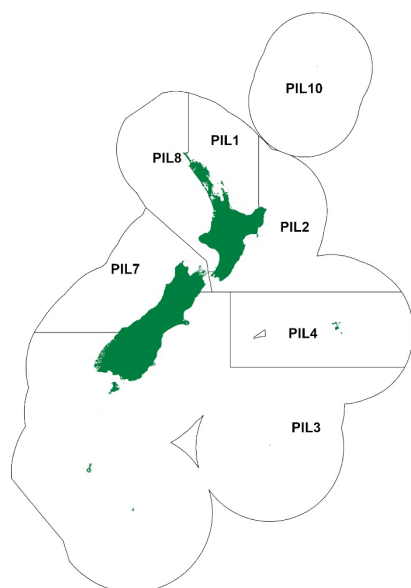


PILCHARD (PIL)

(*Sardinops sagax*)
Mohimohi



1. FISHERY SUMMARY

Pilchards were introduced into the QMS in October 2002 with allowances, TACCs and TACs as shown in Table 1.

Table 1: Recreational and Customary non-commercial allowances, TACCs and TACs by Fishstock.

| Fishstock | Recreational Allowance | Customary Non-commercial Allowance | TACC | TAC |
|-----------|------------------------|------------------------------------|-------|-------|
| PIL 1 | 20 | 10 | 2 000 | 2 030 |
| PIL 2 | 10 | 5 | 200 | 215 |
| PIL 3 | 5 | 2 | 60 | 67 |
| PIL 4 | 3 | 2 | 10 | 15 |
| PIL 7 | 10 | 5 | 150 | 165 |
| PIL 8 | 10 | 5 | 65 | 80 |
| PIL 10 | 0 | 0 | 0 | 0 |

1.1 Commercial fisheries

Pilchards occur around most of New Zealand, however, commercial fisheries have only developed in north-eastern waters (east Northland to Bay of Plenty), and in Tasman Bay and Marlborough Sounds at the north of the South Island. Historical estimated and recent reported pilchard landings and TACCs are shown in Tables 2, 3, and 4, while Figure 1 shows the historical and recent landings and TACC values for the main pilchard stocks.

The first recorded commercial landings of pilchards were in 1931 (Table 2), but a minor fishery existed before this. Informal sales, mainly as bait, or as food for zoos and public aquariums, were unreported. A fishery for pilchards developed in the Marlborough Sounds in 1939 and operated through the war years providing canned fish for the armed forces. Landings reached over 400 t in 1942, but the fishery was unsuccessful for a variety of reasons and ceased in 1950. Between 1950 and 1990 landings were generally less than 20 t, intermittently reaching 70–80 t.

From 1990–91 the northeastern fishery was developed by vessels using both lampara nets and purse seines (Table 4). Lampara netting was the main method in the first couple of years, and continued at a low level through the 1990s. From 1993–94 onwards, purse seining became the dominant method. A diminishing catch (less than 10 t annually) was caught by beach seine. Almost all the pilchard catch

(particularly in the northeastern fishery) is targeted. A small catch (less than 10 t annually), has been recorded as a bycatch of jack mackerel targeting.

Table 2: Reported landings (t) for the main QMAs from 1931 to 1990.

| Year | PIL 1 | PIL 2 | PIL 3 | PIL 4 | Year | PIL 1 | PIL 2 | PIL 3 | PIL 4 |
|---------|-------|-------|-------|-------|------|-------|-------|-------|-------|
| 1931–32 | 5 | 0 | 0 | 0 | 1957 | 2 | 0 | 0 | 0 |
| 1932–33 | 4 | 0 | 0 | 0 | 1958 | 8 | 0 | 0 | 0 |
| 1933–34 | 2 | 0 | 0 | 0 | 1959 | 3 | 2 | 0 | 0 |
| 1934–35 | 0 | 0 | 0 | 0 | 1960 | 3 | 3 | 0 | 0 |
| 1935–36 | 0 | 0 | 0 | 0 | 1961 | 0 | 8 | 0 | 0 |
| 1936–37 | 0 | 0 | 0 | 0 | 1962 | 0 | 1 | 0 | 0 |
| 1937–38 | 0 | 0 | 0 | 0 | 1963 | 0 | 0 | 0 | 0 |
| 1938–39 | 0 | 0 | 0 | 0 | 1964 | 0 | 0 | 0 | 0 |
| 1939–40 | 0 | 5 | 0 | 0 | 1965 | 2 | 0 | 0 | 0 |
| 1940–41 | 3 | 41 | 0 | 0 | 1966 | 3 | 0 | 0 | 0 |
| 1941–42 | 15 | 73 | 0 | 0 | 1967 | 8 | 0 | 0 | 0 |
| 1942–43 | 0 | 69 | 0 | 0 | 1968 | 8 | 2 | 0 | 0 |
| 1943–44 | 0 | 9 | 0 | 0 | 1969 | 3 | 4 | 0 | 0 |
| 1944 | 0 | 0 | 0 | 0 | 1970 | 1 | 0 | 1 | 0 |
| 1945 | 0 | 0 | 0 | 0 | 1971 | 1 | 0 | 0 | 0 |
| 1946 | 0 | 0 | 0 | 0 | 1972 | 0 | 0 | 8 | 0 |
| 1947 | 0 | 0 | 0 | 0 | 1973 | 0 | 67 | 0 | 0 |
| 1948 | 0 | 0 | 0 | 0 | 1974 | 18 | 1 | 0 | 0 |
| 1949 | 0 | 0 | 0 | 0 | 1975 | 2 | 0 | 0 | 0 |
| 1950 | 0 | 0 | 0 | 0 | 1976 | 6 | 0 | 0 | 0 |
| 1951 | 0 | 0 | 0 | 0 | 1977 | 20 | 0 | 0 | 0 |
| 1952 | 0 | 0 | 0 | 0 | 1978 | 5 | 0 | 0 | 0 |
| 1953 | 0 | 0 | 0 | 0 | 1979 | 1 | 0 | 2 | 0 |
| 1954 | 0 | 0 | 0 | 0 | 1980 | 1 | 16 | 0 | 0 |
| 1955 | 0 | 0 | 0 | 0 | 1981 | 0 | 8 | 0 | 0 |
| 1956 | 4 | 0 | 0 | 0 | 1982 | 0 | 16 | 0 | 0 |

| Year | PIL 7 | PIL 8 | Year | PIL 7 | PIL 8 |
|---------|-------|-------|------|-------|-------|
| 1931–32 | 0 | 0 | 1957 | 0 | 0 |
| 1932–33 | 0 | 0 | 1958 | 0 | 0 |
| 1933–34 | 0 | 0 | 1959 | 2 | 0 |
| 1934–35 | 0 | 0 | 1960 | 3 | 0 |
| 1935–36 | 0 | 0 | 1961 | 8 | 0 |
| 1936–37 | 0 | 0 | 1962 | 1 | 0 |
| 1937–38 | 0 | 0 | 1963 | 0 | 0 |
| 1938–39 | 0 | 0 | 1964 | 0 | 0 |
| 1939–40 | 5 | 0 | 1965 | 1 | 0 |
| 1940–41 | 49 | 0 | 1966 | 0 | 0 |
| 1941–42 | 79 | 0 | 1967 | 0 | 1 |
| 1942–43 | 69 | 0 | 1968 | 0 | 0 |
| 1943–44 | 9 | 0 | 1969 | 7 | 0 |
| 1944 | 217 | 0 | 1970 | 81 | 0 |
| 1945 | 74 | 0 | 1971 | 0 | 0 |
| 1946 | 61 | 0 | 1972 | 0 | 0 |
| 1947 | 5 | 0 | 1973 | 3 | 0 |
| 1948 | 46 | 0 | 1974 | 0 | 0 |
| 1949 | 11 | 0 | 1975 | 0 | 0 |
| 1950 | 0 | 0 | 1976 | 0 | 0 |
| 1951 | 0 | 0 | 1977 | 0 | 0 |
| 1952 | 9 | 0 | 1978 | 0 | 0 |
| 1953 | 0 | 0 | 1979 | 0 | 0 |
| 1954 | 0 | 0 | 1980 | 24 | 0 |
| 1955 | 0 | 0 | 1981 | 8 | 0 |
| 1956 | 0 | 0 | 1982 | 16 | 0 |

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.

Total annual landings increased steadily from 1990 as the fishery developed in northeastern waters, reaching over 1200 t in 1999–00, and almost 1500 t in 2000–01. Total commercial landings declined consistently after 2003–04, largely influenced by catches from PIL 1, and since 2010–11 have been between 221 and 624t. Landings in PIL 1 have been below the TACC since this stock was introduced to the QMS in 2002, declining to 129 t in 2019–20. Landings in PIL 7 have generally been low, but reached 93 t in 2001–02, and 233 t in 2017–18, exceeding the 150 t TACC. Landings in PIL 8 have fluctuated between 12 t and 162 t since this stock was introduced to the QMS. The sudden increase in

catches in PIL 8 from 2000–2001 to 2005–06 was thought to be in part the result of previously unreported catches now being reported due to the species being introduced to the QMS. After 2006 landings in PIL 8 exceeded the TACC in 2007–08, 2013–14, 2017–18 and 2019–20.

Table 3: Reported total New Zealand landings (t) of pilchard from 1931 to 1990.

| Year | Landings | Year | Landings | Year | Landings | Year | Landings | Year | Landings | Year | Landings |
|------|----------|------|----------|------|----------|------|----------|------|----------|------|----------|
| 1931 | 5 | 1941 | 168 | 1951 | 0 | 1961 | 17 | 1971 | 1 | 1981 | 17 |
| 1932 | 4 | 1942 | 418 | 1952 | 9 | 1962 | 2 | 1972 | 8 | 1982 | 32 |
| 1933 | 2 | 1943 | 219 | 1953 | 0 | 1963 | 0 | 1973 | 70 | 1983 | - |
| 1934 | 0 | 1944 | 218 | 1954 | 0 | 1964 | 1 | 1974 | 19 | 1984 | - |
| 1935 | 0 | 1945 | 74 | 1955 | 0 | 1965 | 3 | 1975 | 2 | 1975 | 49 |
| 1936 | 0 | 1946 | 61 | 1956 | 4 | 1966 | 3 | 1976 | 6 | 1986 | 29 |
| 1937 | 0 | 1947 | 5 | 1957 | 2 | 1967 | 9 | 1977 | 20 | 1987 | 70 |
| 1938 | 0 | 1948 | 46 | 1958 | 8 | 1968 | 10 | 1978 | 6 | 1988 | 6 |
| 1939 | 10 | 1949 | 11 | 1959 | 7 | 1969 | 15 | 1979 | 4 | 1989 | 1 |
| 1940 | 93 | 1950 | 0 | 1960 | 8 | 1970 | 83 | 1980 | 41 | 1990 | 2 |

Source: Annual reports on fisheries and subsequent MAF data.

A 2000 t annual Commercial Catch Limit (CCL) was introduced for FMA 1 from 01 October 2000. The CCL was subject to a logbook programme, a catch spreading arrangement and the avoidance of areas of particular importance to non-commercial fishers. The CCL was superseded when the PIL 1 stock was introduced to the QMS with a TACC of 2000 t on 1st October 2002.

Table 4: Reported landings (t) of pilchard by Fishstock from 1990–91 to present.

| QMA | PIL 1 | | PIL 2 | | PIL 3 | | PIL 7 | | PIL 8 | | Total Landing |
|---------|----------|-------|---------|------|----------|------|----------|------|----------|------|---------------|
| | Landings | TACC | Landing | TACC | Landings | TACC | Landings | TACC | Landings | TACC | |
| 1990–91 | 15 | - | 0 | - | 0 | - | 9 | - | < 1 | - | 25 |
| 1991–92 | 59 | - | 0 | - | 0 | - | < 1 | - | 0 | - | 59 |
| 1992–93 | 163 | - | 2 | - | 0 | - | 0 | - | 0 | - | 164 |
| 1993–94 | 258 | - | 0 | - | 0 | - | 0 | - | 1 | - | 259 |
| 1994–95 | 317 | - | 0 | - | 0 | - | < 1 | - | < 1 | - | 317 |
| 1995–96 | 168 | - | < 1 | - | 0 | - | 2 | - | 0 | - | 170 |
| 1996–97 | 419 | - | 0 | - | 0 | - | 2 | - | < 1 | - | 421 |
| 1997–98 | 440 | - | 0 | - | 0 | - | 1 | - | 0 | - | 447 |
| 1998–99 | 785 | - | 0 | - | < 1 | - | 2 | - | 1 | - | 788 |
| 1999–00 | 1 227 | - | 0 | - | 0 | - | 4 | - | < 1 | - | 1 231 |
| 2000–01 | 1 290 | - | 0 | - | 0 | - | 12 | - | 188 | - | 1 491 |
| 2001–02 | 574 | - | 0 | - | 0 | - | 93 | - | 129 | - | 796 |
| 2002–03 | 792 | 2 000 | 0 | 200 | 0 | 60 | 8 | 150 | 153 | 65 | 953 |
| 2003–04 | 1 284 | 2 000 | 0 | 200 | < 1 | 60 | 1 | 150 | 34 | 65 | 1 320 |
| 2004–05 | 853 | 2 000 | 0 | 200 | < 1 | 60 | < 1 | 150 | 106 | 65 | 959 |
| 2005–06 | 892 | 2 000 | < 1 | 200 | < 1 | 60 | 2 | 150 | 116 | 65 | 1 010 |
| 2006–07 | 808 | 2 000 | 0 | 200 | 0 | 60 | 11 | 150 | 45 | 65 | 864 |
| 2007–08 | 635 | 2 000 | 0 | 200 | 0 | 60 | 10 | 150 | 71 | 65 | 716 |
| 2008–09 | 644 | 2 000 | < 1 | 200 | 0 | 60 | 3 | 150 | 23 | 65 | 670 |
| 2009–10 | 599 | 2 000 | 0 | 200 | 4 | 60 | 10 | 150 | 54 | 65 | 667 |
| 2010–11 | 319 | 2 000 | < 1 | 200 | < 1 | 60 | 2 | 150 | 12 | 65 | 333 |
| 2011–12 | 178 | 2 000 | 0 | 200 | < 1 | 60 | < 1 | 150 | 42 | 65 | 221 |
| 2012–13 | 332 | 2 000 | < 1 | 200 | 0 | 60 | 2 | 150 | 58 | 65 | 391 |
| 2013–14 | 255 | 2 000 | < 1 | 200 | < 1 | 60 | 13 | 150 | 97 | 65 | 365 |
| 2014–15 | 210 | 2 000 | < 1 | 200 | < 1 | 60 | 6 | 150 | 19 | 65 | 235 |
| 2015–16 | 261 | 2 000 | 0 | 200 | 0 | 60 | 19 | 150 | 44 | 65 | 324 |
| 2016–17 | 226 | 2 000 | 0 | 200 | 0 | 60 | 21 | 150 | 37 | 65 | 284 |
| 2017–18 | 229 | 2 000 | < 1 | 200 | 0 | 60 | 233 | 150 | 162 | 65 | 624 |
| 2018–19 | 203 | 2 000 | < 1 | 200 | 0 | 60 | 78 | 150 | 63 | 65 | 343 |
| 2019–20 | 129 | 2 000 | < 1 | 200 | < 1 | 60 | 18 | 150 | 115 | 65 | 262 |
| 2020–21 | 257 | 2 000 | < 1 | 200 | < 1 | 60 | 82 | 150 | 92 | 65 | 431 |
| 2021–22 | 70 | 2 000 | < 1 | 200 | < 1 | 60 | 31 | 150 | 92 | 65 | 194 |
| 2022–23 | 146 | 2 000 | < 1 | 200 | < 1 | 60 | 72 | 150 | 62 | 65 | 279 |

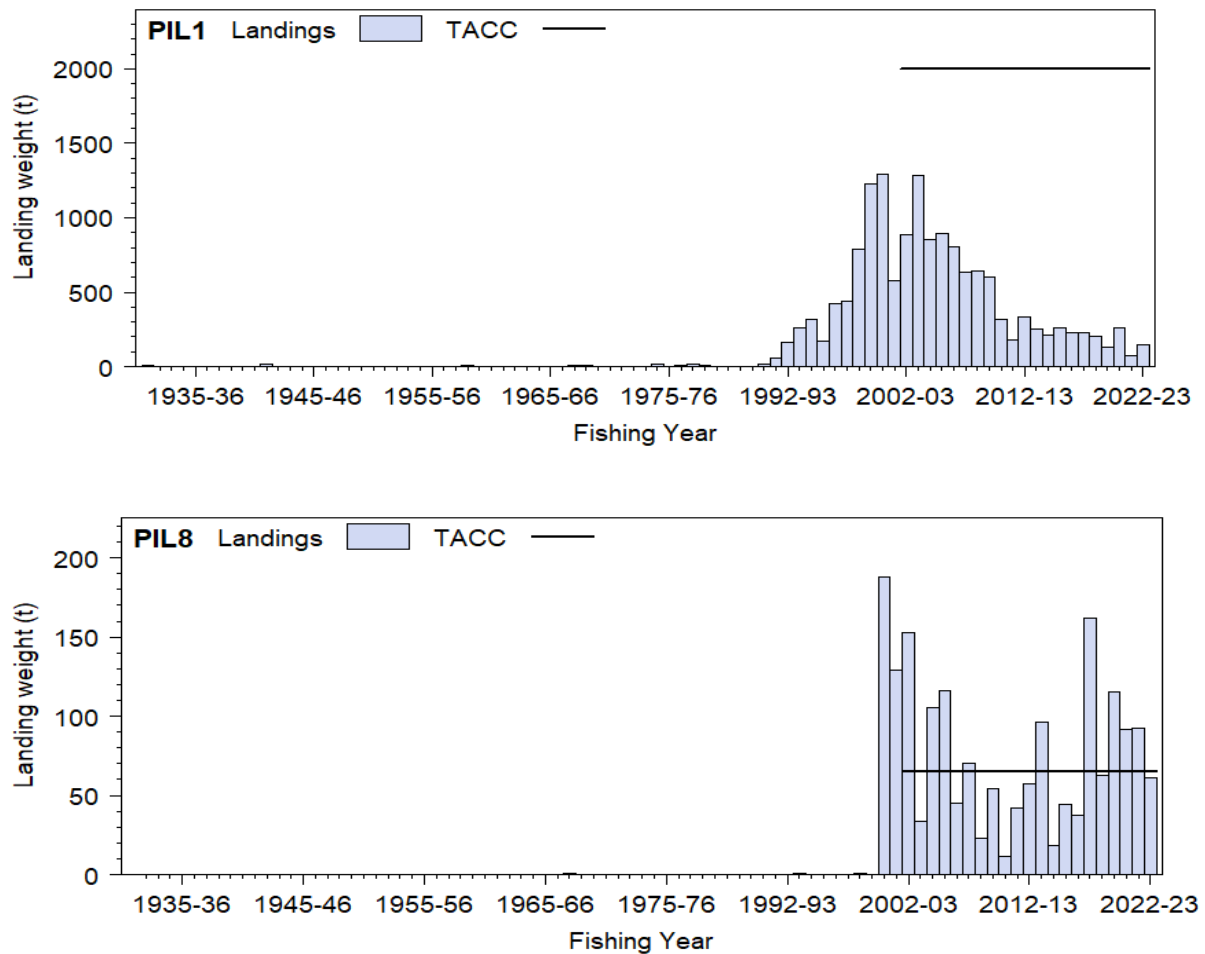


Figure 1: Reported commercial landings and TACC for the two main PIL stocks. PIL 1 (Auckland East), and PIL 8 (Central Egmont, Auckland West).

1.2 Recreational fisheries

Recreational fishers seldom target pilchards, except for bait. However bait is generally bought in commercially frozen packs (the main product of the commercial fishery). Pilchard may be caught accidentally in small mesh nets that are set or dragged to catch mullet, or on small hooks fished from wharves.

Table 5: Recreational harvest estimates for pilchard stocks (Wynne-Jones et al 2014; 2019, Heinemann & Gray in prep). Mean fish weights were not available from boat ramp surveys to convert these catches to tonnes.

| Stock | Year | Method | Number of fish | Total weight (t) | CV |
|-------|---------|--------------|----------------|------------------|------|
| PIL 1 | 2011–12 | Panel survey | 6 888 | - | 0.33 |
| | 2017–18 | Panel survey | 14 876 | - | 0.46 |
| | 2011–23 | Panel survey | 4 596 | - | 0.71 |
| PIL 2 | 2011–12 | Panel survey | 1 022 | - | 0.83 |
| | 2017–18 | Panel survey | 2 875 | - | 0.63 |
| | 2011–23 | Panel survey | - | - | - |
| PIL 3 | 2011–12 | Panel survey | 9 144 | - | 0.99 |
| | 2017–18 | Panel survey | 4 407 | - | 1.00 |
| | 2011–23 | Panel survey | - | - | - |
| PIL 7 | 2011–12 | Panel survey | 101 | - | 1.05 |
| | 2017–18 | Panel survey | 10 346 | - | 0.74 |
| | 2011–23 | Panel survey | - | - | - |
| PIL 8 | 2011–12 | Panel survey | 137 | - | 1.01 |
| | 2017–18 | Panel survey | 27 864 | - | 0.91 |
| | 2011–23 | Panel survey | 11 293 | - | 0.99 |

A National Panel Survey of recreational fishers was conducted for the first time throughout the 2011–12 fishing year. The panel survey used face-to-face interviews of a random sample of 30 390 New Zealand households to recruit a panel of fishers and non-fishers for a full year (Wynne-Jones et al 2014). The panel members were contacted regularly about their fishing activities and harvest information collected in standardised phone interviews. The national panel survey was repeated during the 2017–18 and 2022–23 fishing years using very similar methods to produce directly comparable results (Wynne-Jones et al 2019; Heinemann & Gray, in prep). Recreational catch estimates from the three national panel surveys are given in Table 5. Note that national panel survey estimates do not include recreational harvest taken on charter vessel trips or under s111 general approvals.

1.3 Customary non-commercial catch

Pilchards were known by the early Maori as mohimohi, and could have been taken in fine mesh nets, but there are very few accounts of pilchard capture and use. An estimate of the current customary non-commercial catch is not available.

1.4 Illegal catch

There is no known illegal catch of pilchards.

1.5 Other sources of mortality

Some accidental captures by vessels purse seining for jack mackerel or kahawai may be discarded if no market is available. Pilchard mortality is known to be high in some places as a result of scale loss resulting from net contact.

2. BIOLOGY

The taxonomy of *Sardinops* is complex. The New Zealand pilchard was previously identified as *Sardinops neopilchardus*, but there is now considered to be a single species, *S. sagax*, with several regional subspecies or populations.

Pilchard are generally found inshore, particularly in gulfs, bays, and harbours. They display seasonal changes in abundance (e.g. locally abundant in Wellington Harbour during spring), reflecting schooling and dispersal behaviour, localised movement, and actual changes in population size. The geographical extent of their movements in New Zealand is unknown.

Their vertical distribution in the water column varies, but on the inner shelf they move between the surface and the seafloor. Pilchards form compact schools (known as ‘meatballs’), particularly during summer, and these are heavily preyed upon by larger fishes, seabirds, and marine mammals and are thought to form an important part of the diet for many species. There have been no biological studies that are directly relevant to the recognition of separate stocks.

Spawning is recorded from many coastal regions over the shelf during spring and summer. The pelagic eggs are at times extremely abundant. Otolith readings suggest that pilchard are relatively fast growing and short-lived. They reach a maximum length of about 25 cm, and perhaps 9 years, but the main size range is of 10–20 cm fish, 2 to 6 years old. Maturity is probably at age 2.

A study on the feeding of Northland pilchards found that phytoplankton was probably the dominant food, but organic detritus was also important, and small zooplankton - mainly copepods - were taken and at times were the main component. Feeding by females diminished during the spawning season. Although they generally comprise single-species schools, pilchards associate with other small pelagic fishes, particularly anchovy. In northern waters they also occur with juvenile jack mackerel, and in southern waters with sprats.

During the 1990s pilchard populations were severely impacted by natural mass mortalities, generally attributed to a herpes virus. The first outbreak occurred in Australia and New Zealand in 1995 and Australia experienced another outbreak in 1998.

Biological parameters relevant to stock assessment are shown in Table 6.

Table 6: Estimates of biological parameters.

| Fishstock | Estimate | | Source |
|---|----------------------------|---------|---|
| <u>1. Natural mortality (<i>M</i>)</u> | | | |
| PIL 1 | $M = 0.66$ | | NIWA, unpublished estimate ¹ |
| PIL 1 | $M = 0.46$ | | NIWA, unpublished estimate ² |
| <u>2. Weight = a (length)^b</u> | | | |
| | <u>Both sexes combined</u> | | |
| PIL 1 | a = 2.2 | b = 3.3 | Paul et al (2001) ³ |
| PIL 7 | a = 3.7 | b = 3.3 | Baker (1972) ⁴ |

Notes:

1. Hoenig's rule-of-thumb estimate, maximum age = 7 years.
2. Hoenig's rule-of-thumb estimate, maximum age = 10 years.
3. Fork length in mm, weight in g, n = 493.
4. Standard length in mm, weight in g, n = 660.

3. STOCKS AND AREAS

No biological information is available on which to make an assessment on whether separate pilchard biological stocks exist in New Zealand (in Australia there is evidence of small differences between some populations off the southwest coast).

Pilchard and anchovy are often caught together. Pilchard fishstock boundaries are fully aligned with those for anchovy.

4. STOCK ASSESSMENT

There have been no stock assessments of New Zealand pilchard.

4.1 Estimates of fishery parameters and abundance

No fishery parameters are available.

4.2 Biomass estimates

No estimates of biomass are available.

4.3 Yield estimates and projections

(i) Northeast North Island (PIL 1)

MCY has been estimated using the equation $MCY = cY_{AV}$ (Method 4). The most appropriate Y_{AV} was considered the average of landings for the three years 1998–99 to 2000–01. Although a brief period, three years represents at least half the exploited life span for this species. The mean of these landings is 1101 t. With provisional values of *M* about 0.4 or 0.6, the value of *c* becomes 0.6 (i.e. high natural variability).

1998–99 to 2000–01

$$\begin{aligned}
 MCY &= 0.6 \times 1101 \text{ t} \\
 &= 661 \text{ t (rounded to 660 t)}
 \end{aligned}$$

However, the *MCY* approach is considered to be of limited value for pilchards, because this fishery has been developing rapidly, was historically infrequently targeted, and since 2000 has been subject to a CCL and more recently a TACC. The level of risk to the stock by harvesting the northeast North Island population at the estimated *MCY* value cannot be determined.

(ii) Tasman Bay/Marlborough Sounds (PIL 7)

MCY cannot be estimated for this region because the fishery has been largely unexploited since the 1940s, and no appropriate biological parameters exist.

(iii) Other regions

MCY cannot be estimated because of insufficient information, and absence of fisheries. Current biomass cannot be estimated, so CAY cannot be determined.

4.4 Other factors

It is likely that pilchard, although not strongly migratory, will vary considerably in their regional abundance over time. The larger vessels in the fleet that targets them are capable of travelling moderate distances to the best grounds. Thus, while the resource may have a relatively localised distribution, the catching sector of the fishery does not. Should the pilchard fishery develop again after its recent decline it is likely to become one component of a set of fisheries for small pelagic species (anchovy, sprats, and small jack mackerels). Mixed catches will be inevitable.

Pilchard is abundant in some New Zealand regions. However, it is unlikely that the biomass is comparable to the very large stocks of pilchard (sardine) in some world oceans where strong upwelling promotes high productivity. It is more likely that the New Zealand pilchard comprises abundant but localised coastal populations, comparable to those of southern Australia. They appear to be adaptable feeders, able to utilise food items from organic detritus through phytoplankton to zooplankton. East Northland is a region where under neutral to El Niño conditions moderately productive upwelling predominates but, in La Niña years, downwelling and oceanic water incursion will limit recruitment and may affect adult condition and survival.

In those regions of the world where small pelagic fishes are particularly abundant and have been well studied, there is often a reciprocal relationship between the stock size of pilchard and anchovy, as well as great variability in their overall abundance. Many pilchard/anchovy fisheries have undergone boom-and-bust cycles. In both Australia and New Zealand, pilchard have been affected by mass mortality events, the two in Australia are estimated to have each killed over 70% of the adult fish. The mortality rate of the 1995 event in New Zealand is not known, but was high. In combination, these features of the pilchard's biology suggest that the yield from the New Zealand stock will be variable, both short-term (annual) and long-term (decadal).

5. STATUS OF THE STOCKS

For all Fishstocks there is insufficient information to estimate current stock status.

6. FOR FURTHER INFORMATION

- Baker, A N (1972) Reproduction, early life history, and age-growth relationships of the New Zealand pilchard, *Sardinops neopilchardus* (Steindachner). *Fisheries Research Bulletin* No. 5. 64 p.
- Heinemann A; Gray, A. (in prep.) National Panel Survey of Recreational Marine Fishers 2022-23.
- Jacobson, L D; De Oliveira, J A A; Barange, M; Cisneros-Mata, M A; Félix-Uraga, R; Hunter, J R; Kim, J Y; Matsuura, Y; Ñiqueen, M; Porteiro, C; Rothschild, B; Sanchez, R P; Serra, R; Uriarte, A; Wada, T (2001) Surplus production, variability, and climate change in the great sardine and anchovy fisheries. *Canadian Journal of Fisheries and Aquatic Sciences* 58(9): 1891–1903.
- Paul, L J; Bradford-Grieve, J M; Tasker, R A; Chang, F H; Manning, M J (2005) Guts, gill rakers, and ENSO oceanography: a pilot study on feeding patterns in the New Zealand pilchard, *Sardinops sagax*, off east Northland. Final Research Report for Ministry of Fisheries Research Project PIL2003/01, Objective 1. 30 p. (Unpublished Report held by Fisheries New Zealand, Wellington).
- Paul, L J; Taylor, P R; Parkinson, D M (2001) Pilchard (*Sardinops neopilchardus*) biology and fisheries in New Zealand, and a review of pilchard (*Sardinops*, *Sardina*) biology, fisheries, and research in the main world fisheries. *New Zealand Fisheries Assessment Report 2001/37*. 44 p.
- Schwartzlose, R A; Ahleit, J; Bakun, A; Baumgartner, T R; Cloete, R; Crawford, R J M; Fletcher, W; Green-Ruiz, Y; Hagen, E; Kawasaki, T; Lluch-Belda, D; Lluch-Cota, S E; MacCall, A D; Matsuura, Y; Nevarez-Martínez, M O; Parrish, R H; Roy, C; Serra, R; Shust, K V; Ward, M N; Zuzunaga, J Z (1999) Worldwide large-scale fluctuations of sardine and anchovy populations. *South African Journal of Marine Science* 21: 289–347.

- Ward, T M; Hoedt, F; McLeay, L; Dimmlich, W F; Kinloch, M; Jackson, G; McGarvey, R; Rogers, P J; Jones, K (2001) Effects of the 1995 and 1998 mass mortality events on the spawning biomass of sardine, *Sardinops sagax*, in South Australian waters. *ICES Journal of Marine Science* 58(4): 865–875.
- Wynne-Jones, J; Gray, A; Heinemann, A; Hill, L; Walton, L (2019). National Panel Survey of Marine Recreational Fishers 2017–2018. Draft New Zealand Fisheries Assessment Report held by Fisheries New Zealand.
- Wynne-Jones, J; Gray, A; Hill, L; Heinemann, A (2014) National Panel Survey of Marine Recreational Fishers 2011–12: Harvest Estimates. *New Zealand Fisheries Assessment Report 2014/67*.