8 Kanae (Mullet)

Family: Mugilidae

Species: *Aldrichetta forsteri, Mugil cephalus*

There are two members of the Mugilidae (or mullet) family in Aotearoa-NZ, the yellow-eyed mullet (*Aldrichetta forsteri*) and the grey mullet (*Mugil cephalus*) (Figure 64). Tangata whenua have named the mullet species according to their life cycle stage, and these names vary through-out the regions. For example, the juvenile and adult stage of yellow-eyed mullet are named maraua and makawhiti/aua respectively; and the juvenile and adult grey mullet are also named tīpara and kanae/kanae raukura respectively (Ngata 1993, Moorfield 2011).

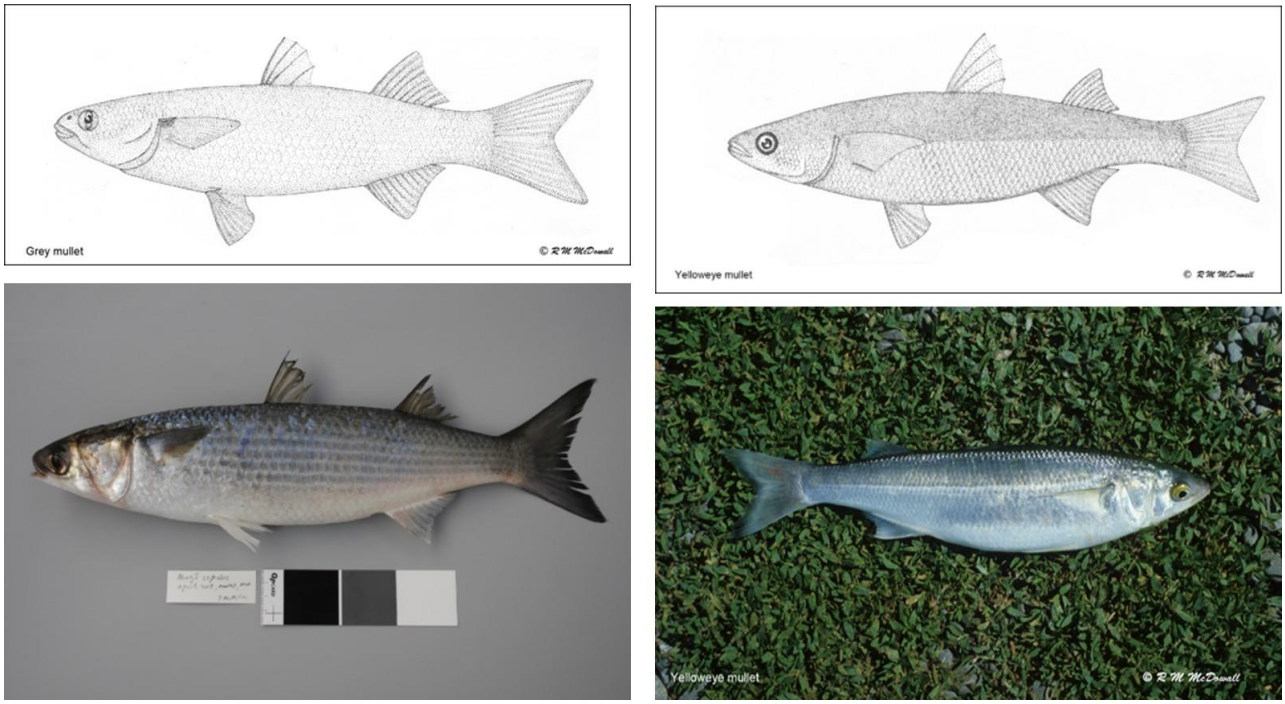

Figure 1: (Left) Grey mullet, and (Right) Yellow-eyed mullet. (Graphics and photos: Bob McDowall & NIWA).

Both mullet species are common in river estuaries and lowland lakes, with grey mullet able to penetrate upstream and become resident dozens of kilometres up rivers. Yellow-eyed mullet occur all around Aotearoa-NZ and they are also found in western and eastern Australia. They are never found far from the coast. Grey mullet have a worldwide distribution and Aotearoa-NZ is at the southern limit of their range. Although they are not usually associated with cooler waters, previous studies found them in mean monthly water temperatures as low as 7–9°C within the Waikato catchment (Wells 1984).

All mullets, including grey and yellow-eyed mullet, have two dorsal fins, and the first one is tall with four obvious spines. They also have large, easily dislodged scales. Aotearoa-NZ mullets belong in two separate genera based on the presence of an adipose eyelid. This is a thick fleshy eyelid that forms an oval, vertical slit over the pupil on the grey mullet. Grey mullet also lack the bright yellow eye found on the appropriately named yellow-eyed mullet.

8.1 Life Cycle

Some mullets are catadromous, they spawn at sea and the larvae are initially marine (Metcalfe et al. 2002), this includes the yellow-eyed and grey mullet. The yellow-eyed mullet may spend

considerable time in fresh water, for example, they are found throughout the year in Te Waihora and the Waikato River (Paulin & Paul 2006), but their spawning takes place in the sea. Yellow-eyed mullet usually move upstream into low elevation rivers and coastal/brackish lakes, seldom much beyond tidal influence (McDowall 2000). Fish are also known to move in and out of estuaries on a tidal cycle, suggesting that it is possible for emigration of immature fish to occur frequently throughout the year (Crow & Bonnett 2013).

Within Te Waihora, emigration of ripening yellow-eyed mullet adults (fish larger than 220 mm) occurs at specific times of the year (April to June); however, as movement into brackish and fresh water is not compulsory for this species, it is quite likely that recruitment of larger fish could occur during almost any month of the year (Crow & Bonnett 2013). In the sea, larvae and juveniles are found in the neuston (very surface of the ocean), up to at least 18 km from the shoreline (Tricklebank 1988, Kingsford & Choat 1989). They are most abundant in open water and around drift algae from November to March (Tricklebank 1988). High densities have also been observed in the slicks of internal waves, which has been suggested as a mechanism promoting on-shore movements (Kingsford & Choat 1986). Yellow-eyed mullet have a maximum life cycle of about seven years and growth rate varies between sites and sexes (e.g., Thompson 1957, Potter et al. 1990, Curtis & Shima 2005).

Similar to yellow-eyed mullet, grey mullet must return to the sea to spawn, but have been found at all times of the year in fresh water including Lake Waahi and the Waikato River at Huntly (Wells 1984). Both sexes of grey mullet mature at three years at an average size of 33 cm fork length for males and 35 cm fork length for females, and females spawn in northern Aotearoa-NZ between November and February (Haggit et al. 2008). Recent work on adult grey mullet has found fish of up to 19 years of age and greater than 4 kg in populations thought to be unfished (Morrison et al. unpubl. data), but in fished populations ages largely range from 3 to 8 years, with an average fish weight around 0.7–1.0 kg.

Estuaries act as nurseries for juvenile grey mullet. Habitat associations within these include intertidal seagrass meadows in the Kaipara Harbour (Morrison et al. 2014), and more widely the use of mangrove habitats (Morrison et al. 2014). This mangrove association may not be obligate (essential), as high density nurseries have also been found in estuaries without mangroves, e.g., in Kāwhia Harbour (Morrison et al. 2014). It may simply be that the biogeographic distribution of mangroves and juvenile grey mullet overlap, with both preferring warm temperate waters, and muddier upper estuary environments. Mangrove habitats appear to provide poorer foraging opportunities, suggesting there may be a trade-off between shelter from predators (e.g., mangrove forests) and food supply (non-mangrove habitats) operating (Morrison et al. 2014). Most of Aotearoa-NZ's upper North Island estuaries support juvenile grey mullet, but range widely in their importance, in terms of the number of juveniles each estuary supports. Larger and muddier estuaries tend to be more important overall (Morrison et al. 2016).

Adult grey mullet are capable of moving large distances, e.g., adult fish tagging work has shown movements between the Waikato River and the Manukau Harbour (Hore 1988). Grey mullet stocks include both estuarine/marine and freshwater populations, with large numbers of adults being found in freshwater systems. Research using grey mullet otoliths (ear-bones) to undertake elemental chemistry has found most grey mullet sampled from fresh water appear to reside there permanently (high barium and low strontium concentrations are markers for fresh water, the converse for marine), with some potential migrations back to the sea (Gorski et al. 2015, Morrison et al. unpubl. data). As most sampling methods commonly used in freshwater systems are not suited to catching adult grey mullet, it is likely that the true numbers/biomass of grey mullet in freshwater systems are greatly under-represented. For example, using a specialist electro-fishing boat, Hicks et al. (2010) sampled beside the Huntly Power Station (Waikato River) and found grey mullet to be the second

most abundant fish present in waters 0.3–2 m deep, with an average density of 0.82 per 100 m^2. The most abundant species was the invasive species, koi carp.

8.2 Distribution

Yellow-eyed mullet are present in coastal areas across Aotearoa-NZ, including Rakiura/Stewart Island, but are not commonly recorded in the NZFFD (Figure 65). They are less abundant in the south of Aotearoa-NZ (Francis et al. 2011). The low level of occurrence in the NZFFD of yellow-eyed mullet (and grey mullet) may be associated with difficulties capturing this species in the lowland/estuarine areas they occupy, where some commonly used sampling methodologies are inefficient (e.g., hand-based electric-fishing, fyke nets).

South Island NZFFD yellow-eyed mullet observations are mostly recorded around Canterbury, Otago, Nelson and along the West Coast. North Island observations are mostly around Paraparaumu, Taranaki, Hamilton and Tauranga. Grey mullet is more commonly found in the North Island than the South Island (Figure 65). The only NZFFD observations for grey mullet in the South Island are around Nelson and Blenheim, while the North Island records are primarily in the Waikato Region. Most of the records are from the Waikato River, where they are found as far inland as Karāpiro Dam (where further upstream movement is blocked) and the neighbouring Waipā River as far as Te Kūiti.

8.3 State and Trends in Abundance

Mullet are not commonly recorded in the NZFFD and therefore state and trends in abundance were unable to be assessed by Crow et al. (2016). For almost 20 years the total TACC for grey mullet has been set at 1,006 tonnes, while the total TACC for yellow-eyed mullet has been set at 68 tonnes since 2001–02.

Grey mullet populations are perceived to be declining over time (e.g., Te Onewa Consultants 2015, Morrison et al. 2016). Indeed, the commercial fishery declined historically, and it was one of the first marine fisheries to be ‘investigated’; however, the lack of information on mullet biology limited historical conclusions (Paulin & Paul 2006). More recent investigations into the fishery has indicated decline in catches, and again, there is insufficient knowledge of mullet biology on which to base an estimate of the sustainable yield and inform management (Paulin & Paul 2006). It was further recommended that stock assessments of grey mullet should attempt to take the historical information of significant grey mullet declines into account to better inform fisheries management (MacDiarmid et al. 2016).

There is no available trend information for yellow-eyed mullet populations in Aotearoa-NZ.

Figure 2: **Locations of NZFFD records where: (Left) Yellow-eyed mullet, and (Right) Grey mullet are present (black circles) and absent (grey circles).**

8.4 Threat Rankings

The latest Conservation Status Assessment classified yellow-eyed and grey mullet as being 'Not Threatened' (Goodman et al. 2014). In 2012, the IUCN ranked grey mullet as being of 'Least Concern' due to its widespread distribution throughout the tropics and sub-tropical seas to warm temperate regions (Kottelat & Freyhof 2012). Similarly, yellow-eyed mullet was considered by the IUCN assessment panel to be widespread (including Southern Australian waters) and locally abundant throughout coastal areas, and therefore of Least Concern (David et al. 2014) (Table 11).

Table 1: Threat rankings for Aotearoa-NZ kanae species according to the New Zealand Threat Classification System and IUCN. (see Section 2.3 for more information about these assessment methods).

Species	DOC Ranking	IUCN Ranking
Grey mullet *(Mugil cephalus)*	Not Threatened	Least concern (Population trend stable)[1]
Yellow-eyed mullet *(Aldrichetta forsteri)*	Not Threatened	Least concern (Population trend stable)[2]

8.5 Pressures on Populations

Pressures on the grey mullet fishery include disrupted fish passage (e.g., river and lake connections to the sea), disconnection/fragmentation of habitats, habitat degradation (including sedimentation), predation, and harvest. Environmental mismanagement and key knowledge gaps (stock size, biomass, biology) have also been identified as barriers to effective mullet fisheries management (Rowe & Graynoth 2002, Paulin & Paul 2006, IKHMG 2010, Te Onewa Consultants 2015, Morrison et al. 2016).

Grey mullet (estuaries) and yellow-eyed mullet (estuaries, sheltered coastal embayments) nursery habitats are sensitive to sediment impacts (MfE 2010). Habitat access is another major issue during migration and feeding. Fish access to rivers and lakes (via outlet streams/estuaries) is required during their migration between freshwater and marine environs to complete their life cycle. As mullet are not strong swimmers they are only found in lakes where there is a low-gradient outlet stream connecting the lake to the sea or river mainstem. Migration into shallow coastal lakes by juveniles and adults is also associated with feeding, and therefore lake/river mouth closures; in-stream dams and weirs can affect mullet populations (e.g., Rowe & Graynoth 2002).

The lack of basic biological information has been highlighted as a key issue for grey mullet fisheries management (IKHMG 2010, Te Onewa Consultants 2015, Morrison et al. 2016). Conflicts surrounding grey mullet state and trends have been exacerbated by a lack of definitive scientific knowledge of national stock dynamics, for example, it is not known to what degree fish move between the various estuaries, and broader areas, within the commercial fishery boundary. Therefore, the spatial scale within which to effectively manage this fishery remains unclear (Morrison et al. 2016).

There is a growing body of knowledge on adult grey mullet movement between marine and freshwater systems, and juvenile estuarine habitat use. Recent genetic research has found evidence of genetic diversity across grey mullet populations throughout Aotearoa-NZ, and suggests that grey mullet populations in Aotearoa-NZ are composed of several different but spatially mixed genetic groups, which in turn suggests these groups have different spawning times and natal homing behaviours (Brito, in review).

[1] http://www.iucnredlist.org/details/135567/0
[2] http://www.iucnredlist.org/details/197036/0

For yellow-eyed mullet, some spawning and/or recruitment periods have been documented, with work to date largely focussed on the South Island (e.g., McDowall 1995, Jellyman 2012, Crow & Bonnett 2013).

8.5.1 Harvest

Mullet are regarded as a valuable food fish, which are harvested by customary, recreational, and commercial user groups. Grey mullet in particular provided an important food resource for pre-European Māori in Northland, and supported one of Aotearoa-NZ's first commercial fisheries (Paulin & Paul 2006). Grey mullet has been harvested commercially since the mid-1880s (e.g., Paulin & Paul 2006) and increased fishery accessibility and improved technologies have put increasing pressure on mullet populations. In addition, grey mullet inhabits easily accessible areas (e.g., only requires small row boats or sailing dories for access), which leads to an easily caught fishery (MacDiarmid et al. 2016, Morrison et al. 2016). In many parts of the world mullet are farmed commercially, but in Aotearoa-NZ the majority of the market is supplied from fishers operating on the Kaipara and Manukau harbours (Morrison et al. 2016). A reduction in grey mullet availability in various North Island bays and estuaries has resulted in conflict between commercial and non-commercial sectors (Morrison et al. 2016).

Grey mullet is a popular recreational species, particularly in the area from east Auckland, across Bay of Plenty and Northland to West Auckland (GMU1, Figure 66). In 1987, the relative levels of commercial and amateur catch of this species in the Manukau Harbour and the lower Waikato River was estimated by a tagging study (note, only a small number of fish were tagged). The results showed that 38% of tags returned were from amateur fishers, suggesting that recreational use of the resource was relatively high. Several recreational fishing surveys have included this species (e.g., Teirney et al. 1997, Bradford 1998, Boyd et al. 2004) with an annual recreational extraction from GMU1 in the order of 100–150 tonnes; most of the commercial catch also occurs in GMU1 (Figure 67, Table 12). According to the latest fisheries assessment report, the annual commercial catches from GMU1–10 have been lower than the annual TACC set since its inception into the QMS in 1986 (MPI 2017a).

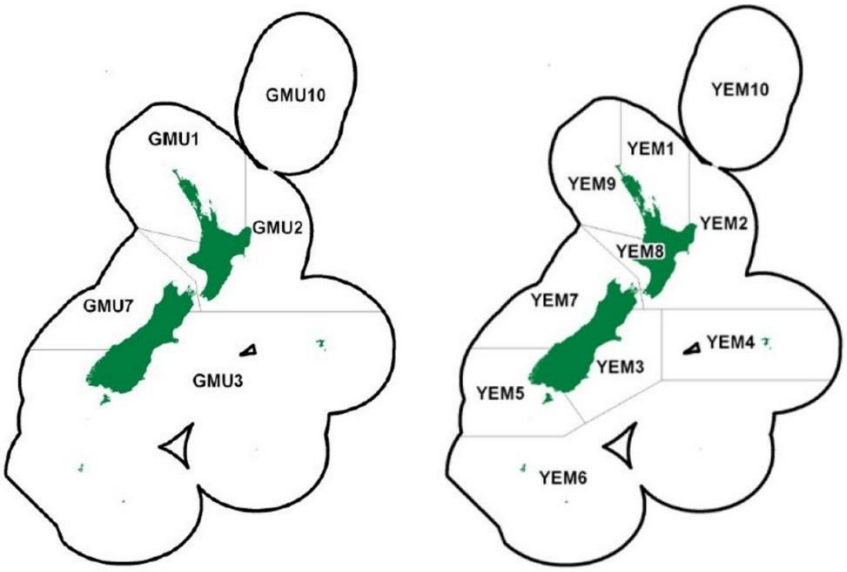

Figure 3: Commercial fish stock areas for: (Left) Grey mullet (GMU); and (Right) Yellow-eyed mullet (YEM). (Source: MPI 2017a).

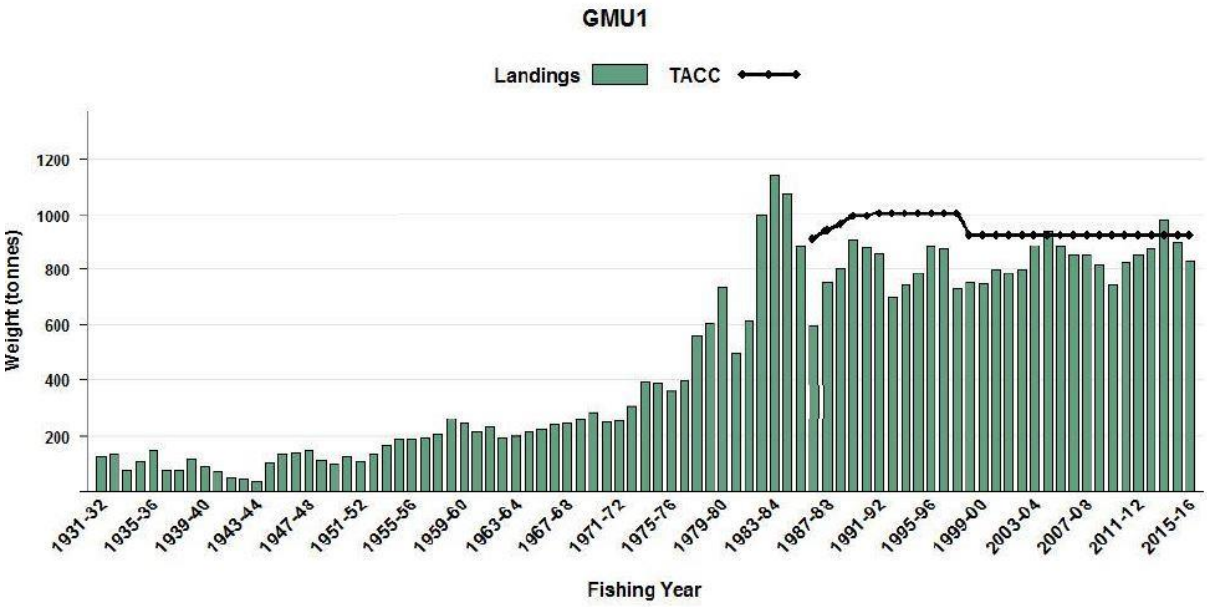

Figure 4: Reported grey mullet commercial landings and TACC for the main fish stock, GMU1 (Source: MPI 2017a).

Table 2: TACCs (t) and reported landings (t) of grey mullet for 2015–16 (Source: MPI 2017a) and TACCs set for 2016–17. (Source: Clements & Associates Ltd 2016).

Fish stock	2015–16 Actual TACC	2015–16 Reported landings	2016–17 TACC
GMU1	925	827	925
GMU2	20	< 1	20
GMU3	30	0	30
GMU7	20	0	20
GMU10	10	0	10
Total	1,006	827	1,006

Recent surveys have found a higher number of recreational fishers reportedly harvest yellow-eyed compared to grey mullet (Wynne-Jones et al. 2014). This likely coincides with the wider availability and abundance of yellow-eyed mullet compared to grey mullet (Francis et al. 2011). Yellow-eyed mullet are a popular recreational species throughout Aotearoa-NZ, particularly in YEM1 (Figure 66). Estimated numbers of fish and harvest tonnages for yellow-eyed mullet taken by recreational fishers between 1991 and 1999 are presented (MPI 2017b), but there are several sources of uncertainty in this dataset. Commercial catches of yellow-eyed mullet have generally been below the TACC in each fisheries management area since it was introduced into the QMS on 1 October 1998 (MPI 2017b) (e.g., YEM1, Figure 68, Table 13). No quantitative information is available on the current level of customary non-commercial harvest of grey or yellow-eyed mullet (MPI 2017a; 2017b).

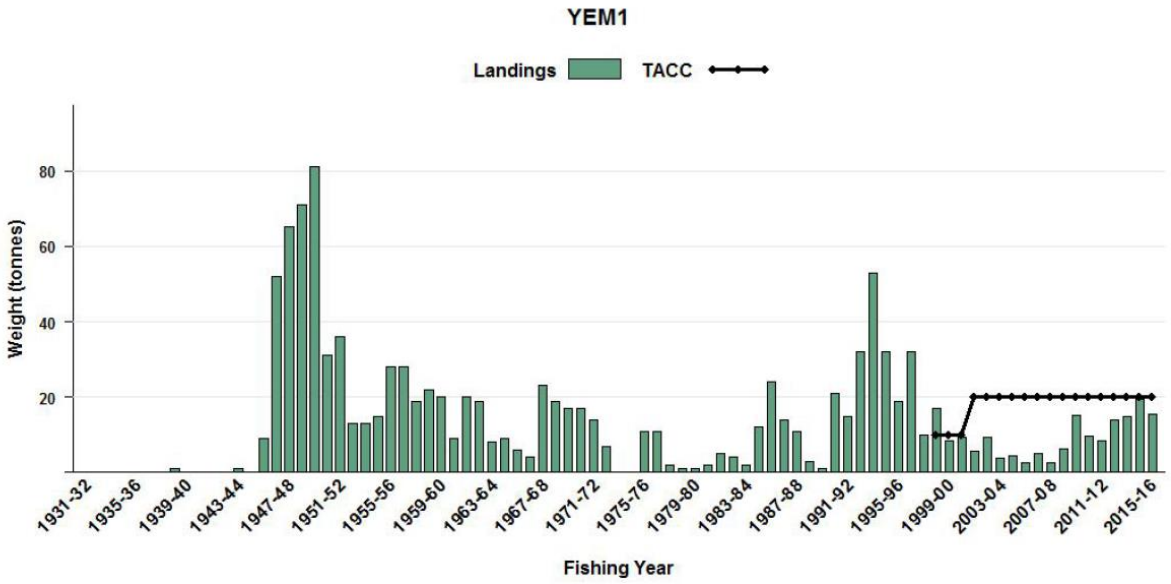

Figure 5: Reported yellow-eyed mullet commercial landings and TACC for one of the two main fish stocks; YEM1. (Source: MPI 2017b).

Table 3: TACCs (t) and reported landings (t) of yellow-eyed mullet for the most recent fishing year (Source: MPI 2017) and TACCs set for 2015–16. (Source: Clements & Associates Ltd 2016).

Fish stock	2015–16 Actual TACC	2015–16 Reported landings	2016–17 TACC
YEM1	20	16	20
YEM2	2	0.03	2
YEM3	8	6	8
YEM4	0	0	0
YEM5	0	0.02	0
YEM6	0	0	0
YEM7	5	0.2	5
YEM8	3	1.5	3
YEM9	30	9	30
YEM10	0	0	0
Total	68	32	68

8.6 Management

The grey and yellow-eyed mullet fisheries are managed by MPI. Grey and yellow-eyed mullet are managed within the GMU and YEM quota management areas, respectively (Figure 66). The grey mullet fishery is currently managed across five GMU quota management areas. GMU1–3 are also divided into sub-stocks (e.g., east coast and west coast) for the purposes of fisheries stock assessments. Since 1998–99 the total TACC for grey mullet has been set at 1,006 tonnes. Yellow-eyed mullet are currently managed across nine quota management areas, but compared to grey mullet, are less commonly targeted by the commercial fishery. Since 2001–02 the total TACC for yellow-eyed mullet has been set at 68 tonnes. MPI (2017b) states that estimates of current and reference biomass for yellow-eyed mullet are not available, and it is not known if recent catch levels are sustainable.

The recreational fishery generally operates within fishery regulations which include daily bag limits, size restrictions and equipment specific rules (drag nets) specific to each fisheries management area. In GMU1, the max daily limit for grey mullet is 30 fish per person, with a minimum set net mesh size of 90 mm and drag net mesh size of 85 mm. There is no daily bag limit for yellow-eyed mullet, but recreational fishers must have a minimum set net mesh size of 25 mm and drag net mesh size of 25 mm.

A customary allowance (per annum) of 100 tonnes for grey and yellow-eyed mullet, respectively, has been provided for by MPI (MPI 2017a; 2017b).