Knuckey, I. A. (1999). Mud crab (*Scylla serrata*) population dynamics in the Northern Territory, Australia and their relationship to the commercial fishery. PhD thesis, Northern Territory University. 249 pp.

Lees, B. G. (1992). Recent terrigenous sedimentation in Joseph Bonaparte Gulf, northwestern Australia. *Marine Geology*, *103*, 199-213.

Meynecke, J.-O., Grubert, M., Arthur, J. M., Boston, R. and Lee, S. Y. (2012). The influence of the La Niña-El Niño cycle on giant mud crab (*Scylla serrata*) catches in Northern Australia. *Estuarine, Coastal and Shelf Science,* vol 100: 93–101.

Mirera, D. O. and Mtile, A. (2009). A preliminary study on the response of

mangrove mud crab (*Scylla serrata*) to different feed types under drive-in cage culture system. *Journal of Ecology and Natural Environment,* vol 1: 7–14.

Poiner, IR, Walker, DI & Coles, RG (1989). Regional studies - seagrasses of tropical Australia. In: Larkum, AWD, McComb, AJ & Shepherd, SA (Eds). *Biology of Seagrasses: A treatise on the biology of seagrasses with special reference to the Australian region*. Elsevier, New York: 279-296.

Przeslawski, R., Daniell, J., Anderson, T., Vaughn Barrie, J., Heap, A., Hughes, M., Li, J., Potter, A., Radke, L., Siwabessy, J., Tran, M., Whiteway, T., and Nichol, S. 2011. Seabed Habitats and Hazards of the Joseph Bonaparte Gulf and Timor Sea, Northern Australia. Geoscience Australia, Record 2011/40, 69pp.

Roelofs, A., Coles, R. and Smit, N. (2005). A survey of intertidal seagrass from Van Dieman Gulf to Castlereagh Bay, Northern Territory, and from Gove to Horn Island, Queensland. *Report to the National Oceans Office*. http://www.seagrasswatch.org/Info_centre/Publications/pdf/meg/Roelofs_et_al_2005.pdf

Ruscoe, I. M., Shelley, C. C. & Williams, G. R. (2004). The combined effects of temperature and salinity on growth and survival of juvenile mud crabs (Scylla serrata Forskal). *Aquaculture,* vol 238: 239–247.

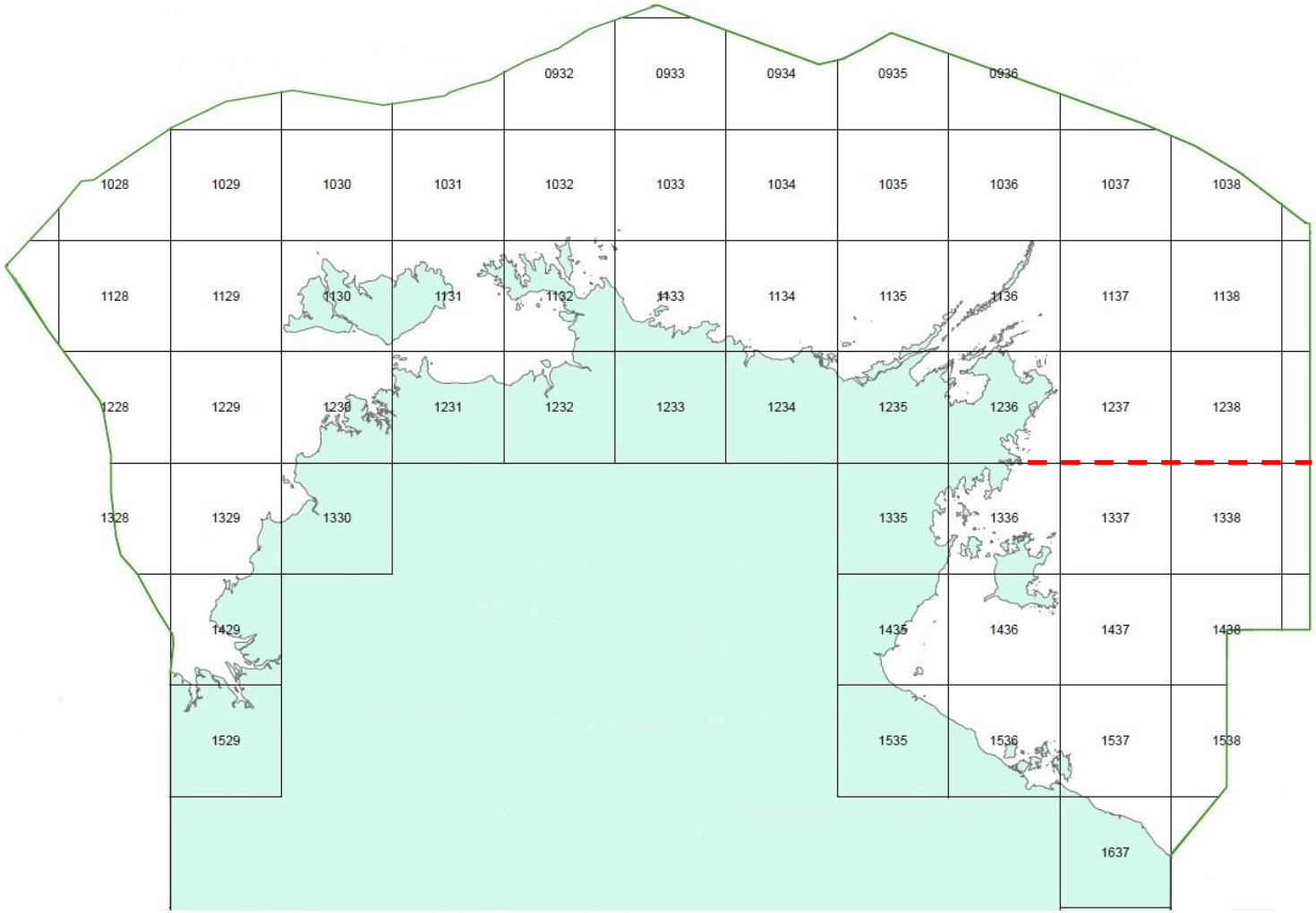
Schenk, S. C. and Wainwright, P. C. (2001). Dimorphism and the functional basis of claw strength in six brachyuran crabs. *Journal of Zoology,* vol 255: 105–119.

Webb, D. J. (1981). Numerical Model of the Tides in the Gulf of Carpentaria and the Arafura Sea. *Australian Journal of Marine and Freshwater Research*, **32,** 31-44.

Webley, J. A. C., Connolly R. M. and Young, R. A. (2009). Habitat selectivity of megalopae and juvenile mud crabs (*Scylla serrata*): implications for recruitment mechanism. *Marine Biology*, vol 156: 891–899.

West, L. D., Lyle, J. M., Matthews, S. R., Stark, K. E. and Steffe, A. S. (2012). Survey of Recreational Fishing in the Northern Territory, 2009-10. Northern Territory Government, Australia. Fishery Report No. 109.

APPENDIX 1 – NORTHERN TERRITORY FISH REPORTING GRIDS



APPENDIX 2 – SPECIES NOT TO BE TAKEN UNDER A COMMERCIAL MUD CRAB LICENCE

- Barramundi
- Black Jewfish
- Golden Snapper
- King Threadfin
- Spanish Mackerel
- Trepang