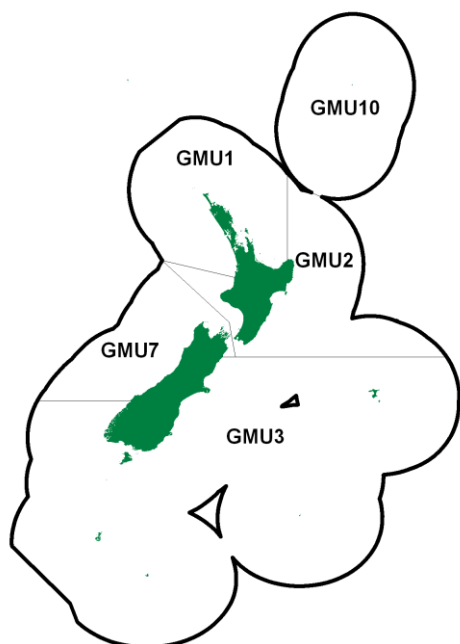


GREY MULLET (GMU)

(Mugil cephalus)
Kanae, Hopuhopu



1. FISHERY SUMMARY

1.1 Commercial fisheries

Commercial fishing for grey mullet occurs predominantly in GMU 1, where annual landings increased from approximately 128 t in 1931 to a maximum of 1142 t in 1983–84 (Table 1; 2). Marked changes in fishing effort occurred during this period through the development of more efficient fishing techniques and an increase in the market demand for this species. Before the introduction of the QMS, total domestic catches declined from the maximum (1160 t) in 1983–84 to 901 t in 1985–86. The TACC was consistently under caught after GMU 1 was introduced into the QMS (Figure 1). The Minister of Fisheries therefore reduced the TACC for GMU 1 to 925 t, beginning in 1998–99. The reduction in TACC had little effect on the annual catches, and it has only ever been reached in GMU 1 in 2004–05 (Table 2).

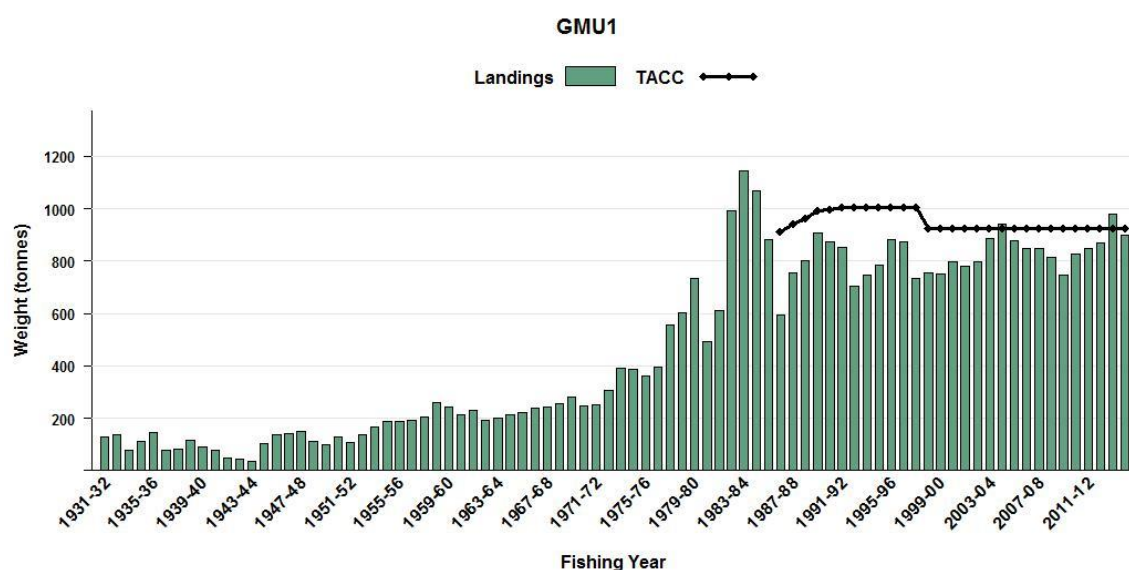


Figure 1: Reported commercial landings and TACC for the main GMU stock; GMU 1 (Auckland).

Table 1: Reported landings (t) for the main QMAs from 1931 to 1990.

| Year | GMU 1 | GMU 2 | GMU 3 | GMU 7 | Year | GMU 1 | GMU 2 | GMU 3 | GMU7 |
|---------|-------|-------|-------|-------|------|-------|-------|-------|------|
| 1931-32 | 128 | 0 | 0 | 0 | 1957 | 204 | 1 | 0 | 0 |
| 1932-33 | 138 | 0 | 0 | 0 | 1958 | 262 | 0 | 0 | 0 |
| 1933-34 | 78 | 0 | 0 | 0 | 1959 | 244 | 0 | 0 | 0 |
| 1934-35 | 111 | 0 | 0 | 0 | 1960 | 213 | 0 | 0 | 0 |
| 1935-36 | 147 | 0 | 0 | 0 | 1961 | 230 | 0 | 0 | 0 |
| 1936-37 | 80 | 0 | 0 | 0 | 1962 | 191 | 0 | 0 | 0 |
| 1937-38 | 82 | 0 | 0 | 0 | 1963 | 199 | 0 | 0 | 0 |
| 1938-39 | 117 | 1 | 0 | 1 | 1964 | 214 | 0 | 0 | 0 |
| 1939-40 | 91 | 0 | 0 | 0 | 1965 | 222 | 2 | 3 | 0 |
| 1940-41 | 77 | 0 | 0 | 0 | 1966 | 240 | 0 | 0 | 0 |
| 1941-42 | 48 | 2 | 0 | 0 | 1967 | 243 | 0 | 0 | 0 |
| 1942-43 | 44 | 2 | 0 | 0 | 1968 | 256 | 0 | 0 | 0 |
| 1943-44 | 35 | 0 | 0 | 0 | 1969 | 283 | 1 | 1 | 0 |
| 1944 | 104 | 0 | 0 | 0 | 1970 | 248 | 1 | 0 | 0 |
| 1945 | 138 | 0 | 0 | 0 | 1971 | 253 | 1 | 0 | 0 |
| 1946 | 141 | 0 | 0 | 0 | 1972 | 305 | 0 | 1 | 0 |
| 1947 | 151 | 0 | 0 | 0 | 1973 | 393 | 1 | 4 | 2 |
| 1948 | 114 | 0 | 0 | 0 | 1974 | 386 | 0 | 0 | 0 |
| 1949 | 100 | 0 | 0 | 0 | 1975 | 360 | 0 | 0 | 0 |
| 1950 | 129 | 0 | 0 | 0 | 1976 | 394 | 0 | 0 | 0 |
| 1951 | 108 | 0 | 0 | 0 | 1977 | 557 | 0 | 0 | 0 |
| 1952 | 136 | 0 | 0 | 0 | 1978 | 604 | 0 | 0 | 0 |
| 1953 | 166 | 0 | 0 | 0 | 1979 | 735 | 0 | 0 | 0 |
| 1954 | 190 | 0 | 0 | 0 | 1980 | 494 | 0 | 0 | 0 |
| 1955 | 188 | 0 | 0 | 0 | 1981 | 612 | 0 | 0 | 0 |
| 1956 | 193 | 0 | 0 | 0 | 1982 | 990 | 0 | 8 | 2 |

Notes:

1. The 1931–1943 years are April–March but from 1944 onwards are calendar years.
2. Data up to 1985 are from fishing returns; Data from 1986 to 1990 are from Quota Management Reports.
3. Data for the period 1931 to 1982 are based on reported landings by harbour and are likely to be underestimated as a result of under-reporting and discarding practices. Data includes both foreign and domestic landings.

Table 2: Reported landings (t) of grey mullet by Fishstock from 1983–84 to 2013–14 and actual TACCs (t) for 1986–87 to 2013–14. QMS data from 1986-present. There have been no report landings for GMU 10.

| Fishstock QMA (s) | GMU 1 | | GMU 2 | | GMU 3 | | GMU 7 | | GMU 10 | Total | |
|----------------------|----------|-------|----------|------|----------|------|----------|------|--------|----------|-------|
| | Landings | TACC | Landings | TACC | Landings | TACC | Landings | TACC | TACC | Landings | TACC |
| 1983–84* | 1 142 | - | 6 | - | 5 | - | 7 | - | - | 1 160 | - |
| 1984–85* | 1 069 | - | 5 | - | 0 | - | 15 | - | - | 1 089 | - |
| 1985–86* | 881 | - | 10 | - | 0 | - | 10 | - | - | 901 | - |
| 1986–87 | 595 | 910 | 3 | 20 | < 1 | 30 | 0 | 20 | 10 | 598 | 990 |
| 1987–88 | 751 | 941 | 3 | 20 | 0 | 30 | 0 | 20 | 10 | 754 | 1 021 |
| 1988–89 | 792 | 963 | 3 | 20 | 0 | 30 | 0 | 20 | 10 | 795 | 1 043 |
| 1989–90 | 907 | 990 | 2 | 20 | 0 | 30 | 4 | 20 | 10 | 913 | 1 070 |
| 1990–91 | 875 | 994 | 2 | 20 | 1 | 30 | < 1 | 20 | 10 | 879 | 1 073 |
| 1991–92 | 848 | 1 006 | 1 | 20 | 2 | 30 | 1 | 20 | 10 | 852 | 1 086 |
| 1992–93 | 711 | 1 006 | < 1 | 20 | < 1 | 30 | 0 | 20 | 10 | 712 | 1 086 |
| 1993–94 | 743 | 1 006 | < 1 | 20 | < 1 | 30 | 0 | 20 | 10 | 706 | 1 086 |
| 1994–95 | 776 | 1 006 | 0 | 20 | < 1 | 30 | 10 | 20 | 10 | 787 | 1 086 |
| 1995–96 | 866 | 1 006 | 0 | 20 | < 1 | 30 | < 1 | 20 | 10 | 866 | 1 086 |
| 1996–97 | 870 | 1 006 | < 1 | 20 | 1 | 30 | < 1 | 20 | 10 | 872 | 1 086 |
| 1997–98 | 730 | 1 006 | < 1 | 20 | < 1 | 30 | < 1 | 20 | 10 | 730 | 1 086 |
| 1998–99 | 750 | 925 | < 1 | 20 | < 1 | 30 | < 1 | 20 | 10 | 750 | 1 005 |
| 1999–00 | 749 | 925 | < 1 | 20 | 0 | 30 | < 1 | 20 | 10 | 750 | 1 005 |
| 2000–01 | 797 | 925 | 1 | 20 | 0 | 30 | < 1 | 20 | 10 | 798 | 1 005 |
| 2001–02 | 782 | 925 | 2 | 20 | < 1 | 30 | < 1 | 20 | 10 | 784 | 1 005 |
| 2002–03 | 797 | 925 | 1 | 20 | < 1 | 30 | 0 | 20 | 10 | 798 | 1 005 |
| 2003–04 | 886 | 925 | < 1 | 20 | 0 | 30 | < 1 | 20 | 10 | 796 | 1 005 |
| 2004–05 | 941 | 925 | < 1 | 20 | 0 | 30 | 0 | 20 | 10 | 941 | 1 005 |
| 2005–06 | 878 | 925 | < 1 | 20 | < 1 | 30 | 0 | 20 | 10 | 878 | 1 005 |
| 2006–07 | 847 | 925 | 1 | 20 | 0 | 30 | < 1 | 20 | 10 | 845 | 1 005 |
| 2007–08 | 848 | 925 | 1 | 20 | < 1 | 30 | < 1 | 20 | 10 | 849 | 1 005 |
| 2008–09 | 814 | 925 | 1 | 20 | 0 | 30 | 0 | 20 | 10 | 815 | 1 005 |
| 2009–10 | 746 | 925 | < 1 | 20 | 0 | 30 | 0 | 20 | 10 | 746 | 1 005 |
| 2010–11 | 825 | 925 | < 1 | 20 | < 1 | 30 | < 1 | 20 | 10 | 826 | 1 006 |
| 2011–12 | 848 | 925 | < 1 | 20 | < 1 | 30 | < 1 | 20 | 10 | 848 | 1 006 |
| 2012–13 | 871 | 925 | < 1 | 20 | < 1 | 30 | < 1 | 20 | 10 | 871 | 1 006 |
| 2013–14 | 981 | 925 | < 1 | 20 | 0 | 30 | 0 | 20 | 10 | 981 | 1 006 |
| 2014–15 | 900 | 925 | < 1 | 20 | 0 | 30 | < 1 | 20 | 10 | 901 | 1 006 |

*FSU data.

1.2 Recreational fisheries

Grey mullet are a popular recreational species particularly in the Auckland FMA. Information is available on the relative levels of commercial and amateur catch of this species in the Manukau Harbour and the lower Waikato River based on limited tagging work undertaken in 1987. Of the number of tags returned 38% were from amateur fishers, suggesting that recreational use of the resource was relatively high.

The 1993–94 North Region Recreational Fishing Survey (Teirney et al 1997) estimated the annual recreational catch from GMU 1 at 150 t (Table 3). This represents 17% of the total landings from GMU 1 in 1993–94. The 1996 National Recreational Fishing Survey (Bradford 1998) estimated the annual recreational catch from GMU 1 in the 1996 fishing year at 106 t (Table 3). The 2000 National Recreational Fishing Survey (Boyd et al 2004) fishing survey provided an estimate of 102 t (Table 3). Results from the three recreational surveys are relatively consistent; it is likely the annual level of recreational extraction from GMU 1 is in the order of 100–150 t. The Minister of Fisheries provided an allowance for customary harvest of 100 t beginning in 1998–99.

Table 3: Estimated number of grey mullet harvested by recreational fishers by Fishstock and survey year, the corresponding estimated survey harvest, and the estimated Fishstock harvest.

| Fishstock | Survey year | Total | | Estimated harvest range (t) | Point estimate (t) |
|-----------|-------------|---------|-----|-----------------------------|--------------------|
| | | Number | CV | | |
| GMU 1 | 1993–94 | 170 000 | 19% | 90–210 | 150 |
| GMU 1 | 1996 | 110 000 | 25% | 80–130 | 106 |
| GMU 1 | 2000 | 110 000 | 33% | 68–136 | 102 |

It was recommended that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and, c) the 2000 and 2001 estimates are implausibly high for many important fisheries. Relative comparisons may be possible between stocks within these surveys.

1.3 Customary non-commercial fisheries

No quantitative information is available on the current level of customary non-commercial take. The Minister of Fisheries provided an allowance for customary harvest of 100 t per annum beginning in 1998–99.

1.4 Illegal catch

Estimates of illegal catch are unknown but anecdotal evidence suggests 10–20% under-reporting is plausible. In the latest stock assessment, an annual under-reporting of 20% was assumed for the period before 1986 and 10% thereafter.

1.5 Other sources of mortality

No quantitative estimates are available regarding the impact of other sources of mortality on grey mullet stocks. Grey mullet principally occur in sheltered harbours and estuarine ecosystems. Some of these habitats are known to have suffered environmental degradation.

2. BIOLOGY

Grey mullet has a worldwide distribution, occurring commonly along coasts, in estuaries, and in lower river systems between latitudes of 42° N and 42° S. Overseas and New Zealand tagging studies indicate that movement patterns of adult grey mullet are complex. Some schools remain in one locality, while others appear to be on the move almost continuously. Recorded movements of tagged grey mullet of 160 km within a few weeks of release are not uncommon.

Females grow faster than males and attain a larger size. Both sexes mature at 3 years of age at an average size of 33 cm fork length (FL) for males and 35 cm FL for females. Maximum ages appear to be 12 to 14 years, with ages 4–8 making up the bulk of the commercial fishery.

Natural mortality was estimated from the equation $M = \log_e 100/\text{maximum age}$, where maximum age is the age to which 1% of the population survives in an unexploited stock. Using 15 years for the maximum age results in an estimate of $M = 0.33$. (Note: the maximum age of 15 years was obtained from an exploited population, so M is likely to be less than 0.33).

Grey mullet commonly occur in schools, which generally become larger and more prevalent in the spawning season. Spawning in northern New Zealand occurs during November to February. Females are highly fecund and may release up to 1 million eggs in a spawning event. It is likely that grey mullet spawn at sea, because running-ripe females have only been caught off coastal beaches or in offshore waters, and eggs and larvae are a component of the offshore coastal plankton at certain times of the year. Small post-larval grey mullet occur seasonally in estuaries, which serve as nursery grounds for juveniles.

Adult grey mullet typically feed on diatom algae and small invertebrates which are gulped along with surface scum or with detrital ooze and sifted by fine teeth and gill-rakers.

Biological parameters relevant to stock assessment are shown in Table 4.

Table 4: Estimates of biological parameters of grey mullet.

| Fishstock | Estimate | | | | | | Source |
|---|------------|-------|--------|------------|-------|--------|--------------------------------|
| 1. Natural mortality (M) | 0.33 | | | | | | NIWA (unpubl. data) |
| GMU 1 | | | | | | | |
| 2. Weight = $a(\text{length})^b$ (Weight in g, length in cm fork length). | Both Sexes | | | | | | |
| | a | | | b | | | |
| GMU 1 | 0.04236 | | | 2.826 | | | Breen & McKenzie (unpublished) |
| 3. Von Bertalanffy growth parameters | | | | | | | |
| | Females | | | Males | | | |
| | L_∞ | k | t_0 | L_∞ | k | t_0 | |
| GMU 1 | 40.1 | 0.587 | 1.3469 | 37.0 | 0.619 | 1.3257 | Breen & McKenzie (unpublished) |

3. STOCKS AND AREAS

There is little biological data to determine the level of sub stock separation within GMU 1. Results from a small scale tagging program in the Manukau Harbour and the Lower Waikato River indicated that there is fish movement between these two localities and also north along the west coast but the net level of movement cannot be ascertained. There is evidence in the CPUE data that GMU 1 may be comprised of six populations with low to moderate mixing between them (McKenzie 1997).

GMU 1 has been divided into two sub-stocks (east coast and west coast) for the purposes of fisheries stock assessment. The boundary between the two sub-stocks is assumed to be due north from North Cape.

4. STOCK ASSESSMENT

4.1 Estimates of fishery parameters and abundance

Standardised CPUE analyses were undertaken for the six largest catching areas in GMU 1. The analysis was based on setnet catch and effort data for the years 1990–91 to 2005–06 (McKenzie & Vaughan 2008), and updated to 2010–11 (Kendrick & Bentley 2012). However, internal and anecdotal evidence suggest that method is being misreported in these fisheries and that standardized CPUE is unlikely to reflect relative abundance for GMU. CPUE was therefore rejected as an index of relative abundance for all sub-areas within GMU 1.

GREY MULLET (GMU)

4.2 Biomass estimates

West coast GMU 1

A stock assessment was undertaken for the west GMU 1 substock using a stochastic dynamic age-structured observation-error time series model (Breen & McKenzie 1998), but this did not prove to be robust and the results were rejected by the Working Group.

4.3 Yield estimates and projections

There is insufficient information with which to revise the yield estimates of either the West or East coast GMU 1 substocks. The *MCY* estimate derived in 1986 using the equation $MCY = cY_{AV}$ (Method 4) remains the accepted yield estimate for GMU 1.

Annual landings of grey mullet in the Auckland QMA for the period 1974–84 showed an increasing trend to a maximum in 1984. There were some fluctuations throughout this period. A general increase in fishing effort occurred during this time. Fishing effort between 1983–84 and 1985–86 appeared relatively constant, and catches during these years were averaged to estimate Y_{AV} . The constant ‘*c*’ was set at 0.8. This is not consistent with the maximum observed age of 14 years, which equates with an estimate of $M = 0.33$ and $c = 0.7$. However, it is believed that they live to older ages in unexploited populations. Therefore, the accuracy of *MCY* derived for grey mullet is uncertain. The estimate of *MCY* for GMU 1 is shown in Table 5. *MCY* cannot be estimated for the other fish stocks.

Table 5: Estimate of *MCY* (t) rounded to the nearest 5 t.

| Fishstock | QMA | Y_{AV} | <i>MCY</i> |
|-----------|----------------|----------|------------|
| GMU 1 | Auckland 1 & 9 | 1 030 | 825 |

The level of risk to the stock by harvesting the population at the estimated *MCY* level cannot be determined.

No estimates of current biomass, fishing mortality, or other information are available which would permit the estimation of *CAY*.

4.5 Other Factors

The minimum legal mesh size for use in the grey mullet fishery is 89 mm. However, fishers typically use mesh larger than 89 mm when fishing for grey mullet (Ministry for Primary Industries data). There are no data available to compare the selectivity characteristics of different mesh sizes. It is possible that a significant fraction of the grey mullet stock comprising larger older fish is poorly selected by the fishery. If this is true then the von Bertalanffy parameter estimates, which are based on random samples from the 1997–98 setnet landings, are likely to be biased: L_{∞} will be biased low, K biased high.

Grey mullet have been exploited by customary, commercial, and recreational fishers for over a hundred years. They are found predominantly in harbours and these environments have undergone considerable change over this period due to a range of anthropogenic sources. The impact of these changes on potential carrying capacity and productivity are not understood and this potentially has impacts on the yields of GMU.

Characterisation shows an overall trend away from set netting towards ring netting, and, within the nominal setnet method, a trend towards shorter nets; a trend that is not seen in flatfish setnet fisheries in the same areas. This suggests there have been systematic changes in fishing strategy that are not captured by the CELR form. Anecdotal information from interviews of net fishers suggests that fishers use the various net method codes interchangeably, and that the methods describe differences in strategy rather than in gear, from passive fishing to spotting and encircling schools of fish. While the passive form of set netting is an appropriate sampling tool, any contamination by ring net or similarly ‘directed’ fishing could mask trends in the abundance of the underlying population.

The Working Group agreed that given the misreporting issues and its consequences, that standardized CPUE is unlikely to reflect relative abundance for GMU.

5. STATUS OF THE STOCKS

Given the misreporting of method and its consequences, standardized CPUE is unlikely to reflect relative abundance for GMU. CPUE was therefore rejected as an index of relative abundance for all sub-areas within GMU 1.

Yields, TACCs and reported landings are summarised in Table 6.

Table 6: Summary of yields (t), TACCs (t), and reported landings (t) of grey mullet for the most recent fishing year.

| Fishstock | QMA | MCY | 2014-15 Actual TACC | 2014-15 Reported landings |
|-----------|---|-----|------------------------|------------------------------|
| GMU 1 | Auckland (East) (West) 1 & 9 | 825 | 925 | 900 |
| GMU 2 | Central (East) (West) 2 & 8 | - | 20 | < 1 |
| GMU 3 | South-East (Coast) (Chatham) 3, 4, Southland and Sub-Antarctic 5 & 6 | - | 30 | 0 |
| GMU 7 | Challenger 7 | - | 20 | <1 |
| GMU 10 | Kermadec 10 | - | 10 | 0 |
| Total | | - | 1 006 | 981 |

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