MUD CRABS

Scylla spp., Scylla olivacea, Scylla serrata

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STOCK STATUS OVERVIEW

Stock status determination

Jurisdiction	Stock	Fisheries	Stock status	Indicators
Northern Territory	Arafura-West Mud Crab Fishery	AWMCF	Sustainable	Catch, effort, catch rate
Queensland	East Coast	MCF	Sustainable	Catch, effort, catch rate, fishing mortality
Queensland	Gulf of Carpentaria	MCF	Sustainable	Catch, effort, catch rate, fishing mortality
Western Australia	Kimberley Developing Mud Crab Fishery	KDMCF	Sustainable	Catch, effort, catch rate
New South Wales	Estuary General Fishery	EGF	Undefined	Catch
Northern Territory	Western Gulf of Carpentaria Mud Crab Fishery	WGOCMCF	Transitional-depleting ↓	Catch, effort, catch rate, fishing mortality

AWMCF Arafura-West Mud Crab Fishery (NT)
EGF Estuary General Fishery (NSW)
KDMCF Kimberley Developing Mud Crab Fishery (WA)
MCF Mud Crab Fishery (QLD)
WGOCMCF Western Gulf of Carpentaria Mud Crab Fishery (NT)

STOCK STRUCTURE

Two species of Mud Crabs are found in Australian waters: 'Mud Crab' (*Scylla serrata*) and Orange Mud Crab (*S. olivacea*). The former constitutes more than 99 per cent of the commercial catch of Mud Crabs in the Northern Territory and Queensland, and the entire commercial catch in New South Wales. The species composition in the Kimberley Developing Mud Crab Fishery (Western Australia) is uncertain, but is known to vary considerably between locations.

The life history and biology of 'Mud Crab' in the Northern Territory and Queensland are well documented [1–6] but, with some exceptions [7–9], corresponding information from Western Australia and New South Wales is scarce. There are no published accounts of the biology of Orange Mud Crab in Australian waters. Hence, all catch and biological information presented here refers to the 'Mud Crab' (*S serrata*), unless otherwise indicated.

Female 'Mud Crabs' in northern Australia migrate up to 95 km offshore to release their eggs [3], which average around 4.5 million per individual [10]. Coupled with a planktonic larval stage that can last for several weeks [11], this facilitates significant gene flow between areas.

Genetic evidence suggests that there are at least two biological stocks of 'Mud Crabs' in Australian waters: one to the west and another to the south-east of the Torres Strait [12], referred to as the Northern Australian and East Coast biological stocks, respectively.

Both previous national stock status reports on Mud Crabs provided overall assessments for these two biological stocks. However, there have been significant changes in the relative performance of the various fisheries operating across these stocks since 2014. These changes, combined with different management arrangements for each of the four jurisdictions that harvest Mud Crabs, and (in some cases) the need for more information on local population dynamics, has resulted in this status report providing different status determinations for Mud Crabs at the level of fishery management units.

The management units within the range of the northern Australian 'Mud Crab' biological stock include: the Kimberley Developing Mud Crab Fishery (Western Australia), the Arafura-West Mud Crab Fishery (Northern Territory), the Western Gulf of Carpentaria Mud Crab Fishery (Northern Territory) and the Gulf of Carpentaria (Queensland) Mud Crab Fishery management unit. The point of separation for the two management units in the Northern Territory is Cape Grey (13°00'S latitude, 136°39' E longitude).

The management units within the range of the East Coast 'Mud Crab' biological stock include the East Coast (Queensland) Mud Crab Fishery management unit and the Estuary General Fishery (New South Wales).

Here, assessment of stock status is presented at the level of the above management units.

STOCK STATUS

Kimberley Developing Mud Crab Fishery

The Kimberley Developing Mud Crab Fishery (Western Australia) (KDMCF) operates in a remote part of Western Australia and harvests a mixture of 'Mud Crab' and Orange Mud Crab in relatively small quantities. Commercial fishing activity in this region over the past decade has been sporadic,

with annual effort (as pot-lifts) ranging over two orders of magnitude. Confidentiality provisions preclude the disclosure of exact catch and effort figures for 2015 as they are based on data from less than three operators. Nevertheless, to provide some perspective, annual catches by the KDMCF have yet to exceed 20 tonnes (t) and annual effort has not reached 30 000 pot-lifts. The average catch rate for the period 2005–14 was 0.7 kg per pot-lift (range 0.5–1.1 kg per pot-lift), which is considered high when benchmarked against the equivalent figure for the Arafura-West Mud Crab Fishery in the Northern Territory (0.5 kg per pot-lift).

Estimates of the Mud Crab harvest by recreational and Indigenous fishers in the Kimberley zone of the North Coast bioregion of Western Australia (the section of the tropical Western Australian coastline east of 120°00' east) indicate that the non-commercial harvest is around two-thirds of the commercial catch (based on survey estimates of the number of crabs kept [13,14] multiplied by a regional average weight of 0.65 kg per crab [15], a method employed in assessments of individual management units).

Western Australia is the only Australian jurisdiction to impose separate minimum size limits for 'Mud Crab' (150 mm carapace width) and Orange Mud Crab (120 mm carapace width). Although size at maturity estimates are not available for either species from this state, reproductive studies from other areas (the Northern Territory and Malaysia, respectively) suggest that the two size limits allow a large proportion of each species to reach sexual maturity before harvest. In the case of 'Mud Crabs', approximately 50 per cent of males and 98 per cent of females are sexually mature at 150 mm carapace width [6]. Reproductive development of Orange Mud Crabs begins at much smaller size, with around 98 per cent of both sexes mature at 120 mm carapace width [16].

There are no estimates of biomass or fishing mortality rate in the KDMCF. However, the modest and sporadic commercial catch by the fishery is considered to have little impact on the resource at the current harvest rate (bearing in mind that the harvest consists of a mixture of two species). The catch rate in 2015 (0.6 kg per pot-lift) was just below the 10-year average of 0.7 kg per pot-lift. The above evidence indicates that the biomass of this stock is unlikely to be overfished.

A history of comparatively light exploitation, high catch rates and minimum size limits that allow a significant proportion of populations to reach sexual maturity before harvest, indicate that the current level of fishing pressure is unlikely to cause this management unit to become recruitment overfished.

On the basis of the evidence provided above, the Kimberley Developing Mud Crab Fishery (Western Australia) management unit is classified as a **sustainable stock**.

Arafura-West Mud Crab Fishery

The Arafura-West Mud Crab Fishery (Northern Territory) (AWMCF) encompasses the city of Darwin and the non-commercial harvest of Mud Crabs close to this population centre is substantial. The only simultaneous estimates of the harvest by visiting recreational fishers, resident recreational fishers and Indigenous fishers within the AWMCF (derived from surveys in 2000–01) indicate that their combined take accounted for around 40 per cent of the overall harvest within this

management unit at that time [13,17] (using a regional weight multiplier of 0.80 kg per crab [13]). A more recent, non-Indigenous, resident only angler survey confirms the ongoing significance of the recreational harvest [18] in this region. However, a lack of annual catch estimates for recreational and Indigenous fishers means that the assessment presented here is primarily based on data from commercial logbooks.

Commercial minimum size limits for Mud Crabs (*Scylla* spp.) in the Northern Territory are 140 mm carapace width for males and 150 mm carapace width for females. These limits ensure that at least 50 per cent of male crabs and around 98 per cent of female crabs reach sexual maturity before harvest [6].

Commercial catches by the AWMCF averaged 124 t for the decade spanning 2005–14 (range 106–149 t). The catch in 2015 equates to 85 per cent of this long-term average. Catch rates from 2005–14 were more variable, ranging from 0.3 kg per pot-lift–0.7 kg per pot-lift (average 0.5 kg per pot-lift), with the relatively low catch rate experienced in 2015 (0.3 kg per pot-lift) being a function of increased fisher competition in a few key areas following effort displacement from the Western Gulf of Carpentaria Mud Crab Fishery.

Relatively stable catches over the past decade, combined with protective management measures (including minimum size limits), long sections of sparsely populated coastline subject to little or no crab fishing (particularly in Arnhem Land), and a strong (westward flowing) long-shore wet season current [19] (that can facilitate long distance dispersal of larvae) indicate that the biomass of 'Mud Crabs' within the AWMCF is unlikely to be recruitment overfished and that current fishing effort is unlikely to cause this management unit to become recruitment overfished.

On the basis of the evidence provided above, the Arafura-West Mud Crab Fishery (Northern Territory) management unit is classified as a **sustainable stock**.

Western Gulf of Carpentaria Mud Crab Fishery

The oceanography of the Gulf of Carpentaria differs from that of adjacent water bodies in northern Australia, such as the Arafura and Timor seas to the west and the Coral Sea to the east [19,20]. Features including rotating currents (gyres) and cross-gulf up-welling and down-welling systems may restrict the dispersal of larval Mud Crabs in the Gulf of Carpentaria compared to other sections of the northern Australian coastline, resulting in Mud Crab in the Gulf being more dependent on recruitment from locally produced larvae, and so susceptible to recruitment decline at low local stock sizes.

The Western Gulf of Carpentaria Mud Crab Fishery (Northern Territory) (WGOCMCF) has accounted for more than 70 per cent of the commercial 'Mud Crab' harvest in the Northern Territory over the past 20 years. The harvest by resident recreational fishers, visiting recreational fishers and Indigenous fishers within this management unit in 2000–01 was relatively low, at around 10 per cent of the overall take [13,17] (using a regional weight multiplier of 0.80 kg per crab [13]).

A more recent (2009–10) survey of Northern Territory anglers (which also collected information on visiting fisher activity at three popular fishing sites) confirmed that the harvest of 'Mud Crab' by resident anglers within the WGOCMCF is less than five per cent of the overall species harvest by this group across the Northern Territory [18]. It also showed that the 'Mud Crab' harvest by interstate fishers visiting King Ash Bay (on the McArthur River) was almost eight times greater than that of resident recreational fishers at this site. The lack of current estimates of the overall harvest of 'Mud Crabs' by visiting recreational fishers, resident recreational fishers and Indigenous fishers within this management unit means that the assessment presented here is primarily based on data from commercial logbooks.

Catch rates (as an index of recruitment and abundance) of 'Mud Crabs' are positively correlated with environmental variables, with wet season rainfall showing the strongest correlation at lower latitudes [21,22]. Monsoonal rainfall across many catchments emptying into the Gulf of Carpentaria has been lower than average for much of the past 5 years, coinciding with a period of predominantly neutral or negative values of the Southern Oscillation Index that began in early 2012. This has been associated with a decline in 'Mud Crab' availability and catch rates.

A size-age-sex stock synthesis model applied to pooled catch and effort data (to December 2010) for the entire Northern Territory Mud Crab Fishery showed no indication of reduced average recruitment at lower levels of spawning stock size observed over that period [23]. The inclusion of more recent data to December 2015 has shown an emerging trend of lower stock size and subsequent low recruitment over the past few years. This pattern suggests that the stock is approaching an overfished state.

A delay-difference modelling approach, using data for the WGOCMCF (to December 2015), was recently developed to assess the recruitment overfishing risk in this management unit [24]. Model runs using an assumed catchability (q) of 0.25–2.0 x 10^{-3} indicated that overfishing (defined as F/F_{MSY} >1) is not currently occurring, but may have occurred between 2009 and 2012. However, if changes in fishing practices have resulted in q exceeding 2.0 x 10^{-3}, there is an increased risk that overfishing is occurring at present while unfavourable environmental conditions are constraining recruitment. It therefore appears that intermittent overfishing of the WGOCMCF has occurred in recent years and that overfishing could be occurring at present. The above evidence indicates that the current level of fishing pressure may cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the Western Gulf of Carpentaria Mud Crab Fishery (Northern Territory) management unit is classified as a **transitional–depleting stock**.

Gulf of Carpentaria

The commercial sector harvests the majority (90 per cent) of the 'Mud Crab' resource in the Gulf of Carpentaria (Queensland) Mud Crab Fishery (MCF) management unit [25] (using a regional weight multiplier of 1.00 kg per crab [13]) and so the status determination for this management unit is primarily based on data from commercial logbooks.

Catches in the Gulf of Carpentaria (Queensland) MCF management unit have historically been the most stable of any commercial Mud Crab fishery in Australia, averaging 170 t (range 136–199 t) between 2005 and 2014. However, the catch (126 t) and catch rate (26 kg per fishing day) in this fishery in 2015 was the lowest and second lowest in a decade, respectively, coincident with several years of poor monsoonal rainfall in the eastern Gulf of Carpentaria. Nevertheless, the catch rate in 2015 was 92 per cent of the average catch rate across the previous 10 years (29 kg per fishing day).

Female Mud Crabs cannot be retained in Queensland and the minimum legal size for male crabs (150 mm carapace width) ensures that roughly 50 per cent of males attain sexual maturity before harvest (based on male size at maturity estimates from the Western Gulf of Carpentaria MCF [6]). The 'Mud Crab' population within this management unit is therefore expected to recover relatively quickly when favourable environmental conditions return. The above evidence indicates the biomass of the management unit is unlikely to be recruitment overfished.

A growth-type groups model applied to catch and effort data (spanning 1998–2008) from the Gulf of Carpentaria (Queensland) MCF management unit (which incorporated an assumed five per cent increase in fishing efficiency each year) estimated that the annual fishing mortality rate for male 'Mud Crabs' in 2008 was around 0.6 [26], 50 per cent below the estimate of annual natural mortality for crabs caught in the adjacent Northern Territory (1.2) [6]. Nominal fishing effort in the Gulf of Carpentaria (Queensland) MCF management unit has decreased 16 per cent since 2008, so it is unlikely that the fishing mortality rate has increased significantly after 2008.

Although female Mud Crabs are not retained by the Gulf of Carpentaria (Queensland) MCF management unit, they are most likely impacted by it to some degree, given that they may be handled and released many times. This can potentially result in handling damage [27], post-release mortality, or non-lethal effects such as reduced reproductive performance (based on observations of captive Rock Lobsters [28]). Nonetheless, the male-only harvest policy maximises the number of female crabs that contribute to the next generation.

A history of comparatively light exploitation of male crabs only (as indicated by the relatively low fishing mortality rate) and the complete protection of female 'Mud Crabs', in conjunction with the rapid growth and high fecundity of this species [6,10], indicate that the current level of fishing pressure is unlikely to cause this management unit to become recruitment overfished.

On the basis of the evidence provided above, the Gulf of Carpentaria (Queensland) Mud Crab Fishery management unit is classified as a **sustainable stock**.

East Coast

The only simultaneous estimates of the recreational and Indigenous harvest within the East Coast (Queensland) Mud Crab Fishery (MCF) management unit are now more than a decade old, but indicate that the combined take by these sectors once exceeded 50 per cent of the total catch within this management unit (using a regional weight multiplier of 1.00 kg per crab) [13]. More recent surveys, which may include some harvest by Indigenous fishers (as survey respondents were not asked about their heritage), confirm the ongoing significance of the non-commercial harvest, at

around 24 per cent of the overall take [25,29]. However, a lack of annual catch estimates for recreational and Indigenous fishers means that the stock status presented here is primarily based on data from commercial logbooks.

The East Coast (Queensland) MCF management unit accounts for approximately 85 per cent of the commercial harvest of the east coast 'Mud Crab' biological stock. The catch in 2015 (1056 t) was six per cent above the average catch across the previous 10 years (995 t). Nominal catch rates by this fishery averaged 28 kg per fishing day for the decade concluding in 2014 (range 24–33 kg per fishing day). The nominal catch rate in 2015 (28 kg per fishing day) was the same as the 10-year average value given above. Although standardised catch rates have not been calculated for recent years, comparisons of nominal and standardised catch rates in earlier years show good agreement.

The male-only harvest policy in Queensland means that fishing mortality on female 'Mud Crabs' is zero. However, female crabs may be handled and released many times during their life and so some incidental damage and discard mortality (as described above) is probable. Nonetheless, this harvest policy maximises the number of females that contribute to the next generation. Protection of some sexually mature male crabs in Queensland is afforded by a minimum size limit (150 mm carapace width; above size at first maturity in this state [2]) recreational possession limits, and restrictions on commercial licence numbers and fishing effort.

A number of "no take" zones (applying to all marine organisms) along the east coast of Queensland provide additional protection to 'Mud Crabs' (particularly males) and result in higher crab densities and larger mean sizes (within the protected area), as well as spill over of crabs into adjacent fished areas [1,30]. However, the benefit of these closures, over and above the single-sex harvest policy (and the male size limit) on a fishery-wide scale has not been quantified. While the localised benefits of spatial closures can be significant, their cumulative benefit on 'Mud Crab' spawning biomass across the entire East Coast (Queensland) MCF management unit is unlikely to be great when considering the other protective measures that are in place.

The most recent estimate of fishing mortality in the East Coast (Queensland) MCF management unit (based on commercial data to 2008) was around 1.5 [26], 24 per cent above the estimate of natural mortality for *S. serrata* (1.2 [6]; derived from crabs in the Northern Territory). There are indications from the size distribution of male crabs that fishing mortality is not evenly spread across eastern Queensland, with localised depletion in some areas and low to moderate fishing mortality in others [31]. Annual fishing effort in 2015 (around 38 000 fishing days) was 15 per cent above the 2008 figure and the 2015 catch rate (28 kg per fishing day) was 11 per cent above the 2008 value. The effect of the modest increase in effort since 2008 on the fishing mortality rate of male crabs is not known.

Recruitment of Mud Crabs in Australia appears to be driven by environmental variables such as rainfall and water temperature, with the impact on catches evident 12–18 months after an environmental perturbation [21,22]. The catch and catch rate of 'Mud Crabs' in the East Coast (Queensland) MCF management unit in 2015 were amongst the highest on record, even though rainfall during the two preceding calendar years was average or below average across much of the

eastern seaboard of Queensland. The current high apparent productivity, combined with the protection all females and many mature males, indicates that the East Coast (Queensland) MCF management unit is unlikely to be recruitment overfished and that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the East Coast (Queensland) Mud Crab Fishery management is classified as a **sustainable stock.**

Estuary General Fishery

The Estuary General Fishery (New South Wales) (EGF) accounts for approximately 15 per cent of the commercial harvest from the East Coast 'Mud Crab' biological stock, with the catch composition by sex being very close to 1:1 (48 per cent female, 52 per cent male). A recent survey of recreational fishing in New South Wales (which may include some harvest by Indigenous fishers) suggests that the non-commercial take accounts for around 10 per cent of the overall 'Mud Crab' harvest in this state [32] (using a regional weight multiplier estimated at 0.70 kg per crab).

Part of the 'Mud Crab' population in New South Wales is protected through a minimum size limit (85 mm carapace length) although the effectiveness of this measure is uncertain as the size at maturity of *S. serrata* in this jurisdiction has not been described. A number of "no take" zones (applying to all marine organisms) along the New South Wales coast afford some protection to 'Mud Crabs' and result in higher crab densities and larger mean sizes (within the protected area), as well as spill over of crabs into adjacent fished areas [8]. However, these spatial closures are relatively small and fragmented, and their cumulative benefit on a fishery-wide scale has not been quantified.

The catch by the EGF increased 70 per cent between 2013 and 2015 (111 t and 189 t, respectively). Uncertainties regarding the accuracy of catch and effort reporting by this fishery mean that it is not appropriate to infer the status of the stock from catch rate data. There are no estimates of the biomass within, or the fishing mortality rate exerted by, the EGF and so there is insufficient information to confidently classify the status of this stock.

On the basis of the evidence provided above, the Estuary General Fishery (New South Wales) management unit is classified as an **undefined stock**.

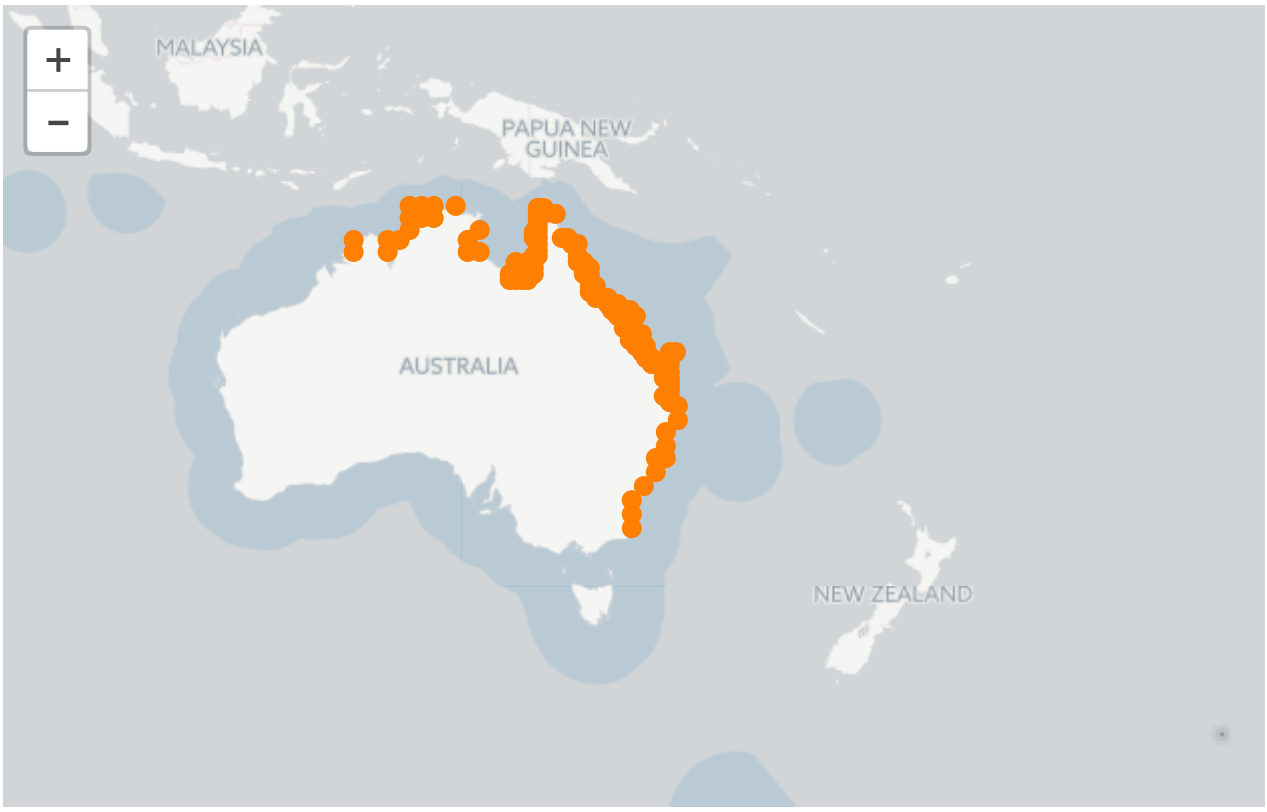
BIOLOGY

'Mud Crab' biology [2,6,8,33,34]

Biology

Species	Longevity / Maximum Size	Maturity (50 per cent)
MUD CRABS	3–4 years; 230 mm CW, but rarely exceeds 200 mm CW in most areas	Varies by sex and location but generally 120–150 mm CW

DISTRIBUTIONS



Distribution of reported commercial catch of ‘Mud Crab’

TABLES

Fishing methods

	Western Australia	Northern Territory	Queensland	New South Wales
Commercial				
Various	✔			
Pots and Traps		✔		
Mud Crab Trap			✔	✔
Indigenous				
Hand collection	✔	✔	✔	✔
Hand Line, Hand Reel or Powered Reels	✔	✔	✔	✔
Coastal, Estuary and River Set Nets	✔	✔	✔	✔
Dip Net	✔	✔	✔	
Spearfishing		✔	✔	
Cast Net		✔	✔	
Beach Seine		✔	✔	
Pots and Traps		✔	✔	✔
Recreational				
Hand collection	✔	✔	✔	✔
Hand Line, Hand Reel or Powered Reels	✔	✔	✔	✔
Coastal, Estuary and River Set Nets	✔	✔	✔	✔
Dip Net	✔	✔	✔	
Spearfishing		✔	✔	

	Western Australia	Northern Territory	Queensland	New South Wales
Cast Net		✔	✔	
Beach Seine		✔	✔	
Pots and Traps		✔	✔	✔

Management methods

Method	Western Australia	Northern Territory	Queensland	New South Wales
Commercial				
Effort limits	✔	✔	✔	✔
Gear restrictions	✔	✔	✔	✔
Limited entry	✔	✔	✔	✔
Male-only harvest			✔	
Protection of berried females	✔	✔	✔	✔
Protection of soft-shelled crabs		✔		
Size limit	✔	✔	✔	✔
Spatial closures	✔	✔	✔	✔
Spatial zoning	✔	✔	✔	✔
Indigenous				
Gear restrictions	✔	✔	✔	✔
Spatial closures	✔	✔	✔	✔
Recreational				
Bag limits	✔			
Gear restrictions	✔	✔	✔	✔
Male-only harvest			✔	
Possession limit		✔	✔	✔
Protection of berried females	✔	✔	✔	✔

Method	Western Australia	Northern Territory	Queensland	New South Wales
Size limit	✔	✔	✔	✔
Spatial closures	✔	✔	✔	✔
Spatial zoning	✔	✔	✔	✔
Vessel limits	✔	✔		

Active vessels

	Western Australia	Northern Territory	Queensland	New South Wales
		42 in MCF	318, 39 in MCF	249 in EGF

EGF Estuary General Fishery (NSW)
MCF Mud Crab Fishery (NT)
MCF Mud Crab Fishery (QLD)

Catch

	Western Australia	Northern Territory	Queensland	New South Wales
Commercial		105.15t in AWMCF, 80.58t in WGOCMCF	1.18Kt in MCF	188.64t in EGF
Indigenous	6 t (2000–01)	69 t (2000–01)	13 t (2000–01)	Unknown
Recreational	4 t (2013–14)	24 t (2009–10)	332 t in East Coast MCF (2013–14), 7 t in Gulf of Carpentaria MCF (2010–11)	21 t (2013–14)

AWMCF Arafura-West Mud Crab Fishery (NT)
EGF Estuary General Fishery (NSW)
MCF Mud Crab Fishery (QLD)
WGOCMCF Western Gulf of Carpentaria Mud Crab Fishery (NT)

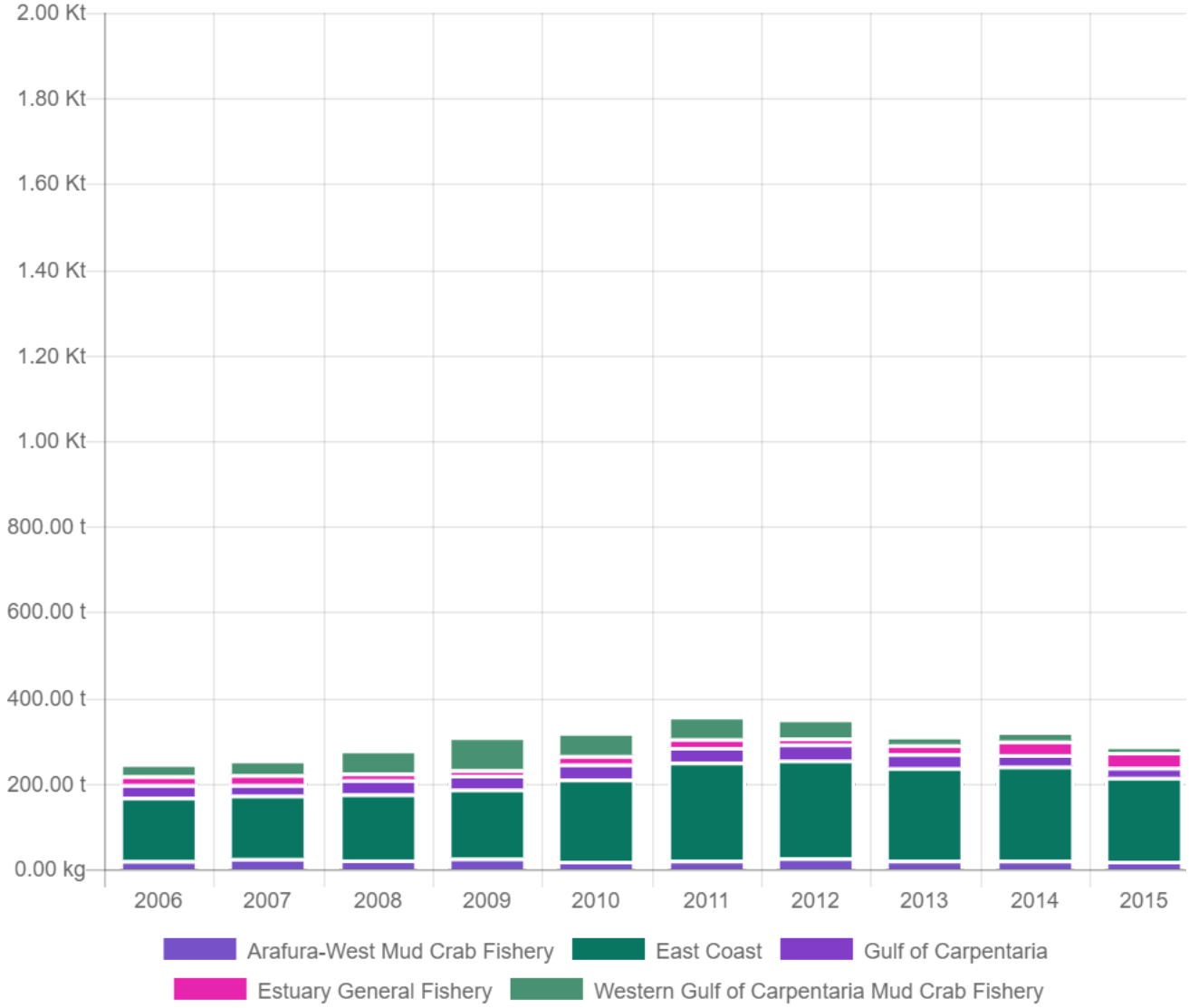
a Queensland – Indigenous (management methods) Under the Fisheries Act 1994 (Qld), Indigenous fishers in Queensland are entitled to use prescribed traditional and non-commercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

b New South Wales – Indigenous (management methods) Aboriginal Cultural Fishing Interim Access Arrangement - allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances, for example, if they are doing so to provide fish to other community members who cannot harvest themselves. Aboriginal cultural fishing authority - the authority that Indigenous persons can apply to take catches outside the recreational limits under the Fisheries Management Act 1994 (NSW), Section 37 (1)(c1), Aboriginal cultural fishing authority.

c Active Vessels The number of active exemption holders (for Western Australia), licences (for the Northern Territory and Queensland) or businesses (for New South Wales) are shown here because the number of active vessels is not an appropriate measure of effort in Australian Mud Crab fisheries. Licensing arrangements also vary significantly between jurisdictions.

d Western Australia – Indigenous (catch) The estimate of the Indigenous harvest tonnage of Mud Crabs in Western Australia has been revised down as the weight multiplier previously used to calculate this value (1.34 kg per crab13) is now considered unrealistically high given that the average weight of harvested Mud Crabs in Western Australia was recently estimated at 0.65 kg15.

CATCH CHART



Commercial catch of 'Mud Crab'

EFFECTS OF FISHING ON THE MARINE ENVIRONMENT

- Entanglement of turtles in polyethylene mesh traps is a problem in eastern Queensland and New South Wales [35,36]. To address this, both jurisdictions have released guides to responsible crabbing, which outline gear modifications and alternative fishing strategies to reduce turtle interactions, prevent trap loss and minimise ghost fishing [37,38].
- Discard rates of undersized Mud Crabs can be as high as 70 per cent of the total catch in some areas [34]. Bycatch of small fishes (particularly Yellowfin Bream) is also of concern on the east coast [27]. Research by the Northern Territory Department of Primary Industry and Resources, and the New South Wales Department of Primary Industries has demonstrated the value of escape vents in reducing the retention of undersized Mud Crabs and small teleost bycatch in a variety of Mud Crab traps [31,39,40]. The former organisation has also developed inexpensive escape vents to fit rectangular wire mesh traps, with around 25 per cent of licensees in the Northern Territory using them on a voluntary basis. Some management agencies are currently considering the mandatory use of escape vents in Mud Crab traps.

- 'Mud Crabs' sometimes lose limbs when caught in or removed from traps; the injury rate is related to the style of trap used [27]. Although limb loss appears to have little impact on the short-term survivorship of 'Mud Crabs' [27], repeated limb damage may potentially compromise their growth and/or reproductive success (based on observations of other crab species [41,42]). More than 20 per cent of 'Mud Crabs' caught in monofilament tangle nets lose one or more limbs during capture and/or removal from the net [26]. This gear also poses a significant ghost-fishing risk if lost, and is prohibited in most jurisdictions.

ENVIRONMENTAL EFFECTS ON MUD CRABS

- Commercial catch rates generally show positive correlations with environmental factors such as rainfall and sea surface temperature, depending on location [21]. Catch rates are more strongly linked to sea surface temperatures at higher latitudes and rainfall at lower latitudes.
- Juvenile 'Mud Crabs' prefer to settle on seagrass rather than mud or sand [43] and also utilise mangrove forests [7]. Therefore, any significant reduction in these habitat types (through human or natural disturbances, including cyclones) could affect recruitment success.
- Mud Crabs may potentially benefit from moderate climate change in some areas [44]. Increased water temperatures at higher latitudes might increase growth rates and reproductive activity. Greater rainfall in the tropics might increase primary and secondary productivity, thereby providing more food for juvenile crabs. Any such benefits will, of course, only occur within the physiological tolerances of the particular developmental stage affected.

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