walker

TOONDAH HARBOUR

CHAPTER 18
COMMERCIAL AND RECREATIONAL FISHERIES

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18. Commercial and Recreational Fisheries

18.1. Introduction

Commercial and recreational fisheries studies were completed by Dr Daryl McPhee from Bond University. Refer to Appendix 1-F for a list of key personnel involved.

18.1.1 Scope of Study

No specific commercial and recreational fishing assessment is required by the EPBC Act EIS guidelines; however they do require a description of fish populations and spawning sites. When describing fisheries values and the potential impacts on them from the Project, an assessment needs to consider:

- The biophysical environment (e.g., fish habitats and water quality) and how it relates to fisheries production; and
- The issues that potentially impact the quality of fishing access for recreational fishers, which is influenced by a range of physical amenities.

In terms of participation, recreational fishing is the dominant leisure activity within Moreton Bay. In addition, Moreton Bay is the most important commercial fishing region in the State of Queensland by volume and value of fish per unit area. Indigenous fisheries are also important for the traditional owners—for this part of Moreton Bay, the Quandamooka People.

In response to the above assessment needs and the importance to the Moreton Bay community, this report:

- Describes fish populations and spawning sites for fish, which is a specific requirement in the EIS guidelines (section 4a);
- Describes the commercial and recreational fishing access arrangements in southern Moreton Bay which includes the Project footprint;
- Interprets available marine habitats at the Project footprint in the context of fisheries;
- Assesses potential direct impacts (positive and negative) of the Project on fisheries access, and the indirect impacts of changes to habitat on fisheries resources; and
- Proposes management options that can be utilised in the design, construction and operational components of the proposed project, and monitoring options.

18.1.2 Activities that May Result in Impacts

Project activities with the potential to impact on commercial and recreational fisheries include the loss of intertidal habitats as a result of the reclamation, and a temporary reduction in foreshore access during construction of the reclamation and other marine infrastructure.

18.2. Assessment Methodology

18.2.1 Desktop Methods

Peer reviewed literature was sourced through the Scopus database. In addition to peer reviewed literature, various technical reports were also sourced. Recreational fishing forums (e.g., Ausfish) were accessed for information on the utilisation of existing marinas and modified foreshores by recreational fishers.

18.2.2 Consultation

At the time of the studies, thorough face-to-face consultation was not possible due to COVID-19. Key recreational and commercial fishing representative bodies were contacted by email including Sunfish Queensland, OzFish Unlimited (Central Moreton Bay chapter), Moreton Bay Seafood Industry Association (MBSIA) and the Queensland Seafood Industry Association. A focus of consultation was refining current use of the area by fishers, the suitability of proposed boat ramp facilities and opportunities for recreational fishing post-construction, and habitat rehabilitation. A log of correspondence sent and received was maintained.

For the commercial fishing sector, further engagement was undertaken with the nominated representative from the MBSIA. This included face-to-face meetings. Consultation with members of the public was also undertaken via the "Talk Toondah" online sessions.

18.2.3 Logbook Analysis

Commercial fishing catch and effort information in Queensland is sourced from a compulsory logbook program that has operated continuously since 1988. The data is used for a range of fisheries and marine park management purposes, including allocation arrangements and structural adjustment. Commercial fishers are legally required to provide accurate data. While there are concerns regarding the veracity of the data, it still represents the best available data on commercial fishing catch and effort. The Queensland Department of Agriculture and Fisheries (DAF) has been working through data validation approaches as part of the current fisheries reform process.

The spatial scale of the commercial logbook data is extremely coarse. It is not possible to determine the commercial catch at or directly adjacent to the Project footprint, or any specific location in Moreton Bay.

Data can be publicly accessed via the QFISH website. For the fisheries assessment, two logbook grids were considered:

- Logbook Grid W38 includes all of southern Moreton Bay southwards from just north of Cleveland Point down to the Southport Broadwater. It also contains Main Beach on Minjerribah (North Stradbroke Island) from approximately the Causeway southwards, and an area directly offshore of Minjerribah. The Project is located in this logbook grid.
- Logbook Grid W37 includes the area of Moreton Bay northwards from just north of Cleveland Point, the beaches of Mulgumpin (Moreton Island), Flinders Beach on Minjerribah and an area directly offshore of Mulgumpin.

The boundary between logbook grids W37 and W38 runs in a straight-line eastward from the mainland foreshore approximately north of Ormiston, through Jercuruba (Peel Island) and Goompi (Dunwich) on Minjerribah (Figure 18-1). A further two logbook grids (X37 and X38) were initially considered, however were excluded due to their remoteness from the Project footprint and limitations to data access due to the "five boat rule". The five boat rules limit public access and use of commercial fishing data where less than five fishing licences have accessed the species, location and time period being considered.

Assessment of commercial fishing catch and effort was undertaken for a period between 2010 and 2018. The year 2010 was chosen as a starting date as it represents the implementation of the Moreton Bay Marine Park Zoning Plan and the associated structural adjustment, which significantly changed the spatial distribution of fishing effort and fishing

capacity overall (Van de Geer *et al*., 2013). At the time of writing, the year 2018 represented the last complete year that data was publicly available in the QFISH database.

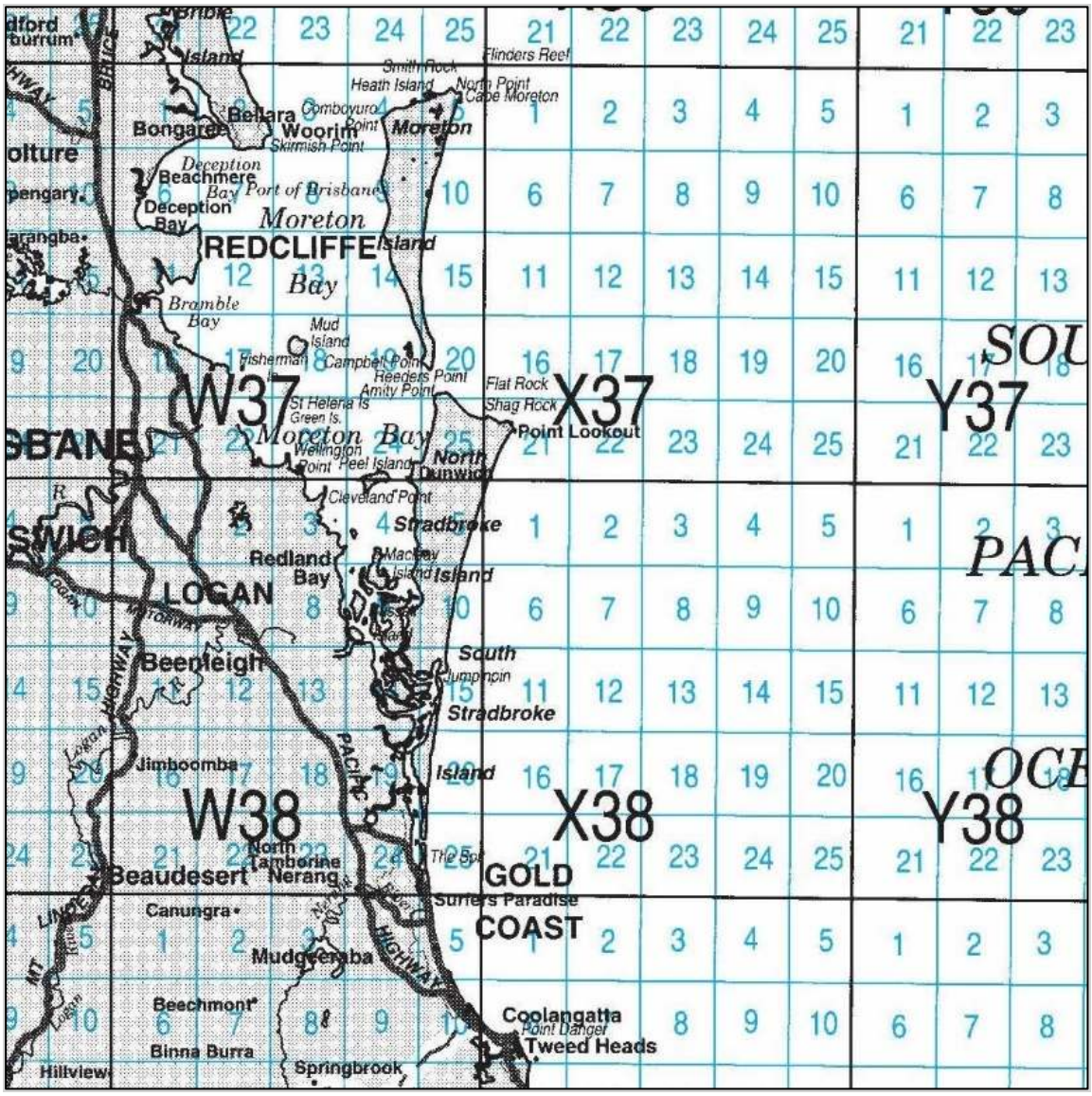

Figure 18-1: Map of the Commercial Fishing Logbook Grids.

18.3. Existing Values

18.3.1 Current Fishing Activities

The Project is in southern Moreton Bay, and it is pertinent to initially describe the commercial, recreational, and Indigenous fisheries in the region. This area is much larger than the Project footprint. Currently all Queensland fisheries are being reformed through a process directed by the *Queensland Sustainable Fisheries Strategy 2017-2027*.

A suite of common tools applies to commercial and recreational fishers for the management of their activities, summarised in McPhee (2008). There are long standing sets of minimum legal sizes that have been periodically reviewed and changed in response to new biological information or changes in fishing activities. These generally aim to limit the

removal of most stock before it has had a chance to spawn at least once. Some species also have maximum sizes, and when combined with a minimum legal size these are called slot limits. An example is dusky flathead (*Platycephalus fuscus*) where there is a minimum legal size of 40 cm and a maximum legal size of 75 cm. There is also a prohibition on the taking of female mud (*Scylla serrata*) and blue swimmer crabs (*Portunus armatus*).

While not a fishery management tool, the MBMP Zoning Plan 2019 also limits the areas where commercial and recreational fishing activities can be undertaken. Further details on the zones of the MBMP are included in Appendix 2-O.

18.3.2 Commercial Fisheries

A variety of limited entry commercial fisheries are licenced to operate within Moreton Bay. Limited entry means that no new additional entrants can enter the fishery. To operate in a commercial fishery:

- The fisher must have a commercial fisher licence;
- The fisher must be operating under a Queensland commercial fishing boat licence or commercial harvest fishery licence; and
- The relevant fishery symbols must be recorded against each commercial fishing boat licence or harvest fishery licence in the register of fishing authorities.

Specific fisheries are represented by a system of fishery symbols, which are recorded against the boat and harvest licences in the register of fishing authorities. These symbols indicate the fisheries the commercial fisher is authorised to fish. Each symbol denotes the species of fish targeted, the fishing method used and a geographical area. Fishing licences and symbols can be bought, sold and leased. Most commercial fishing businesses have licences with more than one fishing symbol, hence they can fish in more than one fishery, depending on seasonal abundance of target species and market demands.

For several commercially fished species in Queensland, a total allowable commercial catch (TACC) is implemented. This provides an upper limit on the volume of a species that can be caught and retained. A TACC is commonly allocated among participants in a fishery as an individual transferable quota (ITQ), which is a market-based property right that can be leased or traded. Further information on TACC and ITQs can be found in McPhee (2008). While the key target species commercially caught in Moreton Bay are not currently subject to TACC or ITQ arrangements, they are proposed as part of the current fisheries management reforms being undertaken by the Queensland Government.

Moreton Bay is the most important commercial fishing region in the State by volume and value of fish per unit area (Thurston *et al*., 2018). Most of the production from Queensland fisheries does not go through a central market. Rather it is sold via a range of wholesalers and processors, or directly by fishermen to restaurants or the public. Most of the production is consumed within the Greater Brisbane region. An overview of each fishery symbol that can be used within southern Moreton Bay follows.

C1 Crab Fishing Symbol

A C1 fishing symbol allows the commercial fisher to target and retain mud crabs (*Scylla serrata*) and blue swimmer crabs (*Portunus armatus*) using crab pots. An operator with a C1 fishery symbol can operate anywhere along the Queensland east coast where commercial crabbing is permissible. The reality is that the majority operate from a single port which is generally close to their residence and operate over a relatively small spatial area. The major mud-crabbing areas on the Queensland east coast are Moreton Bay, the Narrows (near Gladstone), Hinchinbrook Channel and Princess Charlotte Bay.

Most of the commercial blue swimmer crab harvest is taken from Moreton and Hervey Bays, whereas the mud crab catch is widely distributed along the Queensland east coast. Currently mud crabs and blues swimmer crabs are not managed through a TACC. Commercial fishers are limited to 50 pots per C1 endorsement. A commercial fisher can operate 100

pots if they are in possession of two C1 symbols. The minimum legal size for mud crabs is 15 cm carapace width (CW) and 11.5 cm for blue swimmer crabs across the carapace (notch to notch). There is a longstanding prohibition on the taking of female mud and blue swimmer crabs in Queensland (McPhee, 2018). Mud crabs are mostly sold live into local and interstate markets (e.g., NSW), while most of the blue swimmer crab catch is sold cooked and chilled in southern Queensland with only limited sales interstate.

Commercial fishers with a C1 symbol only are not permitted to retain spanner crabs (*Ranina ranina*).

N1 Net Fishing Symbol

The N1 fishing symbol is part of the East Coast Inshore Net Fishery. At the time of writing, an operator with a N1 fishery symbol can operate anywhere along the Queensland east coast where fishing using the various apparatus in the fishery is permissible. An operator with an N1 fishery symbol is permitted to use mesh nets to target finfish, but is not permitted to use set mesh nets or tunnel nets. The N1 fishery is a complex fishery with many permissible gear configurations and many target species. Important target species in Moreton Bay are mullet (principally sea mullet *Mugil cephalus,* but also other species such as flat tail mullet *Mugil georgii*), yellowfin bream (*Acanthopagrus australis*), sand whiting (*Sillago ciliata*), dusky flathead (*Platycephalus fuscus*) and garfish (Family Hemiramphidae). Currently, none of these fisheries are managed through a TACC. In Moreton Bay, the N1 fishery is closed on weekends.

N10 Net Fishing Symbol

The N10 fishing symbol authorises the holder to use a tunnel net in parts of Moreton Bay and the Great Sandy Straits. Tunnel netting is a labour intensive, but efficient fishing method of catching finfish across large and shallow intertidal flats. Each N10 fishing symbol allows the use of up to 1,700 m of net in length (excluding the tunnel length), which is used in such a way that it in effect works as a temporary fish trap. Tunnel netting is undertaken close to the shore, where operators set the net on removable wooden stakes extending from shallow waters to deeper waters. Unwanted or regulated fish can be safely and easily removed from a tunnel net and operators employ bycatch reduction devices. Important target species for tunnel netting in Moreton Bay are mullet - principally sea mullet *Mugil cephalus* but also other species such as flat tail mullet *Mugil georgii*, yellowfin bream (*Acanthopagrus australis*), sand whiting (*Sillago ciliata*), black "trevally" (*Siganus* spp.) and garfish (Family Hemiramphidae).

Within Moreton Bay, tunnel netting is currently restricted under fisheries legislation to the following mainland foreshores and island foreshores:

- Little Rocky Point to 800 m south of Point Talburpin;
- 800 m either side of Moogurrapum Creek, Redland Bay;
- Point Halloran to 700 m south of Oyster Point;
- 800 m south of the southern bank of Hilliards Creek to 1 km south of Wellington Point;
- The eastern shore of Fisherman Island to 800 m north of Wynnum Creek;
- From Juno Point to the northern bank of Serpentine Creek;
- From the western end of Sunnyside Road, Scarborough, to 100 m south of Seaview Parade, Deception Bay;
- From the boat ramp at Deception Bay to the southern bank of the Caboolture River; and
- Moreton Bay island foreshores, other than the western foreshore of Cassim Island and the southern foreshore of Yerobin (King Island), north of the following lines from Little Rocky Point to the southern tip of Kanaipa (Russell Island); and to the nearest point on the western shore of Minjerribah.

In addition to these limitations under fisheries legislation, tunnel netting is further restricted spatially under the MBMP Zoning Plan as it can only occur in the general use and habitat protection zones of the park. In Moreton Bay, the N10 fishery is closed on weekends.

The tunnel net fishery in Moreton Bay has a Code of Best Practice in place which was prepared by the MBSIA with government assistance. Only about 3% of Moreton Bay can be accessed by the N10 Fishery due to spatial closures and unsuitability of habitat for the operation of this fishery in many locations (John Page, commercial fisher, pers. comm.).

T1/M1 and M2 Trawl Fishing Symbols

The T1/M1 and M2 fishing symbols allow the owner to use otter trawl fishing gear to target and retain prawns and a limited suite of by-product species. Operators with a T1/M1 are permitted to trawl in Moreton Bay and other Queensland trawl fishing areas outside of Moreton Bay in the East Coast Trawl Fishery. Those with an M2 fishery symbol are only permitted to trawl in Moreton Bay. To operate effectively and safely, prawn trawlers require water of sufficient depth and a seabed that is relatively flat and free of obstacles (e.g., rocks) and rapid changes in depth. Over time the number of vessels and days fished in this fishery have declined. The number of active licensed vessels participating in the fishery has declined from 207 in 1991 to 57 in 2010. Similarly, fishing effort has fallen from a peak of 13,312 boat-days in 1999 to 3817 boat-days in 2008 – a 71% reduction (Courtney *et al*., 2012). The declines in catch and effort are largely attributed to reduced profitability in the fishery due to increased operational costs and depressed prawn prices driven by availability of imported aquaculture product (Courtney *et al*., 2012).

Prawn trawling in Moreton Bay is prohibited on weekends (i.e., there is no trawling on Friday and Saturday nights). The Moreton Bay otter trawl fishery is a multispecies fishery, with the majority of the catch composed of greasyback prawns (*Metapenaeus bennettae*), brown tiger prawns (*Penaeus esculentus*), eastern king prawns (*Melicertus plebejus*), squid (*Ommastrephes* spp. and *Sepioteuthis* spp.), banana prawns (*Fenneropenaeus merguiensis*), endeavour prawns (*Metapenaeus ensis*, *Metapenaeus endeavouri*) and Moreton Bay bugs (*Thenus parindicus*). Brown tiger prawns are the largest prawn species caught in the bay, and they command higher prices, accounting for most of the prawn catch value (Thurstan *et al*., 2018). Other commercially important by-product includes blue swimmer crabs, three spot crabs (*Portunus sanguinolentus*), cuttlefish and mantis shrimp.

Most of the prawns caught in Moreton Bay are sold locally as food principally, but some is utilised in the domestic bait market. Several operators in this fishery market direct to the public. There is currently a State Government prohibition on the movement of uncooked prawns for biosecurity reasons due to the detection of the virus that causes white spot disease. Uncooked prawns cannot be moved out of the Biosecurity Area that currently extends from Caloundra to the New South Wales (NSW) border and west to Ipswich. Cooked prawns can be moved out of this area. The virus poses no risk to human health.

Other Commercial Fishery Symbols

Several other commercial fisheries operate in Moreton Bay, which are not significant or less significant in the context of the Project footprint than those discussed. Commercial line fishery (L1 symbol) which mostly operate in offshore waters east of Mulgumpin and Minjerribah targeting rocky reef species such as snapper (*Pagrus auratus*) and pearl perch (*Glaucosoma scapulare*). An aquarium fish fishery (A1 and A2 symbols) permits operators to use a variety of apparatus to target small reef fish species (e.g., damselfishes, Family Pomacentridae and butterflyfishes, Family Chaetodontidae). It is dive based, with operators using scuba or surface-supplied air from hookah apparatus.

An Ocean Beach Net Fishery principally targets sea mullet on ocean beaches during their autumn and winter spawning periods. The fishing symbols limit operators to a specific area only – K3 is the fishery symbol that allows an operator to fish on Minjerribah and K4 is the fishery symbol that allows an operator to fish on Mulgumpin. A W2 fishery symbol allows a commercial fisher to dig bloodworms (*Marphysa mullawa*) for use as live bait for recreational fishing in intertidal areas with the seagrass beds of Fisherman Island and Wynnum being important harvesting areas. The Y symbol allows the harvesting of marine yabbies (*Trypea australiensis*) in intertidal areas, again for use as live bait for recreational fishing. Like uncooked prawns, worms and yabbies cannot be moved out of the Biosecurity Area that extends from Caloundra to the NSW border and west to Ipswich, due to white spot disease.

18.3.3 Recreational Fishing

Marine recreational fishing activities require no specific authorisation from government to be undertaken. The activities are, however, managed by fisheries legislation and marine park legislation. Access to land based recreational fishing activities may also be influenced by local authorities. Recreational fishing is an important way that many members of the public experience the marine environment. It enhances social capital, promotes respect for nature and provides health and economic benefits (Young *et al*. 2016). Recreational fishing is the dominant leisure activity in Moreton Bay (McPhee, 2017; Kenyon *et al*., 2019). The dominant form of recreational fishing is angling (hook and line), although in Moreton Bay there are also significant recreational fisheries for mud and sand crabs using pots, a seasonal cast net fishery principally targeting banana prawns, and cast and bait fisheries to supply bait for personal use. Recreational fishing is an important component of lifestyle choice for many residents of south-east Queensland.

Recreational fishers are a heterogenous group and their motivations and expectations for undertaking the activity differ. The product of recreational fishing is not fish per se but a fishing experience. As such recreational fishing has both catch and non-catch related motivations. The relative importance of these motivations varies among the individual participants. Catch in recreational fishing is unevenly distributed – the majority of fishers catch no or very few fish, while a small minority catch the majority (Hilborn, 1985; McPhee, 2008). While the number of species targeted and captured by recreational fishers in Moreton Bay is high, trumpeter whiting and yellowfin bream numerically dominate the catch (Taylor *et al*. 2012).

At the time of writing, the last completed state-wide survey of recreational fishing for which there was a final report was in 2013 (Webley *et al*. 2015). No specific estimates exist for fishing participation rates in Moreton Bay, but estimates are available for south-east Queensland more generally. Participation rates in recreational fishing have been in decline in Queensland over about a 20-year period, including in the Moreton Bay region, a trend that exists in many countries and jurisdictions (Arlinghaus *et al*., 2015). However, this declining participation rate is offset by an increasing population. The number of people who recreationally fished in 2010 and resided in south-east Queensland was ~405 000, which equates to a participation rate of ~15%. This participation rate was a decrease from the survey undertaken in 2000 (Henry and Lyle 2003), which estimated it at 22.6%. Decline in recreational fishing participation is a subset of decline in nature-based recreation in general (Pergams and Zaradic 2008). A more recent survey was completed in 2020 found approximately 660,000 Queenslanders went recreational fishing in 2019/2020 which represents a participation rate of ~13%. Despite the reported declines in recreational fishing participation, it remains an important activity in Queensland coastal areas including Moreton Bay with approximately $600 million spent on recreational items during the 12-month period encompassed by the 2020 survey.

Valuing recreational fisheries (or other recreational outdoor pursuits) is complex, as the activity does not occur in an actual market and the "products" of recreational fishing are non-market commodities. Expenditure on recreational fishing activities in Moreton Bay was valued at $156 million (Williams *et al*. 2008). Expenditure does not directly equate to the economic value of an activity, but it is a measure of economic activity (McPhee and Hundloe 2004; McPhee 2008).

Specific regulations are in place which limit the fishing gears that recreational fishers can use. This includes the number and dimensions of crab pots, the length and mesh sizes of cast and bait nets, and the number of fishing lines in use per person. Recreational fisheries in Queensland are also regulated through individual possession limits which limits the number of each species or species group that a recreational fisher may retain. Minimum and maximum size limits tend to be the same for recreational fishers as commercial fishers.

18.3.4 Indigenous Fisheries

Indigenous Australians can participate in recreational fishing and be authorised to undertake commercial fishing activities as described previously. In addition, they can undertake traditional fishing activities. Archaeological evidence

suggests that Indigenous fishers have harvested seafood in Moreton Bay for thousands of years, including finfish such as mullet (*Mugil cephalus*) (McPhee, 2017).

The Queensland *Fisheries Act 1994* provides that Aboriginal and Torres Strait Islander People may take, use or keep fisheries resources, or use fish habitats, under Indigenous tradition or Island custom, provided there has not been a regulation or management plan made under the Act which expressly applies to acts done under Indigenous tradition or Island custom. The Act also contains restrictions on the use of commercial fishing apparatus for traditional fishing, although a general fisheries permit can be issued under certain conditions to allow the use of commercial apparatus to take fish for customary community events.

Indigenous Australians continue to express a desire to have more economic opportunities around fishing, particularly in their own sea country. To facilitate and encourage the assessment and establishment of fisheries business projects in Indigenous communities, an Indigenous fishing permit is available. This provides limited authority to take fisheries resources to assess business viability before having to acquire a full commercial licence, but in a way that encourages the applicant to proceed to a fully commercial basis of operation within a reasonable timeframe. As part of the Queensland Government Sustainable Fisheries reforms, an Aboriginal and Torres Strait Islander Commercial Fishing Development policy was developed and implemented.

18.3.5 Biology of Key Fish Species

An understanding of the biology of the key fished species is important for understanding the potential impacts of any development on populations of harvested stocks. An understanding of life histories and habitat utilisation of these stocks is a focus. The remainder of this section focusses on the following species: yellowfin bream, sea mullet, black trevally, whiting, garfish, eastern king prawns, tiger prawns, and blue swimmer crabs. These represent the key fished species that occur at and/or rely on the typical habitat types found within the Project footprint and commonly occur in western Moreton Bay. For all species discussed, it is important to recognise that there are no local populations of them at a specific site such as the Project footprint. Describing fish populations and fish spawning areas is a requirement of the EIS guidelines.

Yellowfin Bream

The yellowfin bream is endemic to the Australian east coast and is ubiquitous in the various shallow-water habitats of Moreton Bay including seagrass beds, mangrove forests, natural reefs, artificial rocky habitats and unvegetated habitats (Gannon, 2016; Taylor *et al*., 2016). They are habitat generalists.

The spawning period for yellowfin bream in Moreton Bay is centred on the winter months (with a peak in July–August), with spawning occurring at or adjacent to surf bars (Pollock ,1982a and b; 1985). Adult yellowfin bream migrate from locations throughout Moreton Bay at this time to surf bars for spawning. However, a large proportion of the yellowfin bream population does not participate in the annual spawning migration but remains at feeding locations throughout Moreton Bay (Pollock, 1982). As such it is a partial migration. Jumpinpin Bar is probably the best-known spawning location in Moreton Bay (McPhee, 2017). After spawning, most post larvae enter the estuary at night during the full moon on the flood tide, and the transition from planktonic to littoral existence occurs from August to November when the fish are 13–14 mm total length (Pollock *et al*., 1983).

The reproductive biology of yellowfin bream is complex, involving protandrous sex inversion. This subject is well described by Pollock (1985). The sex ratio of males to females decreases with age. Most juveniles become functional males, but a small proportion of juveniles develop directly into functional females (primary females). Protandrous sex inversion commences after the spawning period when male fish change into female fish; however, some fish remain as males (primary males) throughout their life.

Whiting

Three species of whiting are of fishery significance in Moreton Bay: the diver (trumpeter) whiting (*Sillago maculata*), the sand whiting (*Sillago ciliata*) and the yellowfin (golden-lined) whiting (*Sillago analis*) (McPhee, 2017). The diver whiting is endemic to the Australian east coast, and the sand whiting extends from south-east Tasmania northwards to Cape York (and into Papua New Guinea). Moreton Bay is generally recognised as the southernmost limit of the distribution of yellowfin whiting on the Australian east coast. The diver whiting was historically referred to as the 'winter' whiting and the other two species 'summer' whiting, but these terms are a misnomer as they occur and can be caught in Moreton Bay year-round. Moreton Bay is generally recognised as the southernmost limit of the distribution of yellowfin whiting on the Australian east coast, with the species extending northwards and across northern Australia, then south into Western Australia to approximately Shark Bay. All three species are harvested by recreational fishers, but sand whiting is the dominant species for the commercial sector.

Weng (1986) examined habitat use of the three whiting species (subadults and adults) in Moreton Bay and concluded that diver whiting were distributed almost throughout the bay, to depths of 30 m. Sand and yellowfin whiting typically occurred in shallow water, from the shoreline to 3–5 m depth, respectively. Juveniles of the three species inhabit shallow shores, including lower sections of creeks and rivers; but sand whiting prefer sandy substrates with water <1 m deep. Yellowfin whiting also favour this depth, albeit with a preference for a muddier substrate, while juvenile diver whiting stay in muddy-sand to muddy substrates 1–3 m deep (Weng 1983). Newly settled and metamorphosing whiting larvae of all three species utilise intertidal pools as habitat and feed on meiofaunal copepods and nematodes before moving to adjacent subtidal habitats (Krück *et al*. 2009). This highlights the importance of this type of habitat for the lifecycle of whiting in Moreton Bay, despite the relatively short residence time (days) of the species in that habitat.

Sea Mullet

Sea mullet are widely distributed globally in temperate and sub-tropical coastal waters. On the Australian east coast, the sea mullet is a catadromous species that migrate from estuaries and inshore areas during late autumn and early winter for spawning. This spawning migration is only a partial migration in that not all mature individuals participate in the spawning migration each year but remain in estuarine habitats (Fowler *et al*., 2016).

Often the shoals of sea mullet congregate at the mouth of estuaries, with migration out of the estuary and into the surf zone triggered by strong offshore winds (Thomson, 1955). Although exact spawning locations are unknown, it is thought that spawning occurs in the surf zone and possibly adjacent to surf bars (Kesteven, 1953; Virgona *et al*., 1998). The key habitat-type juvenile mullet recruit to are protected and highly turbid rivers and creeks lined with mangroves such as the Logan and Brisbane Rivers and their tributaries. The movement into these nursery habitats is protracted. In the Logan River, upstream migration occurs as early as spring but persists over summer and into autumn (Harding *et al*., 2019).

They feed on detritus and microalgae in soft sediments. Movements of sea mullet are high dependent on freshwater flows. Where rivers are regulated, this impacts these movements and their populations (Harding *et al*., 2019). They can enter freshwater environments (Chang *et al*., 2004; Fortunato *et al*., 2017; Harding *et al*., 2019). The majority of juvenile mullet remain within the one river system until maturity.

Dusky Flathead

The dusky flathead *Platycephalus fuscus* is an estuarine and coastal species endemic to Australia and restricted to the east and south-east coastal areas. In Queensland, dusky flathead is distributed from about Cairns to the NSW border (Pollock, 2014). Female dusky flathead grow faster and attain a greater overall maximum length, weight and age than males (Gray and Barnes, 2015; Pollock, 2014). Pollock (2014) identified them as rudimentary hermaphrodites with sex determined at a very young age.

Pollock (2014) assessed the spawning of dusky flathead in Moreton Bay. He determined that flathead spawn adjacent to surf bars such as Jumpinpin and have a protracted spawning period between November and April with serial spawning. Gray and Barnes (2015) also identified that spawning aggregations in NSW occurred in the lower reaches of river mouths and adjacent coastal waters. Egg production is highest in females between 55 and 64 cm Pollock (2014). Tagging studies show that both juvenile and adult dusky flathead rarely undergo movements across estuaries (O'Neill, 2000), however populations across estuaries may be genetically homogenous. Dusky flathead within NSW are considered a single genetic stock (Taylor *et al*., 2020). There is no information on the specific habitat preferences of newly recruited dusky flathead, but personal observations are that they are common in estuarine environments and by-catch studies of commercial fisheries support this observation (e.g., Liggins and Kennelly, 1996).

Eastern King Prawns

The species has a geographic range from central Queensland to the Gippsland Lakes in Victoria. Moreton Bay is an important location for juvenile eastern king prawns. Recruitment of eastern king prawns to the nursery grounds in Moreton Bay is distinct and restricted to October to November (Courtney *et al*., 1995). New recruits prefer shallow and more saline areas and reside in both vegetated or unvegetated habitats (Coles and Greenwood, 1983; Courtney *et al*., 1995; Taylor *et al*., 2016, 2017). Skilleter *et al*. (2005) found that the abundance of eastern king prawns in Moreton Bay was significantly and consistently greater in dense seagrass proximal to mangroves than in other types of habitats they surveyed. Eastern king prawns spend limited time in the nursery habitat (e.g., a few weeks) before commencing their movements offshore at a very small size (14–15 mm CL). However, the time they do spend there is critical for the species to complete its life cycle. From their nursery grounds, eastern king prawns continue to grow and migrate out into Moreton Bay and eventually into offshore waters for spawning.

Garfish

Several species of garfish are harvested by commercial and recreational fishers in Moreton Bay with river garfish (*Hyporhamphus regularis ardelio*) and snub-nosed garfish (*Arrhamphus sclerolepis*) widespread in Moreton Bay and being significant components of the catch. Garfish consume filamentous algae, seagrass and various small invertebrates with the relative importance of these dietary components varying across garfish species, diurnally and habitats (Carseldine and Tibbetts, 2005; Tibbetts and Carseldine, 2005; Waltham and Connolly, 2006). Most garfish species in Australia are generally closely associated with seagrass habitats (Tibbetts, 1991). While garfish are fast growing, relative to most other species of marine fish, their fecundity is low, although they do spawn multiple times during a spawning season which can offset this low fecundity (Stewart *et al*., 2005; Hughes and Stewart, 2006; Nuttall *et al*., 2012). In NSW, spawning is protracted with river garfish spawning between July and December and snub-nosed garfish between October and January (Stewart *et al*., 2005; Hughes and Stewart, 2006). Garfish have negatively buoyant eggs that attach to floating or benthic vegetation (Hughes and Stewart, 2006).

Black "Trevally"

Black Trevally (*Siganus fuscescens*) is a marketing name for some members of the Family Siganidae. They are not a trevally at all, with trevally belonging to the Family Carangidae. Black trevally are schooling grazers which consume various algae and seagrass and may also consume the filamentous cyanobacteria (*Lyngbya majuscula*) (Capper *et al*., 2006; Arnold *et al*., 2014). Except for their diet, there is relatively little known about the movements and spawning of black trevally in Moreton Bay. Siganids in general are known to migrate to and aggregate in more oceanic waters for spawning (Domeier and Colin, 1997; Robinson *et al*., 2011).

Brown Tiger Prawns

The brown tiger prawn is endemic to Australia and Moreton Bay represents the southern region of their distribution on the Australian east coast. The Moreton Bay population does not appear to experience significant immigration or emigration and spawning; maturation and recruitment occurs internally in the bay (Courtney & Masel 1997). Seagrass beds are critical juvenile habitat for brown tiger prawns and the species is seagrass dependent with the seagrass

providing food and protection from predators (Wassenberg, 1990; Kenyon *et al*., 1995; Hayward *et al*., 1995). Skilleter *et al*. (2005) found that the abundance of brown tiger prawns tended to be greatest in sparse seagrass distal from mangroves compared with the other habitats.

In Moreton Bay, the spawning period of brown tiger prawns peaks between October and November (Courtney & Masel 1997). Brown tiger prawns have a larval phase of approximately three weeks (Courtney & Masel 1997). Peaks in the settlement of juvenile brown tiger prawns occur between September and November and late January to April (O'Brien, 1994a). Young and Carpenter (1977) identified that while post larval tiger prawns settled at all seagrass locations they sampled – settlement was highest in the Southport Broadwater and the Sandstone Point/Cooks Rocks area at the southern mouth of the Pumicestone Passage. Kienzle and Sterling (2017) identified that temperature in Moreton Bay was the most significant explanatory factor for annual variation in brown tiger prawn recruitment and increased temperatures have increased recruitment of brown tiger prawns.

O'Brien (1994b) investigated the diet of brown tiger prawns in Moreton Bay and found that the most common food types included copepods, decapods, ostracods, gastropods, diatoms, filamentous algae and seagrass. The diversity of food types increased with the size of brown tiger prawns and included pronounced changes in the use of plant material. Plants are essential for the health of juvenile brown tiger prawns, and they appeared to change their diet progressively from diatoms to filamentous algae to seagrass as they grew. Brown tiger prawns actively feed at night (Hill and Wassenberg, 1993).

Blue Swimmer Crabs

Blue swimmer crabs are found in coastal and estuarine waters along the entire Queensland coast although most fishing for them occurs in Moreton and Hervey Bays. While mating of blue swimmer crabs in Moreton Bay can occur throughout the year, it does have two seasonal peaks: the major peak in May–June and a minor peak in November (Sumpton *et al*. 1994). Males copulate with females when females are in the soft-shell stage immediately after moulting (Campbell and Fielder 1986). Female egg-bearing crabs occur throughout the year, with the proportion of females bearing eggs being greatest between August and October (Sumpton *et al*. 1994). In other localities mature blue swimmer crabs migrate to deeper, more oceanic waters for spawning (de Lestang *et al*., 2003).

Juvenile blue swimmer crabs recruit from the plankton into seagrass or shallow sand and mud banks. Increased chlorophyll *a* levels may increase the survival of larval and megalopal blue swimmer crabs, leading to density-dependent effects such as increased competition among juveniles for food and spatial resources, and ultimately, reduced growth (Marks *et al*., 2020). Juvenile blue swimmer crabs are cannibalistic, and this behaviour is more frequent in the absence of appropriate shelter such as complex habitats including seagrass (Marshall *et al*. 2005).

18.3.6 Existing Marine Habitats in Relation to Key Fish Species

The marine habitats at and adjacent to the Project footprint are assessed in detail in Section 16.3. The Project footprint consists of subtidal and intertidal seagrass beds, unvegetated subtidal and intertidal areas, areas of mangroves, small areas of rubble with assorted sessile invertebrates, and a small area of saltmarsh. As such, the Project footprint consists of a number of different types of marine habitat that are high value for fisheries, and these habitats are arranged in a mosaic at the landscape scale which further increases their fisheries value (see Skilleter *et al*., 2005; Saintilan *et al*., 2007; McMahon *et al*., 2012).

The habitats in the Project footprint are currently subjected to disturbance of various types and magnitudes. The mangrove forests along the foreshore within the Project footprint are highly disturbed. These mangrove forests receive local runoff from developed areas and litter was caught in the roots and along the shoreline. The mangroves of Cassim Island adjacent to Toondah Harbour are less disturbed. There are approximately 5.3 ha of mangroves within the Project

footprint that are likely to be of good fisheries and aquatic ecological value based on structural and functional components.

The areas of intertidal and sub-tidal, unvegetated mud and sand habitat around the Fison Channel are extremely disturbed by frequent boat and ferry traffic, with wash affecting exposed areas at low tide. The rest of the area is moderately disturbed, with runoff from developed areas and impacts due to recreational use.

There has been some disturbance of the seagrass meadows by recreational boat traffic and wash from ferries on the southern section adjacent to the channel. The seagrass meadows are in a generally good condition, although there is some epiphytic algal growth on the leaves. Approximately 37 ha of seagrass is located within the Project footprint including in the Fison Channel, with *Zostera muelleri* with some *Halophila ovalis* and *Halophla spinulosa* being the dominant species.

The saltmarsh area near (but outside of) the Project footprint is highly disturbed, receiving runoff from developed areas along the foreshore. The Project footprint contains less than 0.001% of the total area of shallow soft sediment (vegetated and unvegetated) habitat types in Moreton Bay. Saltmarsh habitat makes an important contribution to biodiversity and represents an important transition zone between terrestrial and marine habitats (McPhee, 2017). However, it is only directly utilised by a limited number of juveniles of species of fisheries significance during spring tides including yellowfin bream, sea mullet and other species of mullet (Morton *et al*., 1987; Thomas and Connolly, 2001). None of these species of fisheries significance are obligate users of saltmarsh habitat.

In terms of valuing habitat to fisheries in a direct economic sense, values are not easily transferable between specific locations. For example, an economic value per hectare of mangroves to fisheries production was identified by Morton (1990) at Lota in Moreton Bay, however it is not directly transferable to the Project footprint. There are a range of structural and landscape variables that influence the value of a habitat for fisheries production. This includes the edge to area ratio of habitat patches, species composition, the amount and form of structural diversity and the spatial relationship with other habitat types including sub-tidal habitats and hydrodynamic factors that influence larval recruitment (McNeill *et al*., 1988; Halliday and Young, 1996; Laegdsgaard and Johnson, 2001; Pittman *et al*., 2004; Skilleter *et al*., 2005; Jelbart *et al*., 2007; Saintilan *et al*., 2008; Meynecke *et al*., 2008).

Table 18-1 summarises the use of habitats of key fisheries species during key life history stages.

Table 18-1: Likely Presence at Various Life History Stages in the Habitats at Toondah Harbour.

Species or Species Group	**Juvenile Habitat**	**Adult Habitat**	**Spawning Location**
Sea Mullet	The Project footprint does not contain critical juvenile habitat for sea mullet.	Some sea mullet will pass through the Project footprint as they move to spawning locations or potentially after rainfall. However, adult sea mullet are highly unlikely to reside in the Project footprint.	Toondah Harbour is not a spawning location for sea mullet. Sea mullet spawn adjacent to surf bars.
Yellowfin bream	The proposed Project footprint contains suitable habitat for the recruitment of juvenile yellowfin bream. However, they also recruit to other types of habitats (e.g., upper reaches of estuaries).	The Project footprint contains suitable adult habitat for yellowfin bream.	Toondah Harbour is not a spawning location for yellowfin bream. The species spawns adjacent to surf bars.

Species or Species Group	Juvenile Habitat	Adult Habitat	Spawning Location
Dusky flathead	The Project footprint possibly contains suitable habitat for the recruitment of juvenile dusky flathead. However, they also recruit to other types of habitats (e.g., upper reaches of estuaries).	The Project footprint contains suitable adult habitat for dusky flathead.	Toondah Harbour is not a spawning location for dusky flathead. The species spawns adjacent to surf bars.
Eastern King Prawns	The Project footprint contains suitable habitat for the recruitment of juvenile eastern king prawns.	The Project footprint does not contain suitable adult habitat for eastern king prawns.	Toondah Harbour is not a spawning location for eastern king prawns. They spawn in offshore waters.
Brown Tiger Prawns	The Project footprint contains suitable habitat for the recruitment of juvenile brown tiger prawns.	The Project footprint does not contain suitable adult habitat for brown tiger prawns.	Toondah Harbour is not a spawning location for brown tiger prawns as they spawn elsewhere in Moreton Bay.
Whiting	The Project footprint contains suitable habitat for the recruitment of juveniles of the three whiting species, particularly diver whiting.	The Project footprint contains suitable adult habitat for sand and yellowfin whiting but it should not be considered as prime habitat for these two species. Adult trumpeter whiting are more abundant in deeper parts of Moreton Bay, in particular eastern Moreton Bay, as well as seasonally in Deception and Bramble Bays.	Toondah Harbour is not a spawning location for sand whiting or trumpeter whiting. Sand whiting generally spawn adjacent to surf bars, while trumpeter whiting spawn on the eastern side of Moreton Bay. Some spawning of yellowfin whiting may occur.
Blue Swimmer Crabs	The Project footprint contains suitable habitat for the recruitment of juvenile blue swimmer crabs.	The Project footprint contains suitable adult habitat for blue swimmer crabs, although adults are more abundant in other parts of Moreton Bay where they are heavily targeted by commercial and recreational fishing.	Some spawning of blue swimmer crabs may occur in the Project footprint, but the species does not form distinct spawning aggregations and spawning is most likely more common in eastern areas of Moreton Bay
River and snub-nosed garfishes	The Project footprint contains suitable habitat for the recruitment of juvenile river garfish and snub-nosed garfish.	The Project footprint contains suitable adult habitat for river garfish and snub-nosed garfish	Although uncertainties exist about the exact spawning locations of both, spawning is thought to occur in proximity to seagrass beds. Thus, the Project footprint does potentially contain spawning habitat for this species.
Sea Mullet	The Project footprint does not contain critical juvenile habitat for sea mullet.	Some sea mullet will pass through the Project footprint as they move to spawning locations or potentially after rainfall. However, adult sea mullet are highly unlikely to reside at Toondah Harbour.	Toondah Harbour is not a spawning location for sea mullet. Sea mullet spawn adjacent to surf bars.

18.3.7 Commercial Fishing Data Analysis

The time series of catch and effort (number of licences) for the key species in the trawl, net and crab fisheries and in these fisheries overall is included in Appendix 2-O. Table 18-2 provides summary information from the extracted commercial fishing logbook data and allows for a comparative analysis of the relative direct importance of northern Moreton Bay (W37) and southern Moreton Bay for commercial fishing activities in Moreton Bay that are relevant for the Project. Overall, northern Moreton Bay is more significant in terms of commercial catches than southern Moreton Bay. This is particularly the case for the trawl fishery where approximately 99% of the trawl catch is from northern Moreton Bay. This is unsurprising given the area where trawling can occur is very limited by the zoning provisions of the Moreton Bay Marine Park, closures under Queensland fisheries legislation and the seabed itself, which is not conducive to trawl fishing in much of the area. The southern Moreton Bay area does provide a source of catch for several commercial net and crab fishers targeting blue swimmer crabs, and this contributes to their income. Importantly Toondah Harbour represents only a very small area (less than 0.1%) of the area of the relevant commercial fishing logbook grid (W37). However, the area does provide habitat for juvenile fish and crustaceans of commercial (and recreational) fishing significance which potentially contribute to catch beyond the Project footprint.

Table 18-2: Summary of Commercial Fishing Catch and Effort in Logbook Grids W37 (northern Moreton Bay) and W38 (southern Moreton Bay) between 2010 and 2018.

Fishery / Species	**Grid W37**			**Grid W38**			**Ratio**
	Average Annual No. of Licences	Average Annual Catch (tonnes)	Catch Range (tonnes)	Average Annual No. of Licences	Average Annual Catch	Catch Range	
Net Fishery	**61**	**848**	**603-1,066**	**44**	**269**	**218-364**	**0.76:0.24**
Sea mullet	53	470	280-718	37	142	99-194	0.77:0.23
Yellowfin bream	44	70	36-122	31	18	11-28	0.79:0.21
Garfish	30	32	17-46	17	11	7-15	0.74:0.26
Whiting	42	74	47-93	28	19	11-27	0.80:0.20
Trawl Fishery	**77**	**751**	**560-1,041**	**8**	**7**	**0-20**	**0.99:0.01**
Eastern King Prawn	60	50	40-82	8	4	0-9	0.93:0.07
Tiger prawn	58	161	103-243	N/A	N/A	N/A	N/A
Blue swimmer crab	60	11	5-25	4	<1	N/A	N/A
Crab (Blue Swimmer) Fishery	**51**	**161**	**80-203**	**24**	**45**	**20-75**	**0.78:0.22**

18.3.8 Recreational Fisheries

Unlike commercial fisheries, there is no routine ongoing collection of catch and effort information for recreational fisheries in Queensland. Telephone and diary surveys have been the main sources of broadscale information on recreational fishing in Queensland. This information is reported at the "statistical division" based on the residence of a person fishing and can be augmented by specific finer scale information collected for various purposes (e.g., marine park design or fisheries management).

The summary results of the 2019 Queensland recreational fishing survey identified an estimated 334,100 people over five years of age in the Brisbane Statistical Division (including the Redlands) had been fishing in the previous 12 months. This represented a participation rate of 14.1%. These estimates were an increase from the previous survey conducted in 2013 which identified 235,800 participants and a participation rate of 11.9% (Webley *et al*., 2014). The results of the 2014 survey identified that for residents in Brisbane, the marine species retained the most were trumpeter whiting, sand whiting and yellowfin bream (Webley *et al*., 2014).

The results of the state-wide surveys of recreational fishing are useful in terms of providing a broad snapshot of recreational fishing catch and participation. They do not provide specific information on recreational fishing catch and effort at a specific locality such as the Project footprint and the surrounding area. However, some relevant information exists in Williams *et al*. (2007), who undertook empirical surveys to identify and rank desirable recreational fishing locations within Moreton Bay. A total of 58 desirable locations were identified. The location of the Project and surrounding areas were not among them. Currently within Toondah Harbour, recreational fishing by boats is limited and/or prohibited as it is already an operating port facility and is not a highly desired location. Some boat-based fishing recreational fishing does occur in shallow water on the northern and eastern side of Cassim Island, but it has not been quantified. Some land-based recreational fishing is undertaken at GJ Walter Park, but at and around high tide only as the mud banks are exposed for a considerable distance at low tide. This area is exposed to prevailing south-easterly winds. Feedback from Queensland's peak recreational fishing body Sunfish confirmed there is almost no recreational fishing close to Toondah Harbour at present so the Project will have no direct impact on recreational fishing.

The existing recreational boat ramp at Emmett Drive is underutilised and the extensive trailer-boat car parking is often occupied by overflow car parking from the adjacent ferry operations. Sunfish confirmed this was the case. Recreational vessels that use the current boat ramp must navigate around the path of vehicle and passenger ferries and this poses a marine safety risk.

18.3.9 Key Assessment Outcomes

Many commercial fisheries can operate within the southern Moreton Bay area. Most of these fisheries however do not operate in or adjacent to the Project footprint either due to regulation or a lack of suitable target species. The exception is the tunnel net fishery (N10), the East Coast Inshore Finfish Fishery (N1) and the Crab Fishery (C1).

The biology of key fished species has been described including their spawning location. Many key species undertake movements to eastern Moreton Bay, surf bars or oceanic waters for spawning. This includes brown tiger prawns, eastern king prawns, yellowfin bream and sea mullet. The exception are garfishes which spawn in association with seagrass. While it is unknown whether they do spawn within the Project footprint, it is feasible. Several species including tiger prawns and blue swimmer crabs prefer seagrass as a nursery area. Some species (e.g., yellowfin bream and eastern king prawns) may use seagrass habitat as a nursery area but also use a range of other habitat types, while others such as sea mullet prefer other habitats.

18.4. Potential Impacts

In considering the potential impact of any Project on recreational and commercial fisheries, both potential impacts to fishing access and the impacts of loss or changes to marine habitats that support fisheries have been assessed. Both are considered in the remainder of this section.

18.4.1 Construction Impacts

The construction phase can potentially impact fished species, habitats that support fished species outside of the Project footprint. A number of standard and effective mitigation measures for these impacts exist and are discussed further in the management measures section. With the use of appropriate mitigation measures, potential impacts to fished species and surrounding aquatic habitats during the construction phase are unlikely to impact fisheries.

18.4.2 Fishing Access

For the commercial trawl fishery, the area in and adjacent to the Project footprint cannot be accessed as it is closed to trawling under fisheries legislation and, in any case, is too shallow. Therefore, there will be no impact on the commercial trawl fishery from the Project.

For the commercial net fishery, some access for both the mesh net fishery (N1) and the tunnel net fishery (N10) is permitted, however it is not recognised as a key area in Moreton Bay overall (Williams *et al*., 2007). The analysis of logbook information identified that the logbook grid W37, which is to the north of the Project footprint, is more important for commercial fishing than W38 which contains the Project footprint. However, the northern and eastern side of Cassim Island does represent a location of a tunnel net shot targeting yellowfin bream and sea mullet which makes an important contribution to individual fishing business activities.

For the blue swimmer crab pot fishery (C1), the area adjacent to the Project footprint is accessed by some commercial fishers but it is not recognised as a critical area (Williams *et al*., 2007). Like the tunnel net fishery, the area may contribute to individual fishing business activities. This loss of access is irreversible.

Within the Project footprint, access for the recreational fishing sector is effectively limited to land-based fishing at GJ Walker Park at around high tide and limited boat-based fishing around Cassim Island. Loss of recreational fishing can be mitigated or enhanced, and this is discussed in Section 18.3.8.

18.4.3 Habitat Loss

Declaring and managing fish habitat areas (FHAs) is the key approach that the Queensland Government uses to protect key habitats that support fisheries production. The process for nominating FHAs is appropriately rigorous. The Project is not in an FHA. There are 11 FHAs in the Moreton Bay region (McPhee, 2017), and the nearest declared FHA to the proposed project is the Peel Island FHA, which will not be impacted.

The Project will remove an area of approximately:

- 3.4 ha of mangroves;
- 37 ha of seagrass, including 11.8 ha in the proposed channel that may regrow in that area as it has done after maintenance dredging events;
- 1 ha of rubble; and
- 25 ha of sand bars and mudflats, including 16.2 ha in the proposed channel that are already subtidal mudflat.

Collectively this mosaic of habitat represents a relatively high value habitat, although the existing habitat is subject to varying disturbances which reduce its fisheries value. The main fisheries value of the habitat is a nursery area for some

juvenile fish and crustacean species, rather than a spawning location. The exact value of this loss to fisheries cannot be accurately valued. This loss of habitat is irreversible. Importantly the loss of this habitat will not measurably impact populations of harvested species. This is because the stock distribution of all harvested species populations is large, and the habitats are not unique.

While the Project will remove habitat as described, in its place will be an area of deeper water with vertical and horizontal structure, along with areas that are reclaimed and will no longer be part of the marine environment. As such, the Project consists of a component of habitat loss and a component of habitat modification including the creation of artificial habitat. Artificial habitats of all types attract and maintain local populations many species of fish (Clynick, 2006; 2008). Artificial structures, such as pontoons and pilings associated with marinas, have a strong effect on the distribution of fish (Clynick, 2008; Bouchoucha *et al*., 2016; Bosch *et al*., 2017). The abundance and diversity of fish in marinas is strongly positively correlated with the abundance of foliose algae, mussels and solitary ascidians on pilings (Clynick *et al*., 2007). Yellowfin bream can be more abundant in artificial habitats including marinas than adjacent natural habitats, as can plantivorous species (Clynick, 2008; Olds *et al*. 2018; Tylor *et al*. 2018). However, artificial structures overall may not act as exact surrogates for natural habitats and should not be regarded as direct substitute for natural habitats (Chapman and Bulleri, 2003; Walker and Schlacher, 2014; Benzeev *et al*., 2017).

18.5. Adaptive Management and Monitoring Measures

18.5.1 Management Measures

There are several management measures that can be undertaken to mitigate risks from the proposed project. Table 18-3 provides a summary of the impacts and mitigation measures proposed.

Table 18-3: Impacts and Mitigation Summary.

Potential impact	Mitigation measure	Desired outcomes and effectiveness
Impacts to fish species as a result of the reclamation and dredging works	▪ Identifying and managing acid sulfate soils and other contaminants as outlined in Chapter 7 and 9; ▪ Minimising and managing turbidity plumes in accordance with Chapter 9; ▪ Implement stormwater management in accordance with Chapter 9; ▪ Installing temporary enclosures at low tide to minimise the number of marine vertebrates caught in the area; ▪ Catching any fish trapped in the enclosures and releasing them in appropriate habitat outside the area (specific measures outlined in Chapter 16).	▪ Minimise impacts to fish species and recreational and commercial fisheries as a result of the Project. ▪ Measures identified industry standard and will be highly effective in minimising impacts to fisheries.
Impacts to recreational fishing access and habitat	▪ Dedicated fishing platforms with disabled access; ▪ Install appropriately placed lighting for night-time fishing; ▪ Install rod holders and fish cleaning stations with water supply;	▪ Minimise impacts to fish species and recreational and commercial fisheries as a result of the Project. ▪ Measures identified industry standard and will be highly effective in minimising impacts to fisheries.

Potential impact	Mitigation measure	Desired outcomes and effectiveness
	▪ Fish measuring stations, including signage to promote recreational fishing education e.g., size and possession limits with such signage provided by the state government; ▪ "Tangler bins" to recycle old fishing line; ▪ Shade and safety rails for safe fishing; ▪ Contribute to upgraded facilities at the William St (Cleveland Point) boat ramp to compensate for decommissioning of the existing Emmett Street public boat ramp; ▪ Include design features that overall enhance marina habitat for fished species. This can occur without compromising the core purposes of the marina and associated infrastructure; ▪ Placing restoration sites such as oyster reefs in strategically selected locations within heterogeneous landscapes can maximise the rates of ecological function and the distance over which positive impacts extend.	Proposed infrastructure upgrades will provide benefit to fisheries overall.
Impacts to commercial fishing access and habitat	There are no specific management measures that can effectively mitigate loss of commercial fishing access which principally affects the tunnel net fishery and to a lesser degree the blue swimmer crab fishery. Low significance industry impacts are expected, however offset measures may be sought with industry and the Queensland Government.	▪ Minimise impacts to fish species and recreational and commercial fisheries as a result of the Project. ▪ Measures identified are industry standard and will be highly effective in minimising impacts to fisheries. Proposed infrastructure upgrades will provide benefit to fisheries overall.

18.5.2 Recreational Fisheries

For boat-based recreational fishers, increased demand has been identified for recreational boat ramps and boat trailer parking in the Redland City LGA. The Project proposes to close the existing boat ramp at Toondah Harbour and contribute to substantially upgraded facilities at the William Street boat ramp (Cleveland Point). The popularity of the Emmett Drive boat ramp declined with the construction of the William Street ramp, where commercial vessel traffic is absent. At peak times, the demand for parking and ramp space at William Street exceeds current capacity. During consultation for the Project, recreational fishers specifically identified that an upgrade of the William Street ramp was highly desirable. The Project also includes a launching point for non-motorised vessels (e.g., kayaks).

Marina berths themselves are used by vessels that are involved in recreational fishing and hence contribute to meeting the demand for recreational boating access for fishing. The Project will widen and deepen the Fison Channel, thereby creating a safer, wider and deeper channel for ferry operators, commercial fishers and recreational fishers.

The Proponent has committed to working with local fishers, the Queensland Government and RCC to identify and support the priority needs of the recreational boating community in contributing to the upgrade of the William Street

boat launching facilities. Overall, the Project represents an opportunity to locally enhance land-based and boat-based access. Marine safety for recreational trailer boats will be enhanced and the amenities for recreational boat-based fishers improved.

Commercial Fishing and Commercial Fishing Access

No specific management measures can effectively mitigate the loss of commercial fishing access which principally affects the tunnel net fishery and, to a lesser degree, the blue swimmer crab fishery. While an outlet to sell and promote local produce including seafood is a potential positive for the commercial fishing industry, it represents a benefit of uncertain magnitude that will occur well into the future, whereas the loss of access will commence earlier, during the Project's construction phase. The benefits may also accrue to fisheries not impacted by the Project. It is stressed that the magnitude of this loss of access in the overall context of the fishery is unlikely to be significant, however, a potential offset should be worked through with industry representative organisations and the DAF. This can form a small component of the overall proposed offsets for the Project.

In terms of contributing to their social licence to operate, the MBSIA identified a strong desire to have access to the education centre within the Project for static displays as well as presentations and activities that focus on educating the community on commercial fishing activities and the positive environmental initiatives that the MBSIA has undertaken. The Proponent supports this in principle and will continue to work with the MBSIA to optimise opportunities. The MBSIA did not consider that financial compensation directly to individual fishing licence holders was necessary or practical for mitigating the loss of fishing access.

18.5.3 Fisheries Habitat Construction

Typically, marinas and associated rockwall habitat are not designed specifically to enhance fisheries resources, with any enhancement being incidental to their function as marine infrastructure. However, there is scope to specifically include design features that overall enhance marina habitat for fished species (Patranella *et al*., 2017). This can occur without compromising the core purposes of the marina and associated infrastructure. The Queensland Government has a Fisheries Guideline for Fish Friendly Structures (Derbyshire, 2006). This provides general principles and guidelines for designing coastal structures in general, some of which are applicable to the Project. The Project can incorporate several of the design aspects included in the guideline including the use of different sized rocks in the foreshore revetment wall to increase habitat diversity, geotextile fabric bags at the base of the wall and artificial habitat modules under pontoons.

Subsequent to the work of Derbyshire (2006) it has been recognised that oyster reefs in Moreton Bay were a key habitat component when Europeans arrived, but declined rapidly there, and along the Australian east coast more generally, to become functionally extinct (Ogburn *et al*., 2007; McPhee, 2017; Gillies *et al*., 2020). There is much focus globally and locally on the restoration of oyster reefs to support fisheries produce and restore ecosystem structure and function, with strong community support to do so (Petersen *et al*., 2003; McLeod *et al*., 2019; Gilby *et al*., 2020; Gillies *et al*., 2020; McAfee *et al*., 2020). Importantly, oyster reefs can potentially contribute to improving water quality as their feeding activities filter the water (Nelson *et al*., 2004; Coen *et al*., 2007). There is scope to include oyster reef units in the Project for fisheries enhancement and restoration of ecosystem services, and this can be done in partnership with First Nations stakeholders and relevant community groups. Placing restoration sites such as oyster reefs in strategically selected locations within heterogeneous landscapes can maximise the rates of ecological function and the distance over which positive impacts extend (Duncan *et al*., 2019).

Overall, the Project should incorporate fish friendly structures and oyster reefs to enhance elements of the project infrastructure for fished species. This would not compromise the intended use of the infrastructure. Fisheries stakeholders, including but not limited to OzFish Unlimited, can potentially assist with the design of these structures and their placement within the Project footprint.

18.5.4 Draft Fisheries Monitoring Plan

Construction Phase

Monitoring of the impacts to marine ecology from the Project during the construction phase is addressed in Section 16.4. From the perspective of fisheries, there are no specific additional monitoring requirements.

Recreational Fishing Access

Monitoring should include assessment of the use of the constructed foreshore area by recreational fishers, and a survey to determine attitudes to the facilities provided and the quality of recreational fishing experience overall.

Fisheries Habitat Construction

The use by fish of any deployed oyster reefs and fish friendly structures should be monitored and compared to relevant reference areas. Monitoring activities should focus on non-extractive methods such as underwater video cameras. There is scope to involve stakeholders in monitoring through a "citizen science" approach.

In terms of the creation or modification of habitat, habitats that may be optimal to support fished species and fishing directly may not be optimal for other faunal components (e.g., wader birds) and people that utilise them (e.g. birdwatchers), and vice versa. Nonetheless, the Project can incorporate multiple habitat types that perform a range of functions.

18.6. Residual Risk of Impact

The risk of significant impacts to commercial and recreational fisheries has been assessed following the methodology outlined in Chapter 2 and is presented in Table 18-4.

18.6.1 Recreational Fishing Access

As discussed in the body of this chapter, the Project will enhance land-based fishing access compared to the current arrangements. The Project represents a low risk in terms of negative outcomes for recreational fishing access, however, with the enhancements suggested as part of this chapter, recreational fishing access can be substantially improved. Overall, the Project represents a low risk to recreational fishing access.

18.6.2 Commercial Fishing Access

For the trawl, line and ocean beach fisheries there is no impact on access for these fisheries. This risk assessment applies to the net fishery (including the tunnel net fishery) and blue swimmer crab fishery. Overall, the Project represents a medium risk to commercial fishing access for the net fishery (including the tunnel net fishery) and the blue swimmer crab fishery.

18.6.3 Fisheries Habitat

The Project will remove and alter existing marine habitats including seagrass. These existing habitats are not pristine and are currently subjected to multiple stressors. Structures that function as artificial habitats will be introduced into the marine environment as part of the Project. Clearly, there is practical scope to optimise these habitats for fished species and other marine species. There is also scope for habitat restoration through the use of oyster reef units, which can enhance water quality. The risk the Project proposes differs between fished species based on their habitat use (see Table 18-1). Risk assessment has considered two species – garfish and tiger prawns separately to the other relevant fished species. These two species are reliant on seagrass to complete their life history, whereas other species show greater plasticity in terms of habitat use. For garfish and tiger prawns, the Project represents a medium risk, while for other species the risk is low.

Table 18-4: Summary of risk for recreational and commercial fishing access, and fisheries habitat.

Activity	Initial risk assessment					Mitigated risk assessment				
	Scale	**Duration**	**Impact**	**Likelihood**	**Risk**	**Scale**	**Duration**	**Impact**	**Likelihood**	**Residual risk**
Impacts to fish species as a result of the reclamation and dredging works	Local	Medium	Medium	Possible	**Medium**	Site	Medium	Low	Not Likely	**Very Low**
Impacts to recreational fishing access and habitat	Local	Permanent	High	Likely	**High**	Local	Short	Medium	Not Likely	**Low**
Impacts to commercial fishing access and habitat	Local	Permanent	High	Possible	**High**	Local	Permanent	High	Not Likely	**Medium**