# RED GURNARD (GUR)

(*Chelidonichthys kumu*)
Kumukumu


## 1. FISHERY SUMMARY

### 1.1 Commercial fisheries

Red gurnard are a major bycatch of inshore trawl fisheries in most areas of New Zealand, including fisheries for red cod in the southern regions and flatfish off the west coast of the South Island (WCSI) and in Tasman Bay. They are also directly targeted in some areas e.g., GUR 2. Some minor target fisheries for red gurnard are known in Pegasus Bay, off Mahia, and off the west coast South Island. Red gurnard is also a minor bycatch in the jack mackerel trawl fishery in the South Taranaki Bight. Up to 15% of the total red gurnard catch is taken by bottom longline and set net.

Red gurnard was introduced into the Quota Management System (QMS) in 1986. The 1986 TACCs were based on 1984 landings for Southland and 1983 landings for other regions. TACCs for GUR 2, GUR 8, and GUR 10 have remained unchanged since, and these fisheries remain TACC only fisheries. TACs and allowances have since been set for GUR 7, GUR 3, and GUR 1 (1997, 2000, and 2021, respectively), with GUR 3 and GUR 7 having numerous changes to TACC and allowances since their introduction to the QMS, discussed below. All current TACs, allowances, and TACCs are given in Table 1. Under the Adaptive Management Programme (AMP), which ended 30 September 2009, the TACCs for GUR 3 and 7 were increased to 600 t and 815 t, respectively, for the 1991–92 fishing year, and then the GUR 7 TACC was reduced to 678 t, in 1997–98. The TACC for GUR 3 was increased to 900 t for the 1996–97 fishing year under the AMP but was decreased to 800 t in 2002–03.

For the 2009–10 fishing season, the TACC in GUR 7 was increased to 715 t, including an allocation of 10 t for customary, 20 t for recreational use, and 14 t allocation for other sources of mortality. The GUR 7 TACC was further increased to 785 t in October 2012, 845 t in October 2015, 975 t in October 2017, 1073 t in October 2019, 1180 t in October 2020, and to 1298 in October 2021 along with increased allowances. For the 2009–10 fishing season, the TACC for GUR 3 was increased from 800 t to 900 t, with allocations of 3 t, 5 t, and 45 t for customary, recreational, and other sources of mortality, respectively. The GUR 3 TACC was further increased to 1100 t in October 2012, 1220 t in October 2015, 1320 t in October 2018, and to 1500 t in 2020 along with increases in recreational and other sources of mortality allowances (now 6 t and 105 t, respectively). In October 2021, when a new TAC was set, the TACC for GUR 1 was decreased from 2288 t to 800 t and allocations of 40 t for customary, 100 t for recreational, and 56 t for other sources of mortality were also set.

**RED GURNARD (GUR)**

Reported landings since 1931 are shown in Tables 2 and 3. Historical landings and TACC values for the five main GUR stocks are shown in Figure 1.

**Table 1: Current TACs, TACCs, and allowances (t) for red gurnard by Fishstock as of October 2021.**

| Fishstock | TAC | TACC | Customary allowance | Recreational allowance | Other mortality |
|---|---|---|---|---|---|
| GUR 1 | 996 | 800 | 40 | 100 | 56 |
| GUR 2 | | 725 | | | |
| GUR 3 | 1 614 | 1 500 | 3 | 6 | 105 |
| GUR 7 | 1 422 | 1 298 | 17 | 42 | 65 |
| GUR 8 | | 543 | | | |
| GUR 10 | | 10 | | | |

**Table 2: Reported landings (t) for the main QMAs from 1931 to 1982.**

| Year | GUR 1 | GUR 2 | GUR 3 | GUR 7 | GUR 8 |
|---|---|---|---|---|---|
| 1931–32 | 67 | 0 | 1 | 16 | 0 |
| 1932–33 | 42 | 0 | 0 | 13 | 0 |
| 1933–34 | 67 | 84 | 1 | 20 | 0 |
| 1934–35 | 50 | 179 | 0 | 2 | 0 |
| 1935–36 | 75 | 147 | 18 | 2 | 0 |
| 1936–37 | 114 | 215 | 37 | 25 | 1 |
| 1937–38 | 205 | 193 | 83 | 21 | 0 |
| 1938–39 | 109 | 118 | 151 | 31 | 2 |
| 1939–40 | 121 | 149 | 147 | 25 | 1 |
| 1940–41 | 124 | 222 | 215 | 38 | 1 |
| 1941–42 | 107 | 200 | 267 | 38 | 0 |
| 1942–43 | 124 | 332 | 287 | 58 | 0 |
| 1943–44 | 128 | 244 | 294 | 53 | 0 |
| 1944 | 238 | 292 | 291 | 60 | 0 |
| 1945 | 360 | 338 | 222 | 94 | 3 |
| 1946 | 426 | 387 | 290 | 119 | 4 |
| 1947 | 376 | 297 | 243 | 162 | 10 |
| 1948 | 385 | 243 | 267 | 226 | 9 |
| 1949 | 371 | 264 | 316 | 323 | 13 |
| 1950 | 306 | 186 | 486 | 332 | 13 |
| 1951 | 221 | 231 | 750 | 202 | 10 |
| 1952 | 394 | 378 | 658 | 211 | 5 |
| 1953 | 490 | 494 | 614 | 334 | 3 |
| 1954 | 496 | 462 | 660 | 382 | 7 |
| 1955 | 495 | 283 | 652 | 490 | 25 |
| 1956 | 434 | 312 | 782 | 435 | 29 |
| 1957 | 494 | 402 | 737 | 409 | 46 |
| 1958 | 430 | 394 | 745 | 400 | 51 |
| 1959 | 460 | 320 | 806 | 212 | 44 |
| 1960 | 489 | 417 | 1 008 | 421 | 27 |
| 1961 | 559 | 419 | 1 180 | 419 | 27 |
| 1962 | 505 | 592 | 1 244 | 322 | 14 |
| 1963 | 576 | 562 | 1 364 | 367 | 8 |
| 1964 | 977 | 814 | 1 708 | 397 | 16 |
| 1965 | 1 020 | 668 | 1 459 | 400 | 34 |
| 1966 | 1 157 | 754 | 1 178 | 436 | 27 |
| 1967 | 1 051 | 836 | 745 | 522 | 45 |
| 1968 | 1 137 | 583 | 510 | 368 | 52 |
| 1969 | 1 345 | 632 | 487 | 256 | 33 |
| 1970 | 1 493 | 823 | 841 | 381 | 53 |
| 1971 | 1 225 | 570 | 940 | 379 | 37 |
| 1972 | 770 | 347 | 662 | 333 | 15 |
| 1973 | 1 278 | 406 | 1 393 | 491 | 21 |
| 1974 | 881 | 299 | 1 083 | 586 | 41 |
| 1975 | 691 | 199 | 655 | 365 | 28 |
| 1976 | 1 055 | 217 | 960 | 545 | 52 |
| 1977 | 1 288 | 381 | 975 | 579 | 45 |
| 1978 | 1 571 | 519 | 1 106 | 487 | 26 |
| 1979 | 1 936 | 382 | 690 | 349 | 18 |
| 1980 | 1 845 | 438 | 672 | 253 | 34 |
| 1981 | 2 349 | 603 | 438 | 318 | 16 |
| 1982 | 2 084 | 454 | 379 | 368 | 34 |

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 include both foreign and domestic landings. Data were aggregated to FMA using methods and assumptions described by Francis & Paul (2013).

**Table 3: Reported landings (t) of red gurnard by Fishstock from 1983–84 to the present and actual TACCs (t) from 1986–87 to the present. The QMS data are from 1986 to the present. [Continued on next page]**

| Fishstock | GUR 1 | | GUR 2 | | GUR 3 | | GUR 7 | |
|---|---|---|---|---|---|---|---|---|
| QMA (s) | 1 & 9 | | 2 | | 3, 4, 5 & 6 | | 7 | |
| | Landings | TACC | Landings | TACC | Landings | TACC | Landings | TACC |
| 1983–84* | 2 099 | – | 782 | – | 366 | – | 468 | – |
| 1984–85* | 1 531 | – | 665 | – | 272 | – | 332 | – |
| 1985–86* | 1 760 | – | 495 | – | 272 | – | 239 | – |
| 1986–87 | 1 021 | 2 010 | 592 | 610 | 210 | 480 | 421 | 610 |
| 1987–88 | 1 139 | 2 081 | 596 | 657 | 386 | 486 | 806 | 629 |
| 1988–89 | 1 039 | 2 198 | 536 | 698 | 528 | 489 | 479 | 669 |
| 1989–90 | 916 | 2 283 | 451 | 720 | 694 | 501 | 511 | 678 |
| 1990–91 | 1 123 | 2 284 | 490 | 723 | 661 | 524 | 442 | 678 |
| 1991–92 | 1 294 | 2 284 | 663 | 723 | 539 | 600 | 704 | 815 |
| 1992–93 | 1 629 | 2 284 | 618 | 725 | 484 | 601 | 761 | 815 |
| 1993–94 | 1 153 | 2 284 | 635 | 725 | 711 | 601 | 469 | 815 |
| 1994–95 | 1 054 | 2 287 | 559 | 725 | 685 | 601 | 455 | 815 |
| 1995–96 | 1 163 | 2 287 | 567 | 725 | 633 | 601 | 382 | 815 |
| 1996–97 | 1 055 | 2 287 | 503 | 725 | 641 | 900 | 378 | 815 |
| 1997–98 | 1 015 | 2 287 | 482 | 725 | 477 | 900 | 309 | 678 |
| 1998–99 | 927 | 2 287 | 469 | 725 | 395 | 900 | 323 | 678 |
| 1999–00 | 944 | 2 287 | 521 | 725 | 411 | 900 | 331 | 678 |
| 2000–01 | 1 294 | 2 287 | 623 | 725 | 569 | 900 | 571 | 678 |
| 2001–02 | 1 109 | 2 287 | 619 | 725 | 717 | 900 | 686 | 681 |
| 2002–03 | 1 256 | 2 287 | 552 | 725 | 888 | 800 | 793 | 681 |
| 2003–04 | 1 225 | 2 287 | 512 | 725 | 725 | 800 | 717 | 681 |
| 2004–05 | 1 354 | 2 287 | 708 | 725 | 854 | 800 | 688 | 681 |
| 2005–06 | 1 113 | 2 287 | 542 | 725 | 957 | 800 | 604 | 681 |
| 2006–07 | 1 180 | 2 287 | 575 | 725 | 1 004 | 800 | 714 | 681 |
| 2007–08 | 1 198 | 2 287 | 517 | 725 | 842 | 800 | 563 | 681 |
| 2008–09 | 1 060 | 2 287 | 621 | 725 | 939 | 800 | 595 | 681 |
| 2009–10 | 1 075 | 2 287 | 853 | 725 | 1 018 | 900 | 603 | 715 |
| 2010–11 | 1 046 | 2 288 | 587 | 725 | 929 | 900 | 545 | 715 |
| 2011–12 | 981 | 2 288 | 558 | 725 | 915 | 900 | 684 | 715 |
| 2012–13 | 1 103 | 2 288 | 603 | 725 | 1 168 | 1 100 | 763 | 785 |
| 2013–14 | 1 005 | 2 288 | 555 | 725 | 1 223 | 1 100 | 837 | 785 |
| 2014–15 | 1 020 | 2 288 | 695 | 725 | 1 150 | 1 100 | 852 | 785 |
| 2015–16 | 860 | 2 288 | 748 | 725 | 1 348 | 1 220 | 852 | 845 |
| 2016–17 | 856 | 2 288 | 669 | 725 | 1 279 | 1 220 | 905 | 845 |
| 2017–18 | 785 | 2 288 | 560 | 725 | 1 419 | 1 220 | 882 | 975 |
| 2018–19 | 710 | 2 288 | 587 | 725 | 1 467 | 1 320 | 998 | 975 |
| 2019–20 | 745 | 2 288 | 562 | 725 | 1 537 | 1 320 | 1 182 | 1 073 |
| 2020–21 | 847 | 2 288 | 412 | 725 | 1 646 | 1 500 | 1 153 | 1 180 |

| Fishstock | GUR 8 | | GUR 10 | | | |
|---|---|---|---|---|---|---|
| QMA (s) | 8 | | 10 | | | Total |
| | Landings | TACC | Landings | TACC | Landings | TACC |
| 1983–84* | 251 | – | 0 | – | 3 966 | – |
| 1984–85* | 247 | – | 0 | – | 3 047 | – |
| 1985–86* | 163 | – | 0 | – | 2 929 | – |
| 1986–87 | 159 | 510 | 0 | 10 | 2 403 | 4 230 |
| 1987–88 | 194 | 518 | 0 | 10 | 3 121 | 4 381 |
| 1988–89 | 167 | 532 | 0 | 10 | 2 749 | 4 596 |
| 1989–90 | 173 | 538 | 0 | 10 | 2 745 | 4 730 |
| 1990–91 | 150 | 543 | 0 | 10 | 2 866 | 4 762 |
| 1991–92 | 189 | 543 | 0 | 10 | 3 390 | 4 975 |
| 1992–93 | 208 | 543 | 0 | 10 | 3 700 | 4 978 |
| 1993–94 | 174 | 543 | 0 | 10 | 3 142 | 4 978 |
| 1994–95 | 217 | 543 | 0 | 10 | 2 969 | 4 982 |
| 1995–96 | 182 | 543 | 0 | 10 | 2 927 | 4 982 |
| 1996–97 | 219 | 543 | 0 | 10 | 2 796 | 5 281 |
| 1997–98 | 249 | 543 | 0 | 10 | 2 532 | 5 143 |
| 1998–99 | 170 | 543 | 0 | 10 | 2 284 | 5 143 |
| 1999–00 | 222 | 543 | 0 | 10 | 2 429 | 5 143 |
| 2000–01 | 291 | 543 | 0 | 10 | 3 348 | 5 143 |
| 2001–02 | 302 | 543 | 0 | 10 | 3 429 | 5 143 |
| 2002–03 | 342 | 543 | 0 | 10 | 3 831 | 4 993 |
| 2003–04 | 329 | 543 | 0 | 10 | 3 508 | 4 993 |
| 2004–05 | 370 | 543 | 0 | 10 | 3 974 | 4 993 |
| 2005–06 | 373 | 543 | 0 | 10 | 3 589 | 4 993 |
| 2006–07 | 349 | 543 | 0 | 10 | 3 822 | 4 993 |
| 2007–08 | 223 | 543 | 0 | 10 | 3 344 | 4 993 |
| 2008–09 | 274 | 543 | 0 | 10 | 3 489 | 4 993 |
| 2009–10 | 239 | 543 | 0 | 10 | 3 789 | 5 181 |
| 2010–11 | 182 | 543 | 0 | 10 | 3 289 | 5 181 |
| 2011–12 | 213 | 543 | 0 | 10 | 3 351 | 5 181 |
| 2012–13 | 170 | 543 | 0 | 10 | 3 807 | 5 451 |
| 2013–14 | 151 | 543 | 0 | 10 | 3 769 | 5 451 |
| 2014–15 | 193 | 543 | 0 | 10 | 3 910 | 5 451 |
| 2015–16 | 145 | 543 | 0 | 10 | 3 953 | 5 631 |
| 2016–17 | 145 | 543 | 0 | 10 | 3 854 | 5 631 |
| 2017–18 | 209 | 543 | 0 | 10 | 3 855 | 5 761 |
| 2018–19 | 267 | 543 | 0 | 10 | 4 029 | 5 861 |
| 2019–20 | 386 | 543 | 0 | 10 | 4 412 | 5 959 |

**Table 3 [continued]**

| Fishstock | GUR 8 | | GUR 10 | | | |
|---|---|---|---|---|---|---|
| QMA (s) | | 8 | | 10 | | Total |
| | Landings | TACC | Landings | TACC | Landings | TACC |
| 2020–21 | 249 | 543 | 0 | 10 | 4 306 | 6 246 |

*FSU data.

Annual landings of GUR 1 were relatively stable from 1986–87 to 2014–15, generally ranging between 920 t and 1300 t; substantially lower than the 2288 t TACC. Since then, catches have declined slightly, with 745 t landed in 2019–20. About 60% of the GUR 1 total is taken from FMA 1, as a bycatch of a number of fisheries including inshore trawl fisheries for snapper, John dory, and tarakihi. The remaining 40% is taken from FMA 9, mainly as a bycatch of the snapper and trevally inshore trawl fisheries.

GUR 2 landings have fluctuated within the range of 451–853 t since 1991–92, typically well below the TACC. In addition to the target fishery, red gurnard are taken as a bycatch of the tarakihi, trevally, and snapper inshore trawl fisheries. A decreasing trend in effort in GUR 2 is evident from 2009–10 to 2020–21 and GUR 2 landings in 2020–21 were the lowest since 1989–90.

GUR 3 landings regularly exceeded the TACC between 1988–89 and 1995–96 and this stock has been consistently over-caught since 2004–05. Landings increased steadily from 2010–11 to 2020–21 with multiple small increases in the TACC during that period.

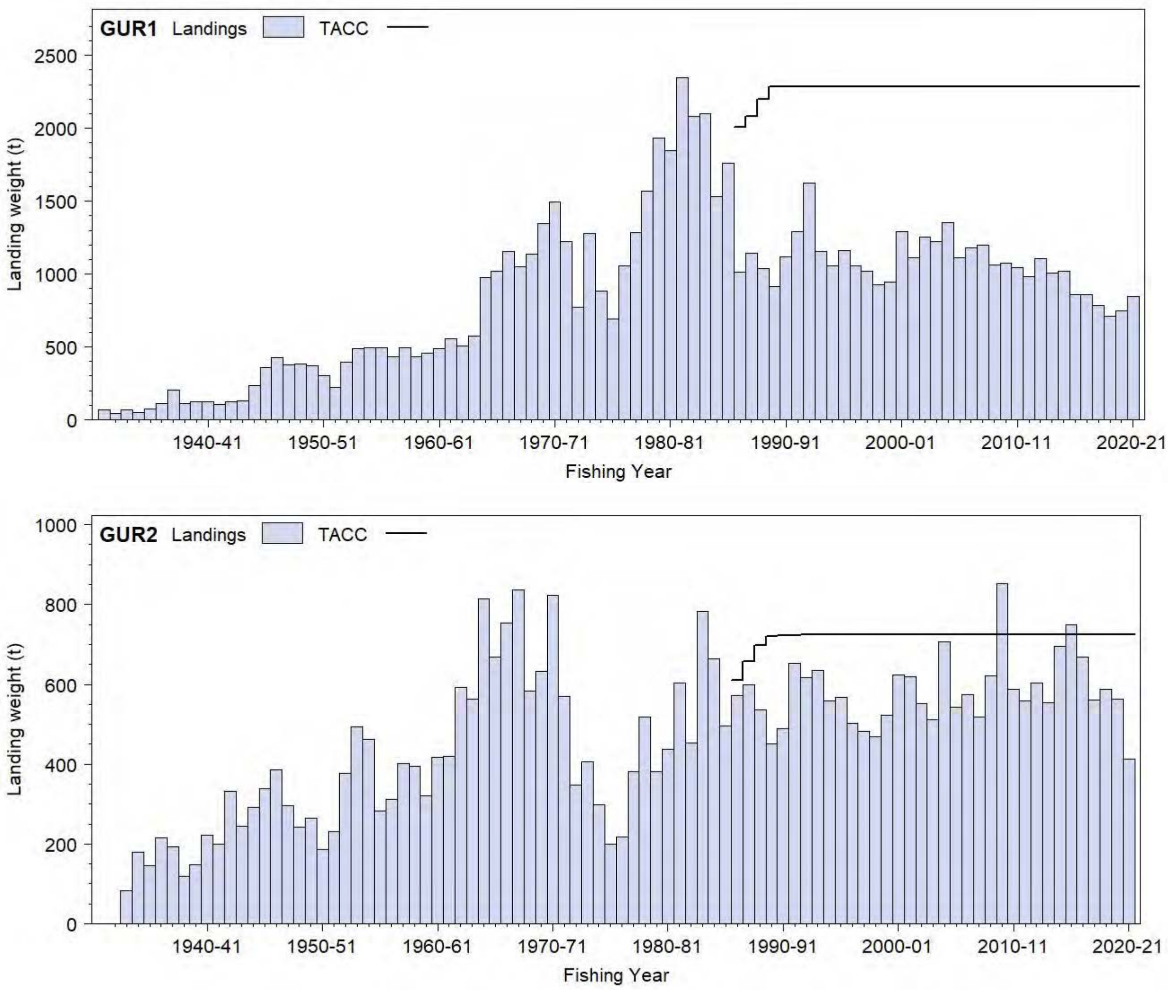



**Figure 1: Reported commercial landings and TACCs for the five main GUR stocks. From top to bottom: GUR 1 (Auckland East) and GUR 2 (Central East).** **[Continued on next page]**

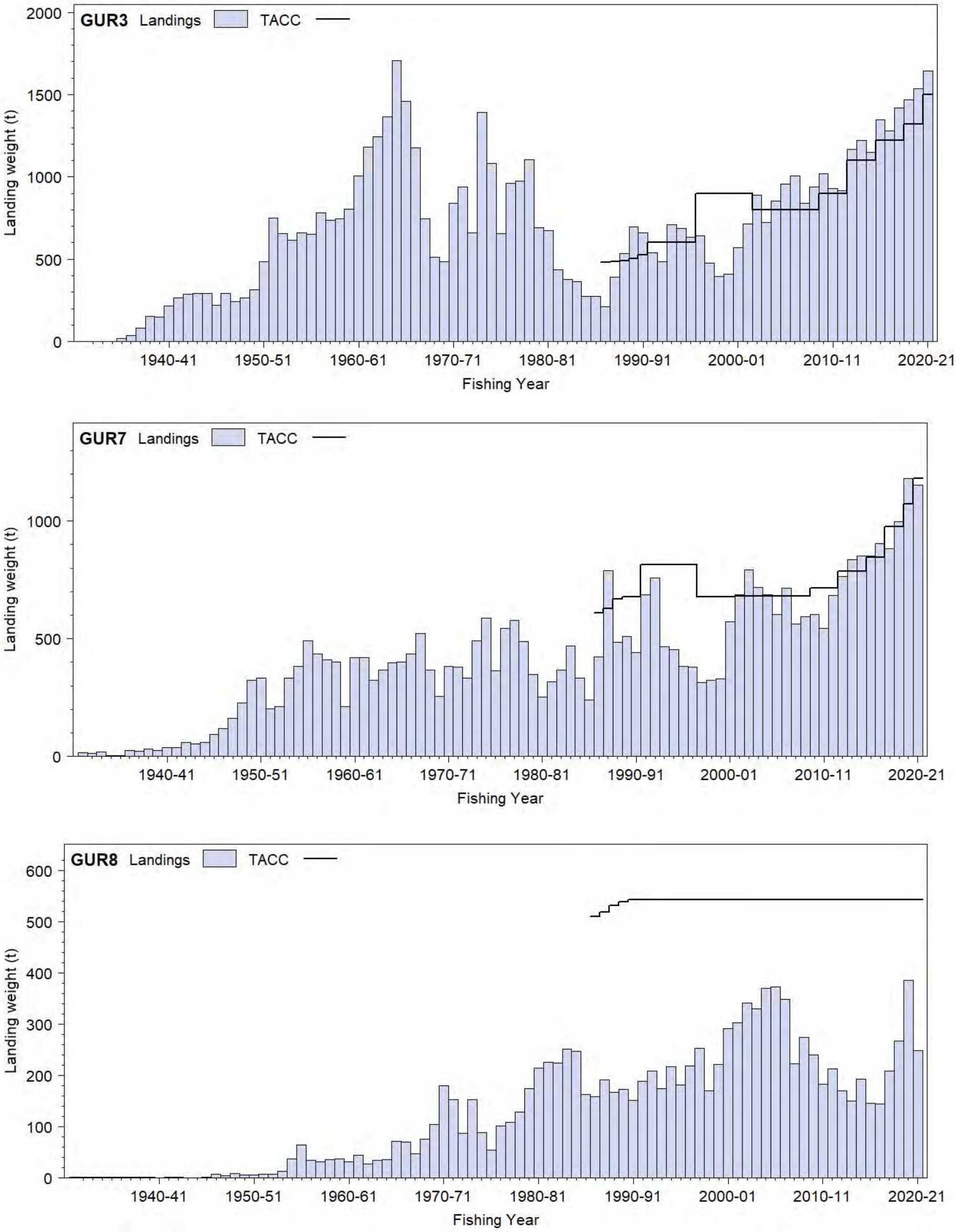



**Figure 1 [Continued]: Reported commercial landings and TACCs for the five main GUR stocks. From top to bottom: GUR 3 (South East Coast), GUR 7 (Challenger), and GUR 8 (Central Egmont).**

GUR 7 landings declined steadily from 761 t in 1992–93, to 309 t in 1997–98, but then increased to 793 t by 2002–03. Landings then generally declined to 2010–11. Landings increased steadily from 2010–11 to 2020–21 with multiple small increases in the TACC during that period.

Landings in GUR 8 have remained well below the TACC since 1986–87, averaging 225 t.

### 1.2 Recreational fisheries

Red gurnard is, by virtue of its wide distribution in harbours and shallow coastal waters, an important recreational species. It is often taken by fishers targeting snapper and tarakihi, particularly around the

North Island. The allowances within the TAC for each Fishstock are shown in Table 1, but have currently only been set for GUR 3 and GUR 7.

### 1.2.1 Management controls
The main methods used to manage recreational harvests of red gurnard are minimum legal size limits (MLS), method restrictions, and daily bag limits. Fishers can take up to 20 GUR as part of their combined daily bag limit and the MLS is 25 cm.

### 1.2.2 Estimates of recreational harvest
Recreational catch estimates are given in Table 4. There are two broad approaches to estimating recreational fisheries harvest: the use of onsite or access point methods where fishers are surveyed or counted at the point of fishing or access to their fishing activity; and offsite methods where some form of post-event interview and/or diary are used to collect data from fishers.

The first estimates of recreational harvest for red gurnard were calculated using an offsite approach: the offsite regional telephone and diary survey approach. Estimates for 1996 came from a national telephone and diary survey (Bradford 1998). Another national telephone and diary survey was carried out in 2000 (Boyd & Reilly 2004) and a rolling replacement of diarists in 2001 (Boyd et al 2004) allowed estimates for a further year (population scaling ratios and mean weights were not re-estimated in 2001).

**Table 4: Recreational harvest estimates for red gurnard stocks. The telephone/diary surveys and earlier aerial-access surveys ran from December to November but are denoted by the January calendar year. The surveys since 2010 have run through the October to September fishing year but are denoted by the January calendar year. Mean fish weights were obtained from boat ramp surveys (for the telephone/diary and panel survey harvest estimates, Hartill & Davey 2015, and Davey et al 2019). [Continued on next page]**

| Stock | Year | Method | Number of fish | Total weight (t) | CV |
|---|---|---|---|---|---|
| GUR 1 | 1996 | Telephone/diary | 262 000 | 108 | 0.07 |
| | 2000 | Telephone/diary | 465000 | 223 | 0.16 |
| FMA 1 only | 2005 | Aerial–access | – | 127 | 0.14 |
| FMA 1 only | 2012 | Aerial–access | – | 24 | 0.09 |
| FMA 1 only | 2012 | Panel survey | 120 500 | 49 | 0.16 |
| | 2012 | Panel survey | 241 957 | 103 | 0.15 |
| FMA 1 only | 2018 | Aerial–access | – | 31 | 0.11 |
| FMA 1 only | 2018 | Panel survey | 85 000 | 36 | 0.14 |
| | 2018 | Panel survey | 168 798 | 86 | 0.15 |
| GUR 2 | 1996 | Telephone/diary | 38 000 | 16 | 0.18 |
| | 2000 | Telephone/diary | 209 000 | 127 | 0.37 |
| | 2012 | Panel survey | 66 661 | 38 | 0.20 |
| | 2018 | Panel survey | 71 702 | 39 | 0.28 |
| GUR 3 | 1996 | Telephone/diary | 1 000 | – | – |
| | 2000 | Telephone/diary | 11 000 | 5 | 0.70 |
| | 2012 | Panel survey | 4 605 | 2 | 0.62 |
| | 2018 | Panel survey | 3 486 | 2 | 0.39 |
| GUR 7 | 1996 | Telephone/diary | 26 000 | 12 | 0.15 |
| | 2000 | Telephone/diary | 36 000 | 11 | 0.23 |
| | 2012 | Panel survey | 23 653 | 12 | 0.24 |
| | 2018 | Panel survey | 60 759 | 38 | 0.18 |
| GUR 8 | 1996 | Telephone/diary | 67 000 | 28 | 0.15 |
| | 2000 | Telephone/diary | 99 000 | 40 | 0.36 |
| | 2012 | Panel survey | 93 656 | 47 | 0.23 |
| | 2018 | Panel survey | 55 314 | 31 | 0.19 |

The harvest estimates provided by these telephone diary surveys are no longer considered reliable for various reasons. With the early telephone/diary method, fishers were recruited to fill in diaries by way of a telephone survey that also estimates the proportion of the population that is eligible (likely to fish). A 'soft refusal' bias in the eligibility proportion arises if interviewees who do not wish to co-operate falsely state that they never fish. The proportion of eligible fishers in the population (and, hence, the harvest) is thereby under-estimated. Pilot studies for the 2000 telephone/diary survey suggested that this effect could occur when recreational fishing was established as the subject of the interview at the outset. Another equally serious cause of bias in telephone/diary surveys was that diarists who did not immediately record their day's catch after a trip sometimes overstated their catch or the number of trips made. There is some indirect evidence that this may have occurred in all the telephone/diary surveys (Wright et al 2004).

The recreational harvest estimates provided by the 2000 and 2001 telephone diary surveys are thought to be implausibly high for many species, which led to the development of an alternative maximum count aerial-access onsite method that provides a more direct means of estimating recreational harvests for suitable fisheries. The maximum count aerial-access approach combines data collected concurrently from two sources: a creel survey of recreational fishers returning to a subsample of ramps throughout the day; and an aerial survey count of vessels observed to be fishing at the approximate time of peak fishing effort on the same day. The ratio of the aerial count in a particular area to the number of interviewed parties who claimed to have fished in that area at the time of the overflight was used to scale up harvests observed at surveyed ramps, to estimate harvest taken by all fishers returning to all ramps. The methodology is further described by Hartill et al (2007).

This aerial-access method was first employed and optimised to estimate snapper harvests in the Hauraki Gulf in 2003–04. It was then extended to survey the wider SNA 1 fishery in 2004–05 and to provide estimates for other species, including red gurnard (FMA 1 only for GUR). In response to the cost and scale challenges associated with onsite methods, in particular the difficulties in sampling other than trailer boat fisheries, offsite approaches to estimating recreational fisheries harvest have been revisited. This led to the development and implementation of a national panel survey for the 2011–12 fishing year (Wynne-Jones et al 2014) and repeated for the 2017–18 fishing year (Wynne-Jones et al 2019). The panel survey used face-to-face interviews of a random sample of New Zealand households to recruit a panel of fishers and non-fishers for a full year. The panel members were contacted regularly about their fishing activities and catch information in standardised phone interviews.

### 1.3 Customary non-commercial fisheries

Red gurnard is an important species for customary non-commercial fishing interests, by virtue of its wide distribution in shallow coastal waters. However, no quantitative estimates of customary non-commercial catch are currently available.

### 1.4 Illegal catch

No quantitative information is available.

### 1.5 Other sources of mortality

No quantitative information is available.

## 2. BIOLOGY

Gurnard growth rate varies with location, and females grow faster and are usually larger at age than males. Maximum age ($A_{MAX}$) is about 16 years and maximum size is 55+ cm. Red gurnard reach sexual maturity at an age of 2–3 years and a fork length (FL) of about 23 cm, after which the growth rate slows. An analysis of the age and growth of red gurnard in FMA 7 revealed that young fish 1–4 years old tend to be most common in Tasman Bay and Golden Bay. Three to six year old fish are found on the inshore areas off the west coast South Island and the older fish are predominantly found further offshore (Lyon & Horn 2011).

Biological parameters relevant to the stock assessment are shown in Table 5.

$M$ was estimated using the equation $M = \log_e 100$/maximum age, where maximum age is the age to which 1% of the population survives in an unexploited stock. Samples from the east coast South Island (ECSI) suggested an $A_{MAX}$ of about 16 years for males and 13 years for females, giving estimates for $M$ of 0.29 and 0.35, respectively. Samples from the west coast South Island (WCSI) indicate an $A_{MAX}$ of about 15 years for both sexes, giving an estimate of 0.31 for $M$. These samples were not from virgin populations, so $M$ may be overestimated.

**Table 5: Estimates of biological parameters for red gurnard.**

| **Fishstock** | | | | | | **Estimate** | **Source** |
|---|---|---|---|---|---|---|---|
| 1. Natural mortality ($M$) | | | | | | | |
| | | | Female | | | Males | |
| GUR 1W & 1E | | | 0.30 | | | 0.35 | Stevenson (2000) |
| GUR 3 | | | 0.29 | | | 0.35 | Sutton (1997) |
| GUR 7 | | | 0.31 | | | 0.31 | Sutton (1997) |
| 2. Weight = $a$(length)$^b$ (Weight in g, length in cm fork length) | | | | | | | |
| | | | Both Sexes | | | | |
| | | | $a$ | | | $b$ | |
| GUR 1 | | | 0.00998 | | | 2.99 | Elder (1976) |
| GUR 1W & 1 E | | | 0.026 | | | 2.775 | Stevenson (2000) |
| GUR 2 | | | 0.0053 | | | 3.19 | Stevenson (2000) |
| 3. von Bertalanffy growth parameters | | | | | | | |
| | Females | | | Males | | | |
| | $L_\infty$ | $k$ | $t_0$ | $L_\infty$ | $k$ | $t_0$ | |
| GUR 1 | 36.4 | 0.641 | 0.189 | 28.8 | 0.569 | -0.552 | Elder (1976) |
| GUR 1W | 45.3 | 0.25 | -0.88 | 36.5 | 0.45 | -0.30 | Stevenson (2000) |
| GUR 1E | 44.5 | 0.28 | -0.76 | 35.2 | 0.49 | -0.24 | Stevenson (2000) |
| GUR 3 | 48.2 | 0.44 | 0.1 | 42.2 | 0.49 | -0.26 | Sutton (1997) |
| GUR 7 | 45.7 | 0.40 | -0.36 | 40.3 | 0.37 | -0.96 | Sutton (1997) |

Red gurnard have a long spawning period which extends through spring and summer with a peak in early summer. In the Hauraki Gulf, ripe adults can be found throughout the year. Spawning grounds appear to be widespread, although perhaps localised over the inner and central shelf. Egg and larval development takes place in surface waters, and there is a period of at least eight days before feeding starts. Small juveniles (under 15 cm FL) are often caught in shallow harbours, but rarely in commercial trawls.

# 3. STOCKS AND AREAS

There are no data that would alter the current stock boundaries. No information is available on stock separation of red gurnard. For GUR 3 the Working Group noted that spatial information from the CPUE analyses indicated that separate stocks or sub-stocks may exist between the east and south coasts of the South Island.

# 4. STOCK ASSESSMENT

## 4.1 Biomass estimates

Relative abundance indices have been obtained from trawl surveys of the Bay of Plenty, west coast North Island, and Hauraki Gulf within the GUR 1 fish stock (Table 6, Figure 2); west coast South Island and Tasman Bay/Golden Bay combined (GUR 7); and east coast South Island (GUR 3) (Table 7).

**East coast South Island (ECSI) inshore trawl survey**

The ECSI winter surveys from 1991 to 1996 in 30–400 m were replaced by summer trawl surveys (1996–97 to 2000–01) which also included the 10–30 m depth range, but these were discontinued after the fifth in the annual time series because of the extreme fluctuations in catchability between surveys (Francis et al 2001). The winter surveys were reinstated in 2007 and this time included additional 10–30 m strata in an attempt to index elephantfish and red gurnard which were officially included in the list of target species in 2012. Only six surveys (2007, 2012, 2014, 2016, 2018, and 2021) provide full coverage of the 10–30 m depth range.

In the 1990s, red gurnard biomass averaged 422 t in the core strata, increasing more than three-fold to 1453 t in 2007. From 2007 to 2014 biomass had an upward trend followed by a substantial decline in 2016 when biomass more than halved (Table 7, Figure 3). The biomass increased again in 2018 to 2043 t, the second highest estimate in the time series, and remained high, at 2068 t in 2021. Biomass for the four core plus shallow strata followed the same general trend as that for the core strata. The proportion of pre-recruit biomass in the core strata varied greatly among surveys, from 2 to 20%, and in 2021 it was 10%. In some years the proportion of pre-recruit biomass in the core plus shallow strata was greater than that of the core strata, indicating that younger fish were more common in shallow water. The proportion of juvenile biomass (based on the length-at-50% maturity) within the core strata was close to zero for all surveys including 2021 when it was 0.4% (Beentjes et al in prep).

**Table 6: Estimates of red gurnard recruited biomass (t) from *Kaharoa* trawl surveys within GUR 1. Red gurnard is assumed to recruit at 30 cm TL. For the west coast North Island trawl survey, core strata are north of New Plymouth.**

| Survey area | Year | Trip code | Biomass (t) | CV(%) |
|---|---|---|---|---|
| Bay of Plenty | 1983 | KAH8303 | 229 | 31 |
| | 1985 | KAH8506 | 27 | 17 |
| | 1990 | KAH9004 | 234 | 11 |
| | 1992 | KAH9202 | 166 | 10 |
| | 1996 | KAH9601 | 185 | 16 |
| | 1999 | KAH9902 | 180 | 17 |
| | 2020 | KAH2001 | 130 | 14 |
| | 2021 | KAH2101 | 85 | 10 |
| Hauraki Gulf | 1984 | KAH8421 | 208 | 21 |
| | 1985 | KAH8517 | 33 | 57 |
| | 1986 | KAH8613 | 124 | 32 |
| | 1988 | KAH8810 | 329 | 25 |
| | 1989 | KAH8917 | 58 | 39 |
| | 1990 | KAH9016 | 64 | 17 |
| | 1992 | KAH9212 | 169 | 7 |
| | 1993 | KAH9311 | 85 | 18 |
| | 1994 | KAH9411 | 98 | 21 |
| | 1997 | KAH9720 | 107 | 22 |
| | 2000 | KAH0012 | 15 | 52 |
| | 2019 | KAH1907 | 120 | 34 |
| | 2020 | KAH2006 | 96 | 12 |
| West coast North Island | 1989 | KAH8918 | 758 | 13 |
| | 1991 | KAH9111 | 1435 | 18 |
| | 1994 | KAH9410 | 1662 | 28 |
| | 1996 | KAH9615 | 1090 | 11 |
| | 1999 | KAH9915 | 610 | 13 |
| | 2018 | KAH1806 | 551 | 14 |
| | 2019 | KAH1906 | 758 | 13 |
| | 2020 | KAH2005 | 824 | 13 |

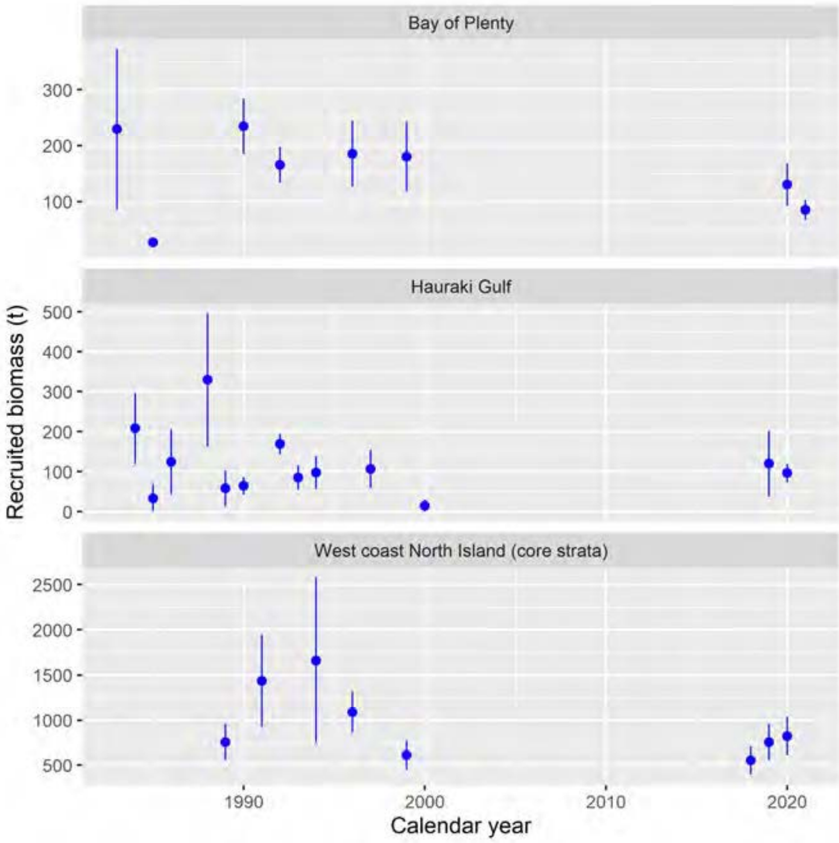



**Figure 2: Estimates of recruited (length ≥ 30 cm) red gurnard biomass (t) from *Kaharoa* trawl surveys within GUR 1. Error bars are ± two standard deviations.**

**Table 7: Relative biomass indices (t) and coefficients of variation (CV) for red gurnard around the North Island and South Island*. Biomass estimates for ECSI in 1991 were adjusted to allow for non-sampled strata (7 & 9 equivalent to current strata 13, 16, and 17). The sum of pre-recruit and recruited biomass values do not always match the total biomass for the earlier surveys because at several stations length frequencies were not measured, affecting the biomass calculations for length intervals. – , not measured; NA, not applicable. Recruited is defined as the size-at-recruitment to the fishery (30 cm). Biomass estimates from current surveys with extreme catchability are denoted with a #.**

| Region | Fishstock | Year | Trip number | Total biomass estimate | CV (%) | Total biomass estimate | CV (%) | Pre-recruit | CV (%) | Pre-recruit | CV (%) | Recruited | CV (%) | Recruited | CV (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1992 | KAH9204 | 572 | 15 | – | – | – | – | – | – | – | – | 454.0 | 15.4 |
| WCSI | GUR 7 | 1994 | KAH9404 | 559 | 15 | – | – | – | – | – | – | – | – | 478.3 | 16.0 |
| | | 1995 | KAH9504 | 584 | 19 | – | – | – | – | – | – | – | – | 501.6 | 21.7 |
| | | 1997 | KAH9704 | 471 | 13 | – | – | – | – | – | – | – | – | 309.8 | 14.5 |
| | | 2000 | KAH0004 | 625 | 15 | – | – | – | – | – | – | – | – | 444.0 | 14.9 |
| | | 2003 | KAH0304 | #270 | 20 | – | – | – | – | – | – | – | – | 253.7 | 20.9 |
| | | 2005 | KAH0503 | 442 | 17 | – | – | – | – | – | – | – | – | 374.7 | 16.2 |
| | | 2007 | KAH0704 | 553 | 17 | – | – | – | – | – | – | – | – | 431.6 | 17.9 |
| | | 2009 | KAH0904 | 651 | 18 | – | – | – | – | – | – | – | – | 400.4 | 19.1 |
| | | 2011 | KAH1104 | 1 070 | 17 | – | – | – | – | – | – | – | – | 798.6 | 18.6 |
| | | 2013 | KAH1305 | 754 | 12 | – | – | – | – | – | – | – | – | 546.5 | 13.4 |
| | | 2015 | KAH1503 | 1 774 | 16 | – | – | – | – | – | – | – | – | 1 335.2 | 18.6 |
| | | 2017 | KAH1703 | 1 708 | 12 | – | – | – | – | – | – | – | – | 1 352.0 | 12.0 |
| | | 2019 | KAH1902 | 1 642 | 16 | – | – | – | – | – | – | – | – | 1 079.0 | 16.0 |
| | | 2021 | KAH2103 | 2 022 | 18 | – | – | – | – | – | – | – | – | 1 663 | 18 |
| North Island east coast | GUR 2 | 1993 | KAH9304 | 439 | 44 | – | – | – | – | – | – | – | – | – | – |
| | | 1994 | KAH9402 | 871 | 16 | – | – | – | – | – | – | – | – | – | – |
| | | 1995 | KAH9502 | 178 | 26 | – | – | – | – | – | – | – | – | – | – |
| | | 1996 | KAH9602 | 708 | 29 | – | – | – | – | – | – | – | – | – | – |
| ECSI (winter) | GUR 3 | | | 30–400 m | | 10–400 m | | 30–400 m | | 10–400 m | | 30–400 m | | 10–400 m | |
| | | 1991 | KAH9105 | 763 | 33 | – | – | NA | NA | – | – | NA | NA | – | – |
| | | 1992 | KAH9205 | 142 | 30 | – | – | 21 | 58 | – | – | 121 | 30 | – | – |
| | | 1993 | KAH9306 | 576 | 31 | – | – | 26 | 45 | – | – | 551 | 31 | – | – |
| | | 1994 | KAH9406 | 123 | 34 | – | – | 2 | 42 | – | – | 121 | 34 | – | – |
| | | 1996 | KAH9606 | 505 | 27 | – | – | 8 | 44 | – | – | 496 | 26 | – | – |
| | | 2007 | KAH0705 | 1 453 | 35 | 2 048 | 27 | 298 | 40 | 494 | 32 | 1 155 | 35 | 1 554 | 27 |
| | | 2008 | KAH0806 | 1 309 | 34 | – | – | 100 | 59 | – | – | 1 210 | 33 | – | – |
| | | 2009 | KAH0905 | 1 725 | 30 | – | – | 62 | 34 | – | – | 1 663 | 30 | – | – |
| | | 2012 | KAH1207 | 1 680 | 28 | 3 515 | 17 | 193 | 40 | 742 | 31 | 1 487 | 27 | 2 773 | 16 |
| | | 2014 | KAH1402 | 2 063 | 25 | 3 215 | 17 | 409 | 45 | 585 | 32 | 1 654 | 23 | 2 630 | 16 |
| | | 2016 | KAH1605 | 941 | 30 | 2 420 | 15 | 63 | 41 | 306 | 19 | 877 | 30 | 2 114 | 15 |
| | | 2018 | KAH1803 | 2043 | 19 | 3 831 | 17 | 308 | 24 | 610 | 21 | 1735 | 20 | 3 221 | 18 |
| | | 2021 | KAH2104 | 2068 | 32 | 3 724 | 19 | 215 | 50 | 422 | 28 | 1854 | 14 | 3 302 | 18 |
| ECSI (summer) | GUR 3 | 1996–97 | KAH9618 | 765 | 13 | – | | – | – | – | – | – | – | – | – |
| | | 1997–98 | KAH9704 | 317 | 16 | – | | – | – | | – | – | – | – | – |
| | | 1998–99 | KAH9809 | 493 | 13 | – | – | – | – | – | – | – | – | – | – |
| | | 1999–00 | KAH9917 | 202 | 20 | – | – | – | – | – | – | – | – | – | – |
| | | 2000–01 | KAH0014 | 146 | 34 | – | – | – | – | – | – | – | – | – | – |

*Assuming areal availability, vertical availability, and vulnerability equal 1.0. Biomass is only estimated outside 10 m. Note: because trawl survey biomass estimates are indices, comparisons between different seasons (e.g., summer and winter ECSI) are not strictly valid.

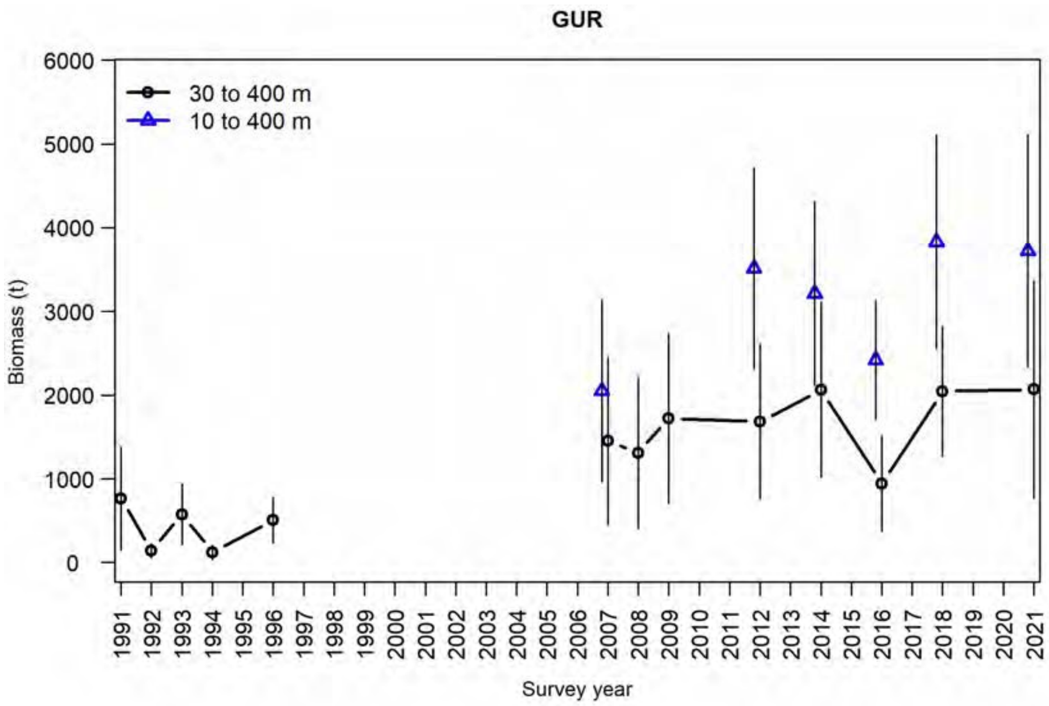



**Figure 3: Red gurnard total biomass for all ECSI winter surveys in core strata (30–400 m), and core plus shallow strata (10–400 m) in 2007, 2012, 2014, 2016, 2018, and 2021. Error bars are ± two standard deviations.**

The additional red gurnard biomass captured in the 10–30 m depth range accounted for 29%, 52%, 36%, 61%, 47%, and 44% of the biomass in the core plus shallow strata (10–400 m) for 2007, 2012, 2014, 2016, 2018, and 2021, respectively, indicating the importance of shallow strata for red gurnard biomass. These observations indicate that the core strata survey (30–400 m) may not be shallow enough to provide an index for sub-mature gurnard.

The addition of the 10–30 m depth range had no significant effect on the length frequency distributions in some years (2007, 2014, and 2018), but in 2012 and 2016 there were abundant 1+ cohorts in 10–30 m that were poorly represented in the core strata. In 2021, a 0+ cohort (13–18 cm) is apparent that was only sampled in the 10–30 m depth range (Beentjes et al in prep). Based on the six surveys that included the 10–30 m strata, there are generally more pre-recruit fish in the shallow strata, suggesting that the core plus shallow strata (10 to 400 m) survey is probably indexing red gurnard abundance, including juveniles. The distribution of red gurnard hot spots varies, but overall this species is consistently well represented over the entire survey area from 10 m to 100 m, but is most abundant in the shallow 10–30 m strata. They are almost absent deeper than 100 m.

**West coast South Island (WCSI) inshore trawl survey**

Relative biomass estimates were consistent from 1992 to 2000 but had declined by the 2003 survey (**Error! Reference source not found.**). Biomass increased after 2003 and, since 2015, has been at record highs, with 2021 being the highest estimate in the time series (2022 t) (**Error! Reference source not found.**, **Error! Reference source not found.**). A large proportion of the biomass had always occurred in the Tasman Bay and Golden Bay region, but markedly more was from the west coast South Island in most years since 2011.

The trend in pre-recruit biomass for the entire survey area has largely followed that of the recruited (> 30 cm) fish; however, in 2019 recruited biomass dropped compared with 2017 and pre-recruited biomass increased, and in 2021 recruited biomass increased and pre-recruited biomass decreased (Figure 5).

Scaled length frequencies are similar between surveys. Larger numbers of smaller fish are found in Tasman Bay and Golden Bay which is thought to be a nursery area, and larger numbers of large fish are found off the west coast. This was more pronounced in 2021 than it was in 2019. However, a wide size range occurs in both areas (see figure 5i from MacGibbon et al 2022). Almost all trawl stations in strata less than 100 m capture red gurnard. Catches in 100–200 m strata decline markedly and no stations in strata deeper than 200 m catch red gurnard.

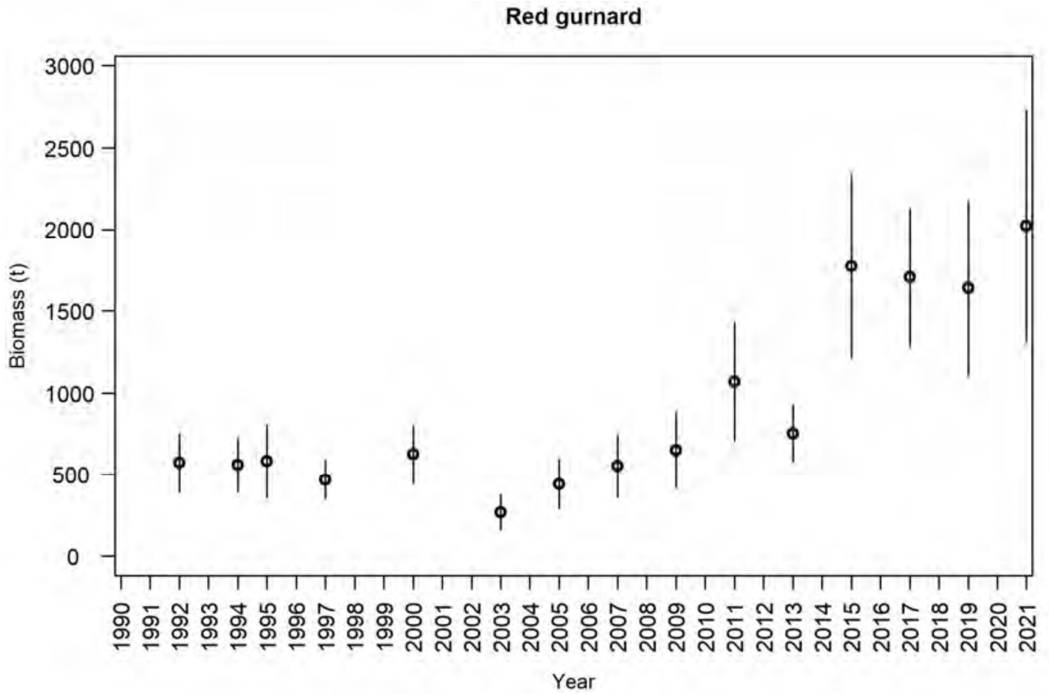



**Figure 4: Red gurnard biomass trends from the west coast South Island inshore trawl survey time series. Error bars are ± two standard deviations.**

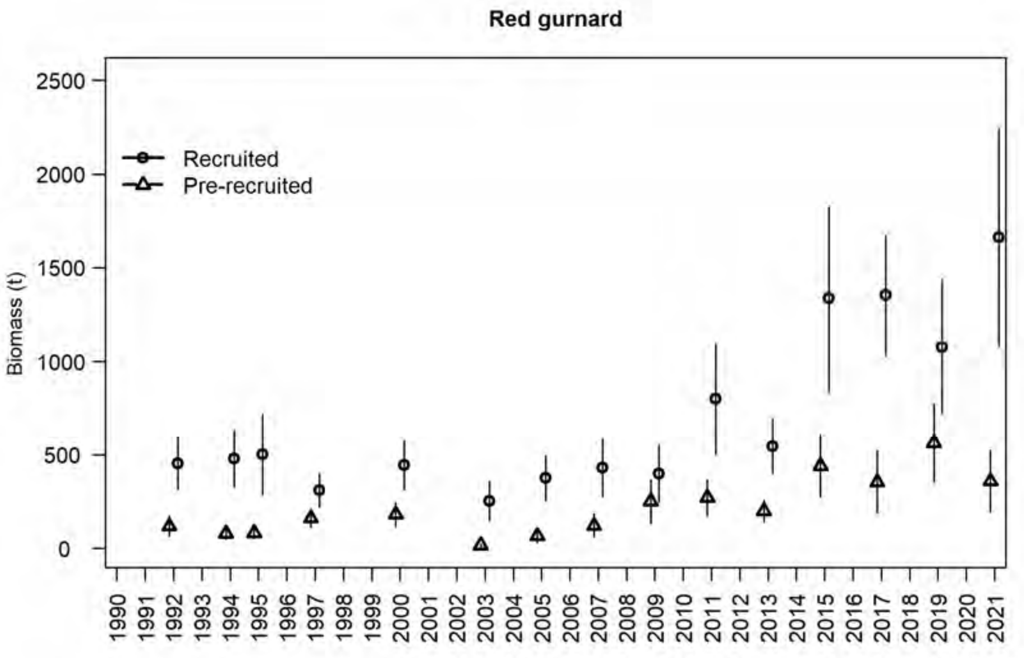



**Figure 5: Red gurnard pre-recruit (< 30 cm) and recruited biomass trends from the west coast South Island inshore trawl survey time series. Error bars are ± two standard deviations.**

## 4.2 CPUE Analyses

### GUR 1

In 2022, McKenzie (in prep) updated CPUE analyses for GUR 1W (west coast, Figure 6), GUR 1E (east Northland and Hauraki Gulf, Figure 7), and GUR 1BP (Bay of Plenty, Figure 8).

The analyses were based on catch and effort data for individual tows reported on TCEPR, TCER, and ERS forms because adequate time series are available in the northern inshore trawl fisheries from 1995–96. Based on catch and effort data from single bottom trawls targeting gurnard, snapper, trevally, tarakihi, barracouta, or John dory, two GLM models were produced for each subarea: one based on the magnitude of positive catch (lognormal distribution), and the other a binomial model of the probability of capture (based on the proportion of tows capturing GUR). The two models were then combined to produce a single series for each sub-area, and the Working Group accepted the combined models as indices of abundance. The data used to generate the GLM models were restricted to core fleets of vessels having had at least three trips in each of three years.

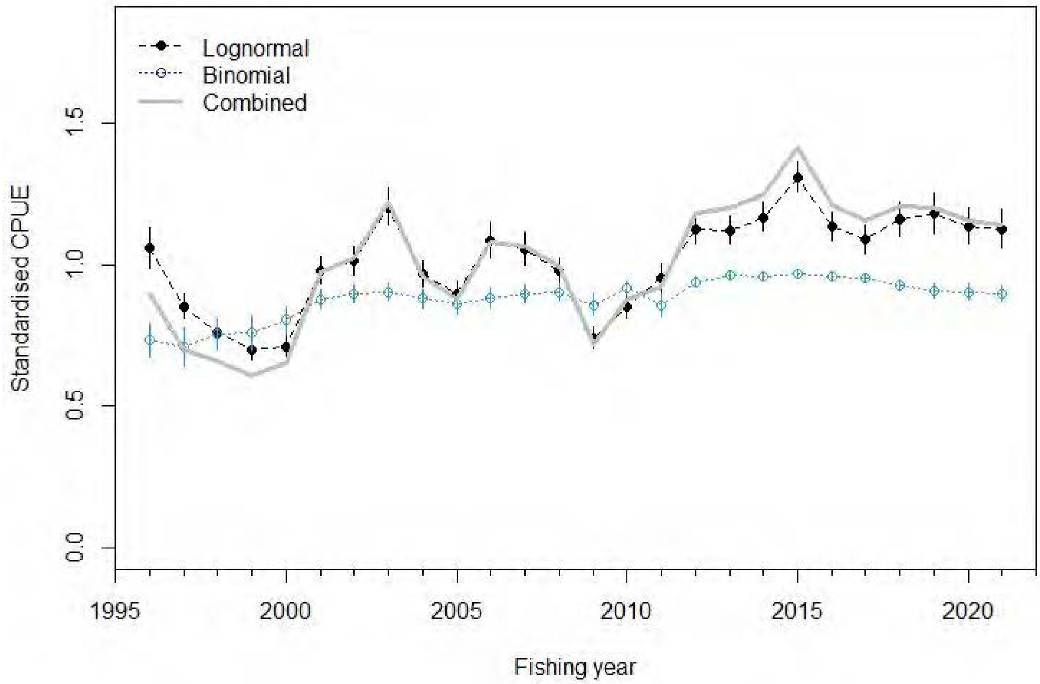



**Figure 6: Standardised probability of catch (binomial model), positive CPUE indices (lognormal model), and combined model for GUR 1W using bottom trawl tow data from TCEPR/ TCER/ERS forms (McKenzie in prep). Error bars are 95% confidence intervals.**

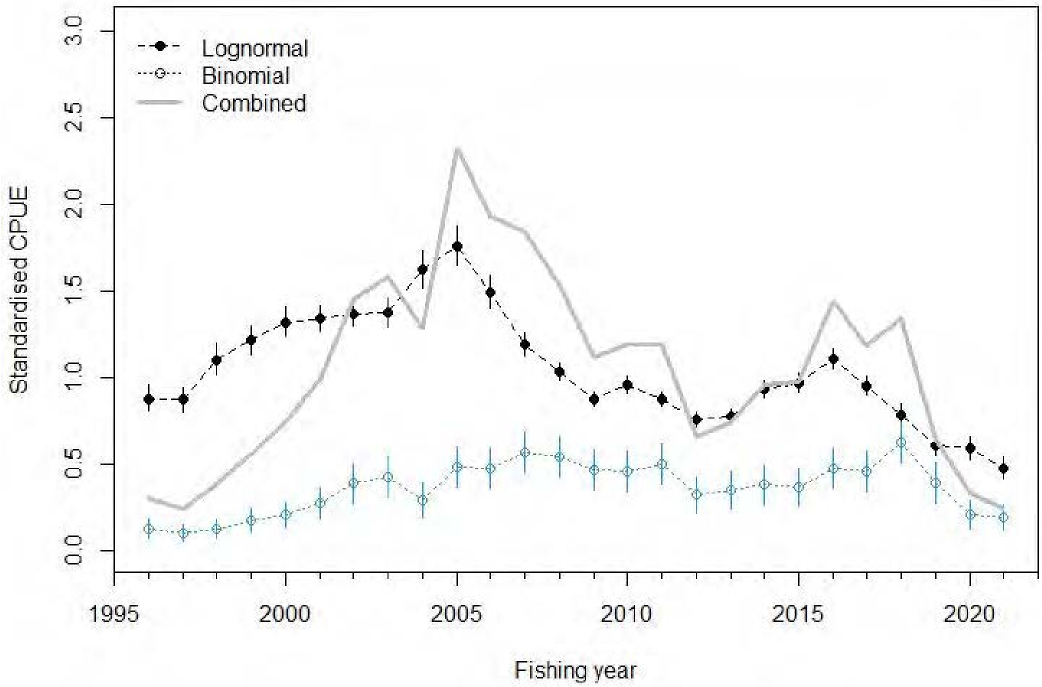



**Figure 7: Standardised probability of catch (binomial model), positive catch CPUE indices (lognormal model), and combined model for GUR 1E using bottom trawl tow data from TCEPR/ TCER/ERS forms (McKenzie in prep). Error bars are 95% confidence intervals.**

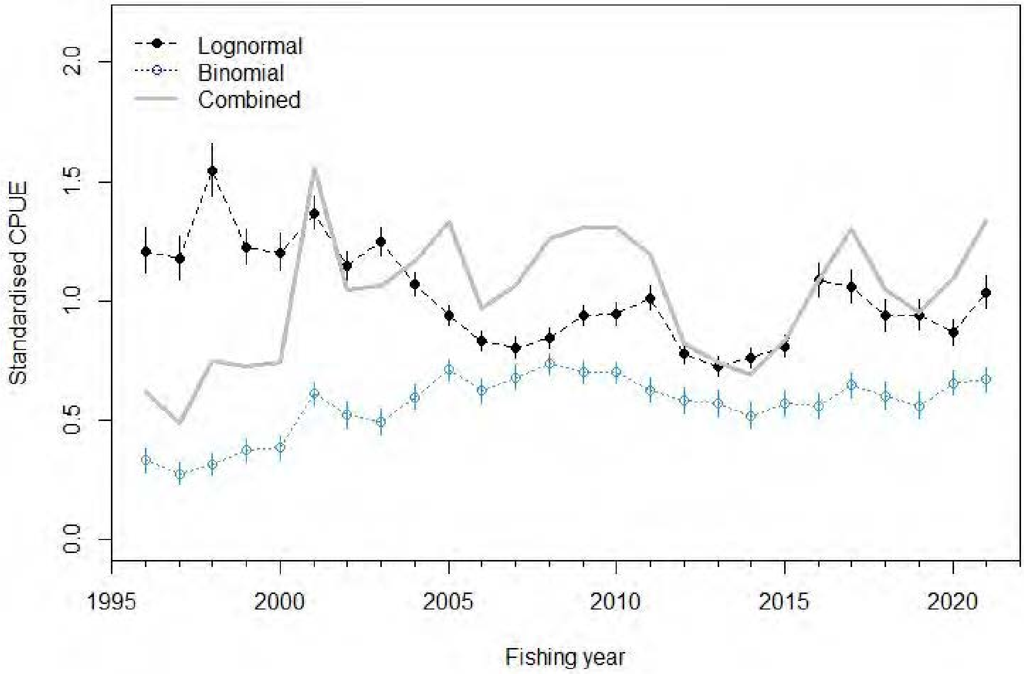



**Figure 8: Standardised probability of catch (binomial model), positive catch CPUE indices (gamma model), and combined model for GUR 1BP using bottom trawl tow data from TCEPR/ TCER forms (Kendrick & Bentley in prep a). Error bars are 95% confidence intervals.**

All three series show strong cyclical fluctuations with a recovery from low levels between 1996 and 1999 to a peak in the early 2000s, followed by a subsequent decline to low levels again between 2009 and 2013, then an increase to levels near, over above the long-term average between 2015 and 2017. In subsequent years the levels have declined (GUR 1W, GUR 1E), or declined then increased again (GUR 1BP). Despite overall similarities, the series differ somewhat with respect to the magnitude of the fluctuations and the specific years for the nadir and the peak.

### Establishing $B_{MSY}$ compatible reference points for GUR 1

In 2013, the Working Group accepted mean standardised bottom trawl CPUE for the period 1995–96 to 2011–12 as $B_{MSY}$-compatible proxies for each of the GUR 1 sub-stocks. All three series were based on combined positive catch and probability of capture models derived from event scale fishing events (i.e., tow). GUR abundance tends to fluctuate in cycles, according to recruitment, and the period was chosen because it included at least one cycle of abundance and high catch. The Working Group accepted the default Harvest Strategy Standard definitions that the Soft Limit and Hard Limit would be one half and one quarter the target for each sub-stock, respectively.

### Future Research Considerations

- Integrate the results of the re-instated west coast North Island (WCNI) trawl survey and CPUE series into the stock assessment.
- Integrate the results of the re-instated Hauraki Gulf trawl survey and CPUE series into the stock assessment.
- Integrate the results of the re-instated Bay of Plenty trawl survey and CPUE series into the stock assessment.
- Age otoliths from recent surveys for the stock assessments.

## GUR 2

GUR 2 is monitored using standardised CPUE from the bottom trawl fishery targeting gurnard, snapper, or trevally.

In 2017, Schofield et al (2018a) updated CPUE analyses for GUR 2. Landings were allocated to daily aggregated effort using methods described by Langley (2014) to improve the consistency of the data collected from the different statutory reporting forms (CELR and TCER). A core fleet of vessels that had completed at least five trips per year in at least seven years was modelled using a Weibull distribution. A shorter time series based on TCEPR and TCER (available since 2007–08) data, analysed at tow by tow resolution, closely resembled the mixed-form series for the years in common.

The NINSWG noted that almost of the records in the aggregated data had catches of gurnard and that a binomial index was flat. As a result, the positive catch index was retained as the key monitoring series.

The indices were updated in 2018 and 2019, and in 2020 a new fisheries characterisation was also carried out. This indicated that the fishery had been stable in the intervening period, and the accepted indices were updated with the addition of data from the ERS – Trawl reporting regime which was introduced for deepwater vessels from 2017–18, and for all other fisheries during 2019. The indices were further updated in 2022, with data to 30 September 2021.

In the longer CPUE series using aggregated data (i.e., PseudoCELR series) there are indications of cyclical variations in abundance with a 4- to 5-year period (Figure 9). There was an overall decreasing trend in CPUE from 1990 to 2007, after which CPUE stabilised and then increased to 2016, before decreasing to 2017. CPUE then increased to 2020, but dropped in 2021. As before, the series using tow level data showed a similar pattern to the longer, daily aggregated, index for years after 2007–08 (Figure 9).

In 2022, a further tow level series was added, including tarakihi as a target species. Tarakihi-target effort has been excluded from previous GUR 2 CPUE standardisations due to the deeper distribution of tarakihi effort. However, depth is included as a covariate in the event level data and the positive catch component of a mixed-target CPUE series, with tarakihi target effort included, and this index shows a similar pattern to both the existing series (Figure 8). However, gurnard are not caught universally in tarakihi-target trawling and a combined (binomial and positive catch) CPUE series is required if tarakihi effort is included.

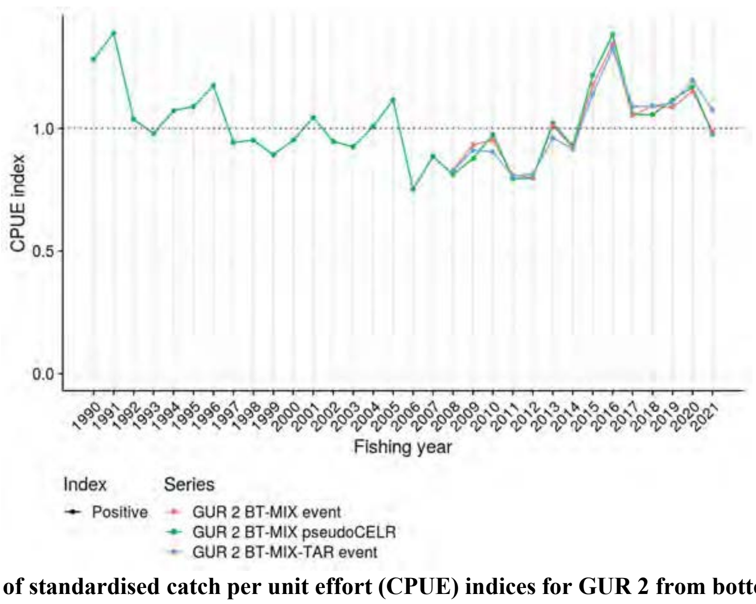



**Figure 9: Comparison of standardised catch per unit effort (CPUE) indices for GUR 2 from bottom trawling targeting gurnard, snapper, and trevally (BT-MIX pseudoCELR; Weibull) combined over all form types, and more recently from data based on TCEPR/ TCER/ER (tow) format data only (BT-MIX event; gamma). The positive catch series using tow format data and including tarakihi as a target species is also illustrated (BT-MIX-TAR event; Weibull). The series are scaled relative to the geometric mean of the years they have in common.**

Chapman-Robson estimates of total mortality (*Z*) for GUR 2, based on the age composition of bottom trawl landings in 2009–10, were 0.518 (SE = 0.0159, CV=3.1%) and 0.632 (0.0196, 3.1), depending on whether the age at full recruitment was at 2 or 3 years (Parker & Fu 2012). Assuming an instantaneous rate of natural mortality of 0.307, fishing mortality was estimated to be 0.189 or 0.303.

Although it was not possible to produce reliable estimates of spawner biomass per recruit based targets of *F* (due to unreliable estimates of growth rate and size at maturity), estimates of *F* from this study were either lower or approximately equal to the estimate of natural mortality (depending on the age at full recruitment assumed). Assuming that the fishery is sampling the age structure of the population, and given that catches and standardised CPUE have been reasonably constant over the last decade, these results suggest that GUR 2 was not over-exploited in 2010, and that the stock is likely to be at or above $B_{MSY}$.

**Establishing $B_{MSY}$ compatible reference points**

In 2014, the NINSWG adopted mean CPUE from the (BT(MIX)) model for the period 1990–91 to 2009–10 as a $B_{MSY}$-compatible proxy for GUR 2. In 2020 the reference period was extended from 1991 to 2018, on the grounds that the new period included two peaks in abundance. The Working Group adopted the default Harvest Strategy Standard definitions for the Soft Limit and Hard Limit of one half and one quarter the target, respectively.

**Future research considerations**

- Include tarakihi target effort in future tow-level indices for GUR 2 and consider the inclusion of tarakihi target effort in CPUE analyses for other gurnard stocks.

**GUR 3**

Prior to 2022, GUR 3 was monitored based on trends in standardised CPUE indices from the main trawl fisheries: the flatfish target fishery and a mixed trawl fishery (targeting red cod, giant stargazer, barracouta, tarakihi, and red gurnard). These indices were derived from data from the main inshore statistical areas of GUR 3 (018, 020, 022, 024, 026, 025, and 030).

In 2022, the CPUE analyses were revised and restricted to Pegasus Bay (Statistical Area 020) and Canterbury Bight (022) to enable a more direct comparison with the ECSI trawl survey biomass indices. The CPUE analyses were also partitioned by depth (proxied by target species) to be comparable with the depth partition of the trawl survey indices. The BT-MIX CPUE series was derived from trawls targeting red cod, tarakihi, and barracouta and is comparable to the longer time series of trawl surveys encompassing the 30–400 m depth range, while the BT-FLA CPUE indices are comparable with the shallower area (10–30 m) sampled by the more recent trawl surveys.

The catch and effort data from the two fisheries were aggregated (‘rolled up’) to a standard vessel-day format for the period 1989–90 to 2020–21. A core fleet was defined for each data set and CPUE indices were derived using a delta-lognormal modelling approach, including the explanatory variables fishing year, vessel, month, target species, statistical area, and fishing duration to model the probability of red gurnard catch (binomial model) and the magnitude of positive catches (lognormal model).

The two sets of CPUE indices increased considerably over the time series, although the scale of the increase was substantially higher for the BT-FLA (8-fold) compared with the BT-MIX CPUE indices (3 fold). The BT-MIX indices were the preferred set of indices because they encompassed data from a broader area compared with the BT-FLA fishery. There has also been a marked reduction in the scale of the BT-FLA fishery in recent years due to the recent retirement of several vessels and considerably higher variability in the associated CPUE indices.

The scale of the increase in the BT-MIX CPUE indices is comparable with the overall increase in the biomass indices from the 30–400 m core area of the ECSI trawl survey, although there is some variability in the trends in the two sets of indices particularly during the 2010s (Figure 10).

A separate CPUE analysis was conducted for the FLA trawl fishery in the Otago and Southland area (Statistical Areas 024, 025, 026, and 030) (BT-SouthFLA). From 2000, the indices increased 3–4 fold, with generally similar annual trends in the indices as the BT-FLA and BT-MIX CPUE indices (Figure 11).

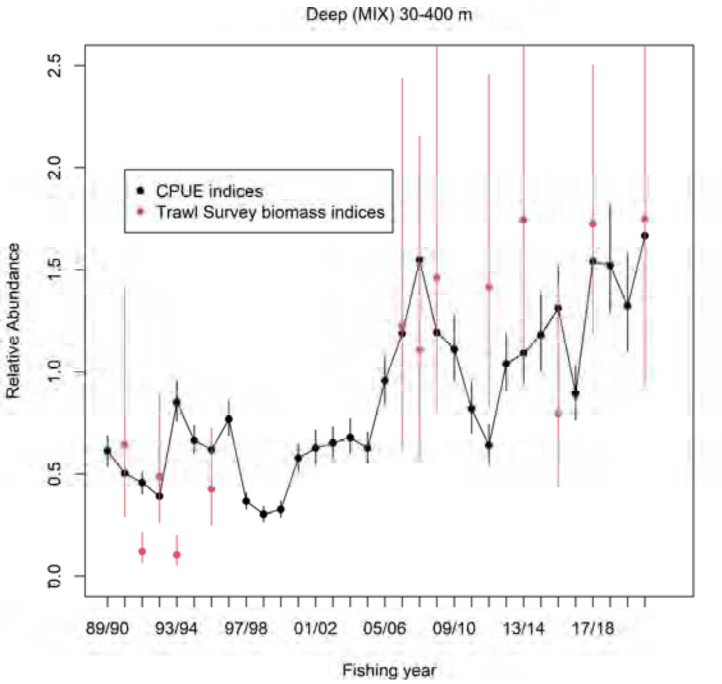



**Figure 10: A comparison of the standardised BT-MIX CPUE indices and the trawl survey biomass estimates for red gurnard from the winter ECSI inshore trawl survey for the 30–400 m depth strata. Error bars show ±95% confidence intervals. Both sets of indices have been normalised to the average for the years with a survey biomass index.**

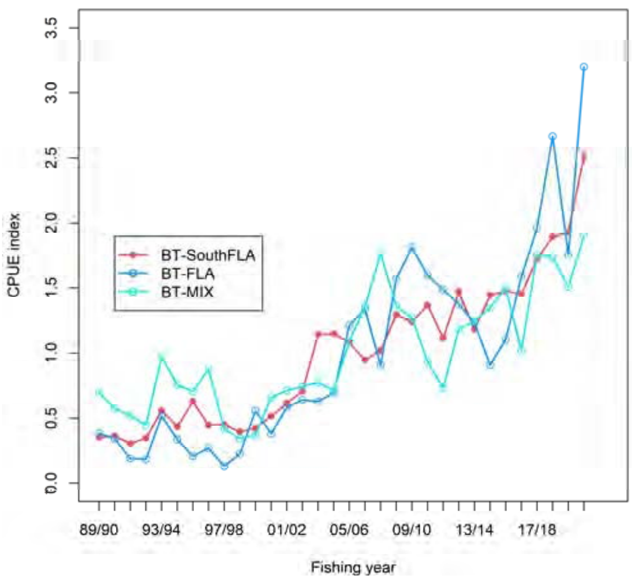



**Figure 11: A comparison of the standardised BT-MIX, BT-FLA, and Southland/Otago FLA (BTSouthFLA) red gurnard CPUE indices.**

## GUR 7

Previously, CPUE indices were derived for the main trawl fisheries in GUR 7. The most recent analysis was completed in 2017 and included CPUE indices for the west coast South Island flatfish (WCSI-FLA) and mixed (WCSI-MIX) trawl fisheries. The trends in the CPUE indices deviated from the time series of red gurnard biomass indices from the WCSI trawl survey. In 2017, the Plenary adopted the trawl survey biomass indices as the main tool for monitoring GUR 7 and the CPUE indices have not been subsequently updated.

### 4.3 Stock assessments

**GUR 3**

The first fully quantitative stock assessment of GUR 3 was conducted in 2022. Previously, GUR 3 was assessed using partial quantitative stock assessments based on standardised CPUE indices.

The stock assessment was conducted using an age-structured population model implemented in Stock Synthesis. The model incorporated data to the 2020–21 fishing year (2021 model year). The input data were limited to commercial catches for 1985–2021, trawl CPUE indices (MIX), and *Kaharoa* ECSI trawl survey biomass indices and length/age compositions (1991–2021).

**Catches**

Commercial catch data are available for the GUR 3 fishery from 1931. However, the catch data are considered less reliable from the period prior to the introduction of the Quota Management System in 1986. The model was initialised in 1985 assuming equilibrium, exploited conditions. Commercial catch included in the stock assessment is shown in Figure 11. An initial model including the full catch series from 1931 did not perform as well due to implausibly high estimates of exploitation rates.

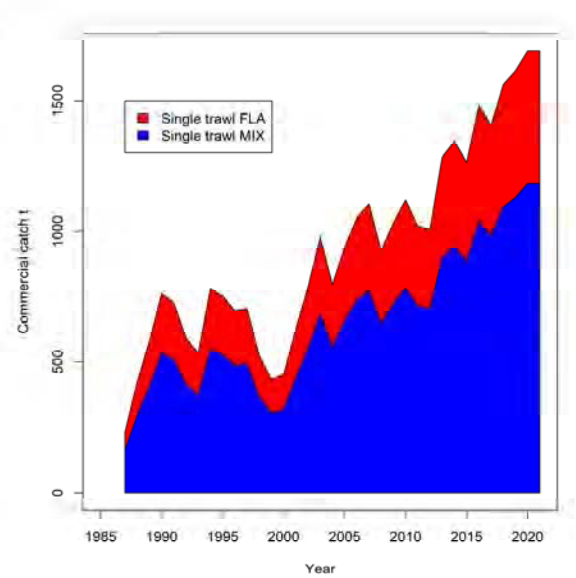



**Figure 11: Commercial catch for GUR 3 included in the stock assessment models.**

The model data set was configured to include the red gurnard catch from two commercial trawl fisheries: the flatfish trawl fishery and the deeper mixed trawl fishery. Reported annual catches were increased by 10% to account for an assumed level of under-reporting of catches from the commercial fishery. No length or age composition data are available from the commercial fishery.

Estimates of annual recreational catches of red gurnard from GUR 3 are small (< 5 t) and were not included in the assessment model.

There are no estimates of customary catch available for GUR 3. Recent customary catches are likely to have been a minor component of the total catch and are not explicitly included in the model catch history.

**Trawl survey**

The *Kaharoa* east coast South Island inshore trawl survey commenced in 1991. Red gurnard is one of the target species for the trawl survey and there is comprehensive biological sampling of the red gurnard catch (including the collection of otoliths). The survey was conducted in winter (April-May) during 1991–1996 and 2007–2021 (N=13). A separate set of trawl surveys was conducted in summer (December) during the intervening years (1997–2001, N= 6).

Initially, the trawl survey area encompassed the 30–400 m depth range. From 2007, the survey area was extended to include the 10–30 m depth range, primarily to improve the monitoring of red gurnard; approximately 50% of the red gurnard trawl survey biomass is within the shallower area of the survey although the proportion varies between surveys. Catches of red gurnard in the deeper portion (> 30 m) of the survey area generally comprised a higher proportion of larger male fish compared with the shallower area of the survey.

Age compositions were available from three early winter surveys (1992, 1993, and 1994) and length compositions were used for the remainder of the surveys.

**CPUE indices**

CPUE indices were derived from the daily catch and effort data from the mixed inshore bottom trawl fishery in Pegasus Bay/Canterbury Bight. The fishery included trawl records from targeting red cod, barracouta, and tarakihi (BT-MIX). The CPUE indices from the FLA trawl fishery were not included in the assessment modelling due to the recent retirement of several vessels and considerably higher variability in the associated CPUE indices.

**Model structure and assumptions**

A statistical age-structured population model for GUR 3 was implemented using Stock Synthesis (Methot & Wetzell 2013). Input data are listed in Table 8. The main model structural assumptions for the base model are as follows:

- The initial population (1985) was assumed to be an exploited, equilibrium state. The population is partitioned by sex and consists of 10 age classes, including a plus group. The model data period is 1985–2021 (the 2021 model year represents the 2020–21 fishing year) with no seasonal structure.
- Biological parameters for growth and natural mortality are available for GUR 3 and were fixed (Table 9). Estimated parameters are listed in Table 10.
- Recruitment was parameterised using a Beverton-Holt stock-recruitment relationship (SRR) with a steepness parameter ($h$) of 0.85. Recruitment deviates were estimated for 1985–2020. Recruitment for 2021 was assumed based on the average level of recruitment from the stock-recruitment relationship.
- For each *Kaharoa* trawl survey series, age based selectivities were parameterised using a sex-specific logistic function. Separate selectivities were estimated for the three sets of surveys: winter 30–400 m, summer 30–400 m, and winter 10–400 m. The trawl survey catchability coefficients ($q$) were freely estimated.
- A single commercial fishery selectivity was parameterised as an age-based logistic function, equivalent for both sexes. The selectivity parameters were fixed at values to approximate full selectivity of fish at a length of about 30 cm (TL), the minimum length of red gurnard in the landed catch.
- The initial (1985) fishery mortality rates for the two fisheries were estimated, informed by prior distributions that assumed relatively high initial levels of fishing mortality.
- The BT-MIX CPUE indices were assigned a CV of 0.20 based on the RMSE of the fit to the indices from preliminary model runs.
- The *Kaharoa* trawl survey length compositions were assigned an Effective Sample Size (ESS) of 10, while the age compositions were assigned a higher weighting (ESS 20). These ESS values generally approximate the relative weighting of the compositional data recommended following the approach of Francis (2011). Further evaluation of the relative weighting of the compositional data was conducted as sensitivities to the base assessment model.

The base model provided a good fit to the time series of CPUE indices. The model fitted the general increase in the 30–400 m winter trawl survey biomass indices, although it under-estimated the overall magnitude of the increase between the two time blocks (1991–1996 and 2007–2021) (Figure 12). The model also fitted the two shorter series of trawl survey biomass indices (summer 30–400 m and winter 10–400 m) and provided a reasonable fit to associated age and length composition data from the trawl surveys.

**Table 8: Summary of input data sets for the Base Case assessment model. The relative weighting includes the Effective Sample Size (ESS) of age/size composition data and the coefficient of variation (CV) associated with the abundance data. Note that model year 2021, is fishing year 2020–21, and includes the trawl survey conducted in March 2021. Nobs is number of observations.**

| Data set | Model years | Nobs | Error structure | CVs/ESS |
|---|---|---|---|---|
| CPUE indices BT-MIX | 1990–2021 | 32 | Lognormal | 0.20 |
| **Trawl survey indices** | | | | |
| Winter 30-400m | 1991, 1992, 1993, 1994, 1996, 2007, 2008, 2009, 2012, 2014, 2016, 2018, 2021 | 13 | Lognormal | 0.19–0.35 |
| Summer 30-400m | 1997, 1998, 1999, 2000, 2001 | 5 | Lognormal | 0.13–0.34 |
| Winter 10-400m | 2007, 2012, 2014, 2016, 2018, 2021 | 6 | Lognormal | 0.15–0.27 |
| **Trawl survey age comp** | | | | |
| Winter 30-400m | 1992, 1993, 1994 | 3 | Multinomial | ESS 20 |
| **Trawl survey length comp** | | | | |
| Winter 30-400m | 1991, 1996, 2007, 2008, 2009, 2012, 2014, 2016, 2018, 2021 | 10 | Multinomial | ESS 10 |
| Summer 30-400m | 1997, 1998, 1999, 2000, 2001 | 5 | Multinomial | ESS 10 |
| Winter 10-400m | 2007, 2012, 2014, 2016, 2018, 2021 | 6 | Multinomial | ESS 10 |

**Table 9: Details of parameters that were fixed in the base model.**

| | | |
|---|---|---|
| Natural mortality | female | 0.29 $y^{-1}$ |
| | male | 0.35 $y^{-1}$ |
| Stock-recruit steepness (Beverton & Holt) | | 0.85 |
| Std deviation of rec devs (sigmaR) | | 0.6 |
| Proportion mature | | 0 for age 1, 0.5 for age 2, 1 for ages > 2 |
| Length-weight [mean weight (kg) = $a$ (length (cm))$^b$] | | $a$ = 5.3 × 10-6, $b$ = 3.19 |
| Growth parameters - female | | $L\infty$ = 48.2, $k$ = 0.44, Length1=19.4 |
| | male | $L\infty$ = 42.2, $k$ = 0.49, Length1=19.4 |
| Coefficients of variation for length-at-age | | 0.10 |
| Selectivity BT commercial | | 2 |

**Table 10: Estimated parameters for the base model.**

| Parameter | Number of parameters | Parameterisation, priors, constraints |
|---|---|---|
| Ln$R_0$ | 1 | Uniform, uninformative |
| Rec devs (1980–2020) | 41 | SigmaR 0.6 |
| Selectivity trawl surveys (3) | 8 | Logistic, female offset |
| Trawl Survey ln $q$ | 3 | Free |
| Initial $F$ | 2 | Normal (0.4, 0.2) |

The inclusion of data from the separate 10–400 m and 30–400 m trawl survey series duplicates the data from the deeper area of the survey from overlapping years (2007–2021) rather than configuring the recent data as a separate time series of 10–30 m trawl survey indices. The inclusion of the entire depth range of the recent trawl surveys enables the whole population of red gurnard to be monitored as a single index (with the assumption of full selectivity of older fish). A sensitivity run with the 10–30 m and 30–400 m trawl surveys gave similar results.

The CPUE and trawl survey indices indicate stock abundance has been higher since the late 2000s. The model estimates that the increase in abundance is attributable to higher recruitment in the mid-2000s and from 2010 to 2019, with exceptionally high recruitments in 2016 and 2019 (Figure 13). There are no age composition data available to inform the estimates of recruitment, although the increase in recruitment is consistent with the substantial increase in the trawl survey biomass indices for smaller (less than 30 cm) red gurnard from 2007 (the pre-recruit index was not explicitly fitted in the model).

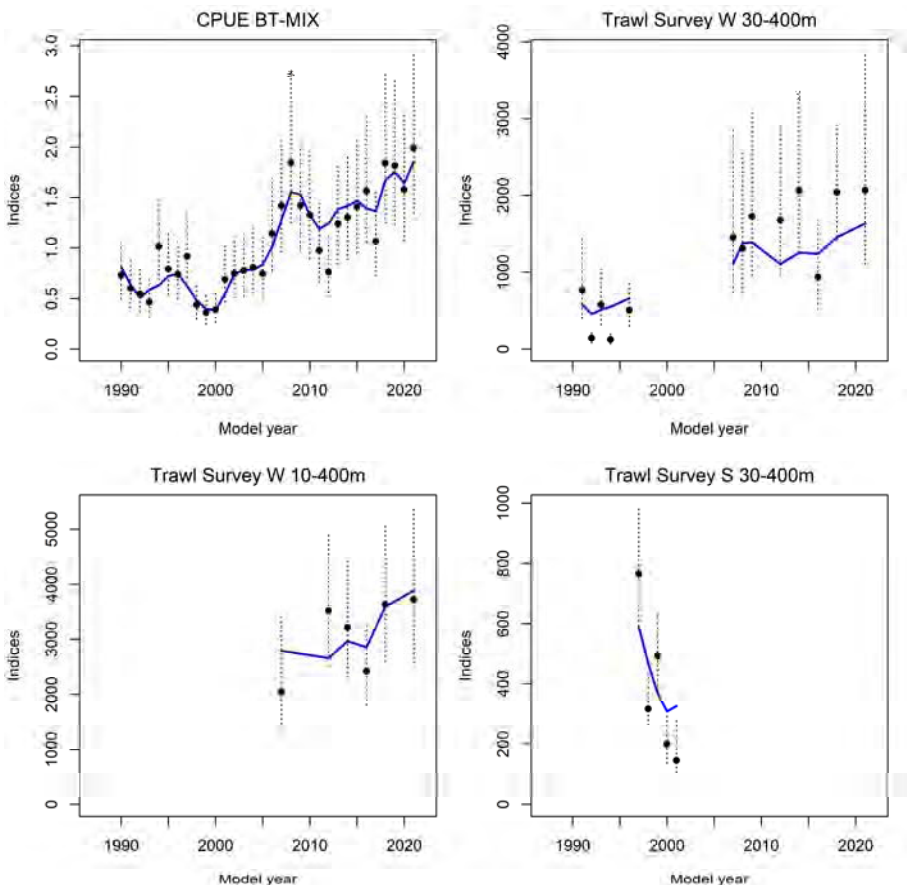



**Figure 12: The fit (MPD) to the trawl survey biomass indices (points) for the base model option. W=winter and S=summer.**

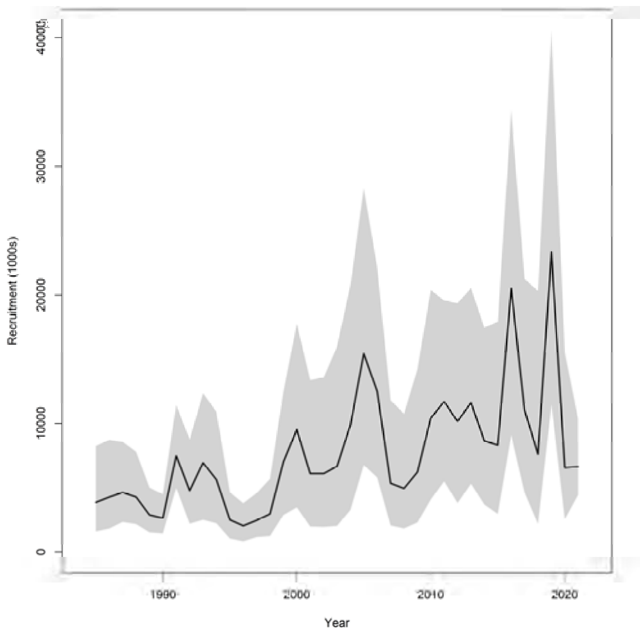



**Figure 13: Annual recruitment for the base model (MCMC results). Recruitment deviates were estimated for 1985–2020. The line represents the median and the shaded area represents the 95% credible interval.**

During the model development a wide range of model options were evaluated to investigate key model assumptions. A set of model options were retained as key sensitivities to capture plausible uncertainty in assessment results, including: a lower (0.25) value of natural mortality (compared with females = 0.29 and males = 0.35), excluding the CPUE indices from 2007 onwards, and limiting the model catch to the FMA 3 (ECSI) portion of GUR 3 (Table 11). FMA 5 has accounted for approximately 25% of the GUR 3 catch since the late 1990s, however, this area is not monitored by the CPUE and trawl survey abundance indices. The sensitivities were treated as single changes from the base model.

**Table 11: Description of model sensitivities.**

| Sensitivity run | Description |
|---|---|
| ExCPUE2007 | Exclude 2007–2021 CPUE indices |
| FMA3catch | Exclude non FMA3 catch |
| LowM | Natural mortality $M$ 0.25 |

Stock status (current 2021 = 2020–21 fishing year and forecast to 2025–26) for the GUR 3 spawning biomass was reported relative to the default hard limit of 10% $SB_0$ and the default soft limit of 20% $SB_0$ and interim target biomass level of 35% $SB_0$. Fishing mortality (2021) was reported relative to $F_{SB40\%}$ reference level. The reference points represent the default values for a medium productivity stock as described by the Harvest Strategy Standard Operational Guidelines.

For the base model and the range of model sensitivities, biomass is estimated to have increased considerably from 2007 and current (2021) stock status is estimated to be well above the target biomass level although there is considerable uncertainty associated with the estimate of current stock status (Table 12, Figure 14).

For all model options, current rates of fishing mortality are near the fishing mortality threshold ($F_{SB40\%}$) (Table 12, Figure 15).

For all model options, estimates of current and equilibrium yield were derived for the stock based on the fishing mortality rate that corresponds to the interim target biomass level (Table 13). Equilibrium yields at the interim target biomass level are estimated to be about 800–1000 t per annum (for GUR 3). $F_{SB40\%}$ yields at 2020–21 biomass levels are substantially higher than the equilibrium yields (about 1400–1800 t).

**Table 12: Estimates of current (2020–21) and virgin spawning biomass (t) (median and the 95% confidence interval from the MCMCs) and probabilities of current biomass being above specified levels and probability of fishing mortality being below the level of fishing mortality associated with the interim target biomass level.**

| Model option | $SB_0$ | $SB_{2021}$ | $SB_{2021}/SB_0$ | Pr($SB_{2021}$ > X% $SB_0$) | Pr($SB_{2021}$ < X% $SB_0$) | |
|---|---|---|---|---|---|---|
| | | | | 35% | 20% | 10% |
| Base | 6 307 | 4 061 | 0.644 | 0.999 | 0 | 0 |
| | (5 552–7 749) | (2 500–6 808) | (0.435–0.924) | | | |
| CatchFMA3 | 4 804 | 3 083 | 0.638 | 0.995 | 0 | 0 |
| | (4 250–5 814) | (1 903–5 096) | (0.434–0.906) | | | |
| exCPUE2007 | 6 475 | 4 397 | 0.684 | 0.997 | 0.001 | 0.001 |
| | (5 658–7 761) | (2 542–7 531) | (0.428–0.993) | | | |
| LowM | 6 164 | 3 123 | 0.506 | 0.960 | 0.007 | 0.004 |
| | (5 592–6 969) | (1 941–4 784) | (0.325–0.722) | | | |

| | $F_{SB40\%}$ | $F_{2021}/F_{SB40\%}$ | Pr($F_{2021}$ < $F_{SB40\%}$) |
|---|---|---|---|
| Base | 0.2028 | 0.996 | 0.506 |
| | | (0.627–1.513) | |
| CatchFMA3 | 0.2028 | 1.004 | 0.492 |
| | | (0.645–1.517) | |
| exCPUE2007 | 0.2028 | 0.925 | 0.632 |
| | | (0.569–1.499) | |
| LowM | 0.1857 | 1.297 | 0.087 |
| | | (0.884–1.987) | |

**Table 13: Estimates of equilibrium yield (t) at $F_{SB40\%}$ and yield at the 2020–21 biomass levels for the base model and the model sensitivities. The values represent the median and the 95% confidence interval from the MCMCs.**

| Model option | $F_{SB40\%}$ | |
|---|---|---|
| | Equilibrium Yield | Yield at current biomass |
| Base | 986 | 1 617 |
| | (867–1211) | (1 411–1 855) |
| CatchFMA3 | 751 | 1 229 |
| | (664–908) | (1 069–1 397) |
| exCPUE2007 | 1 012 | 1 655 |
| | (884–1 213) | (1 451–1 888) |
| LowM | 932 | 1 632 |
| | (846–1 054) | (1 390–1 865) |

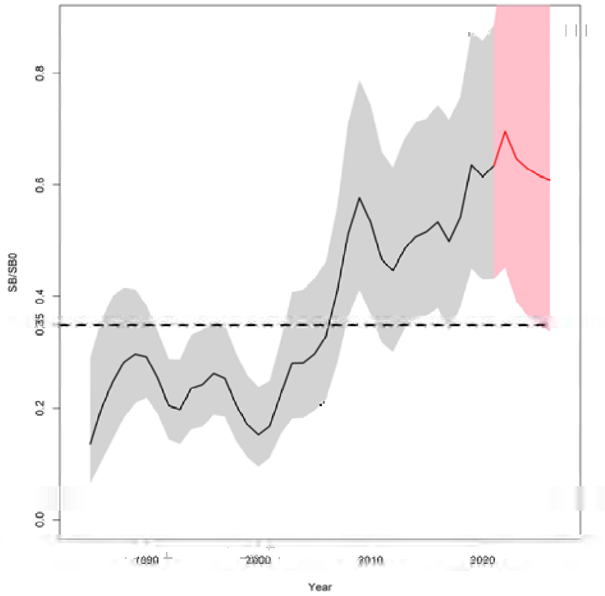



**Figure 14: Annual trend in spawning biomass relative to the 35% $SB_0$ interim target biomass level for the base model. The line represents the median and the shaded area represents the 95% credible interval. The projection period (2022–2026) is in red. The dashed line represents the interim target level.**

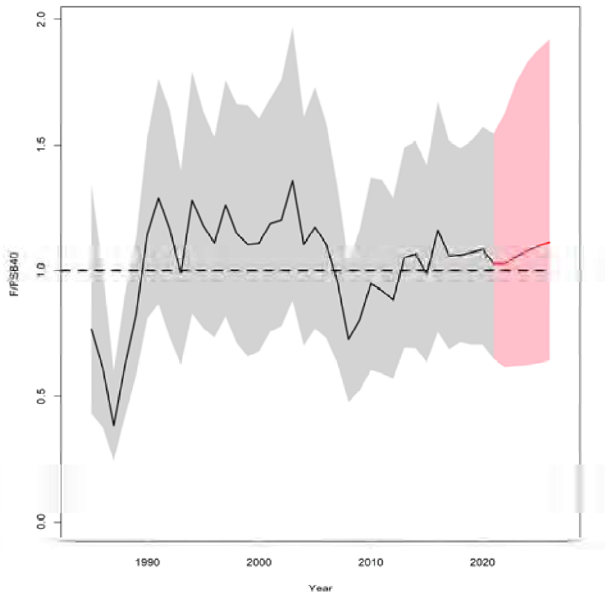



**Figure 15: Annual trend in fishing mortality relative to the $F_{SB40\%}$ interim threshold exploitation level for the base model. The line represents the median and the shaded area represents the 95% credible interval. The projection period (2022–2026) is in red. The dashed line represents the interim threshold level.**

## Projections

Projections were conducted for the base model. Stock projections were conducted for the 5-year period following the terminal year of the model (i.e., 2022–2026). Projections assumed future recruitments were resampled from the average level of recent recruitment (2011–2020) and variation equivalent to sigmaR. Commercial catches in the projection period were held constant at the current TACC of 1500 t with an additional 10% allowance for unreported catch. There was no explicit allowance for unreported catch, recreational catch, or customary catch.

For the base case, stock abundance is predicted to remain at about the current level during the projection period, well above the target biomass level (Table 14). However, there is considerable uncertainty in the stock projections due to the uncertainty associated with the estimates of recent recruitment (especially the strong 2016 and 2019 year classes).

**Table 14: Estimates of projected (2025–26) spawning biomass (t) (median and the 95% confidence interval from the MCMCs) and probability of the spawning biomass being above default biomass limits and the interim target level in 2026 from the base model projections.**

| Model option | $SB_{2026}/SB_0$ | Pr(SB 2026 < X% $SB_0$) | | Pr(SB 2026 > X% |
|---|---|---|---|---|
| | | 10% | 20% | 35% |
| **Base** | 0.609 (0.337–0.970) | 0 | 0 | 0.970 |

## Qualifying comments

The base model includes the catch from the entire GUR 3 QMA, whereas the trawl survey and CPUE indices are limited to FMA 3. Since 2000, approximately 25% of the GUR 3 catch has been taken from outside of FMA 3 (principally in Southland FMA 5). Limiting the model catch to FMA 3 did not appreciably change the estimate of current stock status.

There are no direct observations to determine the selectivity of the commercial fishery and the commercial catch is assumed to comprise fish larger than 30 cm.

Reference points ($SB_0$ based) are derived from the average level of recruitment during 1985–2020. There was an apparent shift in the productivity of GUR 3 from the mid-2000s. The increasing catches since the mid-2000s were sustained by the higher level of recruitment. Recent strong recruitments (in 2016 and 2019) are supported by higher abundance of pre-recruit red gurnard from recent trawl surveys but are yet to be confirmed from age sampling.

The model does not include GUR 3 catches prior to 1987 and the initial level of fishing mortality (in 1985) is estimated.

There are large differences between MPD and MCMC results for $R_0$ that require further investigation.

## Future research considerations

- Determine the age compositions of red gurnard sampled by the ECSI trawl surveys, particularly for one or two of the most recent surveys. These data will improve estimates of recent recruitments, provide for more recent estimates of growth rate and the CV of length at age, and potentially resolve the differences between MPD and MCMC results. Also, consider re-examining the earlier 1992–1994 age estimates.
- Determine the length/age composition of the east coast commercial catch of GUR 3 from primarily the BT-MIX but also the BT-FLA trawl fisheries to inform the model regarding the selectivity of the two fisheries.
- Consider standardising the LF and age survey data outside the model.
- Consider spatio-temporal modelling of the trawl survey biomass data potentially including environmental covariates (INLA or VAST).
- Re-examine summer trawl survey data for maturity and the winter survey data for changes in the length-weight relationships.
- Investigate stock relationships between FMAs 3 and 5.
- Explore changes in commercial mesh sizes over time.

## GUR 7

The first fully quantitative stock assessment of GUR 7 was conducted in 2022; previous assessments were partial quantitative assessments based on the WCSI trawl survey series. The stock assessment was conducted using an age-structured population model implemented in Stock Synthesis. The model incorporated data to the 2020–21 fishing year (2021 model year). The input data were limited to commercial catches (1987–2021) and *Kaharoa* WCSI trawl survey biomass indices and length/age compositions (1992–2021, N = 15).

## Catches

Commercial catch data are available for the GUR 7 fishery from 1931. However, the catch data are considered less reliable from the period prior to the introduction of the Quota Management System in

1986. There are no other composition or abundance data available prior to 1987. The model was initialised in 1987 assuming equilibrium, exploited conditions. Catch data used in the stock assessment are presented in Figure 16.

The model data set was configured to include a single commercial trawl fishery. There was no allowance for the under-reporting of catches from the commercial fishery. No catch composition (length or age) data are available from the commercial fishery.

Estimates of annual recreational catches of red gurnard from GUR 7 are relatively small (10–48 t) and were not included in the assessment model.

There are no estimates of customary catch available for GUR 7. Recent customary catches are likely to have been a minor component of the total catch and are not explicitly included in the model catch history.

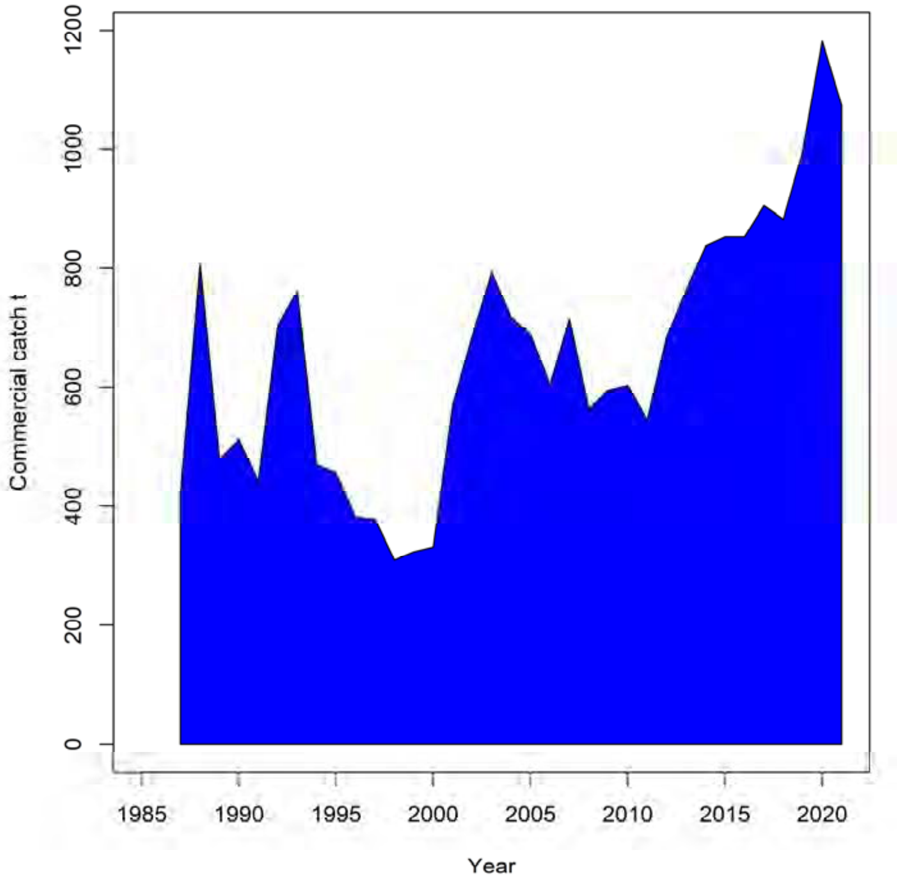



**Figure 16: Commercial catch for GUR 7 included in the stock assessment models.**

### Trawl survey

The west coast South Island inshore trawl survey, including the Tasman Bay/Golden Bay area, commenced in 1992 and has been conducted biennially since 2002. Red gurnard is one of the target species for the trawl survey; red gurnard is one of the main species caught and there is comprehensive sampling of the red gurnard catch (including the collection of otoliths).

Age compositions were available from five surveys (1994, 1995, 2003, 2005, and 2007) and length compositions were available for the remainder of the surveys.

### Model structure and assumptions

A statistical age-structured population model for GUR 7 was implemented using Stock Synthesis (Methot & Wetzell 2013). Input data are listed in Table 15. The main model structural assumptions for the base model were as follows:

- The initial population (1987) was assumed to be in an exploited, equilibrium state. The population was partitioned by sex and consists of 10 age classes, including a plus group. The model data period was 1987–2021 (the 2021 model year represents the 2020–21 fishing year) with no seasonal structure.
- Biological parameters for growth and natural mortality are available for GUR 7 and were fixed (Table 16). Estimated parameters are listed in Table 17.
- Recruitment was parameterised using a Beverton-Holt stock-recruitment relationship (SRR) with a beta prior assumed for the steepness parameter. Recruitment deviates were estimated for 1987–2020. Recruitment for 2021 was assumed based on the average level of recruitment from the stock-recruitment relationship.
- Age based selectivity for the *Kaharoa* trawl survey was parameterised using a sex-specific logistic selectivity function. The trawl survey catchability coefficient ($q$) was parameterised with a relatively uninformative prior.
- Commercial fishery selectivity was an age-based logistic function with the two parameters informed by priors that approximate full selectivity of fish at a length of about 30 cm (TL), the minimum size of red gurnard in the landed catch. No length or age data were available from the commercial fishery.
- The initial (1987) fishing mortality rate was estimated, informed by a prior distribution that assumed a relatively high initial fishing mortality rate.
- The trawl survey age and length compositions were assigned a relative high weighting (Effective Sample Size (ESS) of 50). The high weighting reflected the comprehensive sampling conducted for each survey and ensured the model was informed by these data.

**Table 15: Summary of input data sets for the Base Case assessment model. The relative weighting includes the Effective Sample Size (ESS) of age/size composition data and the coefficient of variation (CV) associated with the abundance data. Note that model year 2021, is fishing year 2020–21. Nobs is number of observations.**

| Data set | Model years | Nobs | Error structure | CV/ESS |
|---|---|---|---|---|
| Trawl survey indices | 1992, 1994, 1995, 1997, 2000, 2003, 2005, 2007, 2009, 2011, 2013, 2015, 2017, 2019, 2021 | 15 | Lognormal | 0.12–0.19 |
| Trawl survey age comp | 1994, 1995, 2003, 2005, 2007 | 5 | Multinomial | ESS 50 |
| Trawl survey length comp | 1992, 1997, 2000, 2009, 2011, 2013, 2015, 2017, 2019, 2021 | 10 | Multinomial | ESS 50 |

**Table 16: Details of parameters that were fixed in the base model.**

| | |
|---|---|
| Natural mortality (male and female) | 0.31 $y^{-1}$ |
| Std deviation of rec devs (sigmaR) | 0.6 |
| Proportion mature | 0 for age 1, 0.5 for age 2, 1 for ages > 2 |
| Length-weight [mean weight (kg) = $a$ (length (cm))$^b$] | $a$ = 5.3 × 10-6, $b$ = 3.19 |
| Growth parameters - female | $L\infty$ = 45.7, $k$ = 0.40, Length1=19.4 |
| male | $L\infty$ = 40.3, $k$ = 0.37, Length1=19.4 |
| Coefficients of variation for length-at-age | 0.10 |

**Table 17: Estimated parameters for the base model.**

| Parameter | Number of parameters | Parameterisation, priors, constraints |
|---|---|---|
| Ln$R_0$ | 1 | Uniform, uninformative |
| Stock-recruit steepness (Beverton & Holt) | 1 | Beta(0.80, 0.125) |
| Rec devs (1987–2020) | 34 | SigmaR 0.6 |
| Selectivity trawl survey | 3 | Logistic, female offset |
| Selectivity BT commercial | 2 | Logistic |
| Trawl Survey ln $q$ | 1 | Normal (-1.1, 1) |
| Initial $F$ | 1 | Normal (0.4, 0.2) |

For the base model option, the model also provides a good fit to the time series of trawl survey biomass indices, with the exception of the 2003 trawl survey index (Figure 17). The model also provides an acceptable fit to associated age and length composition data.

The trawl survey indices increased considerably from 2009 to 2021. The model estimates that the increase in abundance was due to a considerably higher level of recruitment from 2008 onwards. There are age data from 5 surveys (1994, 1995, 2003, 2005, 2007) but all remaining surveys have length data. These are used by the model to inform recruitment (Figure 18). Recruitments since 2007 are estimated with lower precision. The increase in recruitment is, however, consistent with the substantial (3–4 fold) increase in the trawl survey biomass indices for smaller (less than 30 cm) red gurnard from 2007.

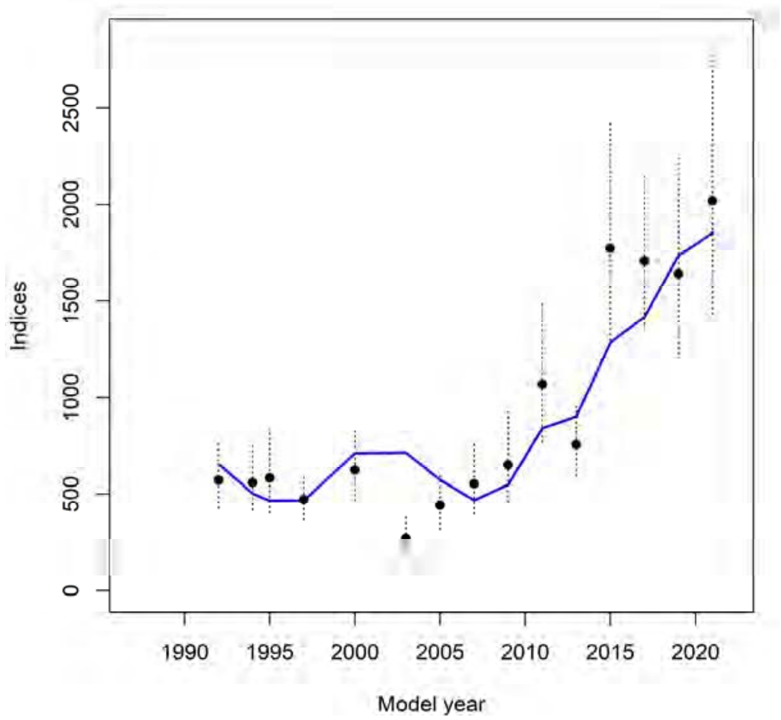



**Figure 17: The fit (MPD) to the trawl survey biomass indices (points) for the base model option.**

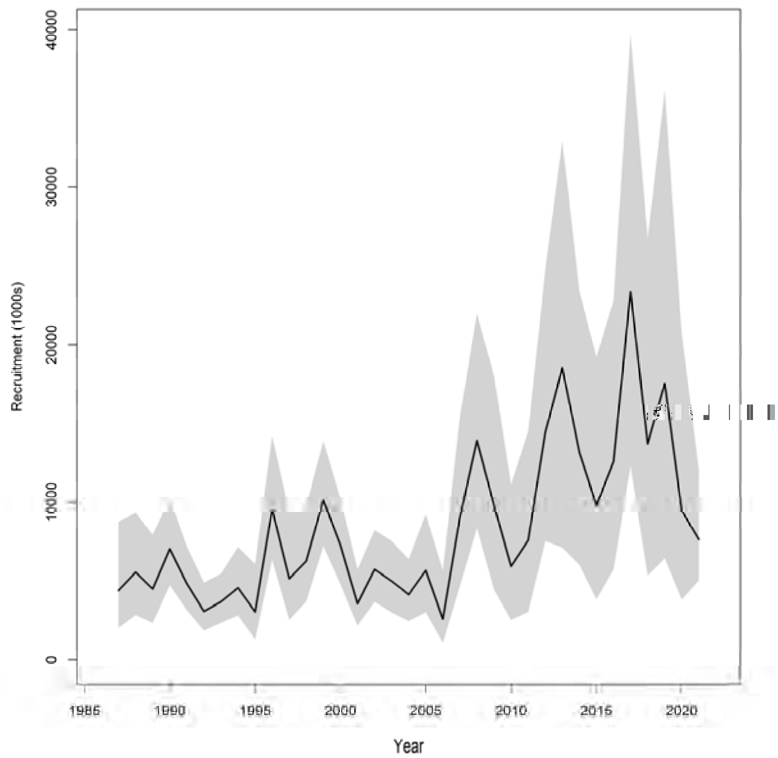



**Figure 18: Annual recruitment for the base model (MCMC results). Recruitment deviates were estimated for 1987–2020. The line represents the median and the shaded area represents the 95% credible interval.**

A range of model sensitivities was undertaken to investigate the key model assumptions; these included: lower (0.25) and higher (0.35) values of natural mortality (compared with 0.31), the prior on the initial (1987) level of fishing mortality, and the precision of the trawl survey biomass indices (Table 18). The sensitivities were implemented as single changes from the base model.

Additional model trials were conducted relating to the selectivity of the commercial fishery, the relative weighting of the length/age composition data from the trawl survey, and relaxing the prior on trawl survey *q*. These changes did not appreciably change the model results.

**Table 18: Description of model sensitivities.**

| Sensitivity run | Description |
|---|---|
| InitialFlow | Initial *F* prior Norm(0.2,0.2) |
| Mhigh | Natural mortality *M* 0.35 |
| Mlow | Natural mortality *M* 0.25 |
| Trawl Survey Indices Process Error | Process Error 0.1 |

Stock status (current 2021 = 2020–21 fishing year and forecast to 2025–26) for the GUR 7 spawning biomass was reported relative to the default hard limit of 10% $SB_0$ and the default soft limit of 20% $SB_0$ and interim target biomass level of 35% $SB_0$, and fishing mortality (2021) was reported relative to $F_{SB40\%}$. The interim reference points represent the default values for a medium productivity stock as described by the Harvest Strategy Standard Operational Guidelines.

For the base model and the range of model sensitivities, biomass is estimated to have increased considerably from 2010 and current (2021) stock status is estimated to be at about the equilibrium, unexploited level (i.e. $SB_0$) (Table 19, Figure 19).

For all model options, current rates of fishing mortality are well below the fishing mortality threshold ($F_{SB40\%}$) (Table 19, Figure 20).

**Table 19: Estimates of current (2020–21) and virgin spawning biomass (t) (median and the 95% confidence interval from the MCMCs) and probabilities of current biomass being above specified levels and probability of fishing mortality being below the level of the fishing mortality threshold.**

| Model option | $SB_0$ | $SB_{2021}$ | $SB_{2021}/SB_0$ | Pr($SB_{2021}$ > X% $SB_0$) | Pr($SB_{2021}$ < X% $SB_0$) | |
|---|---|---|---|---|---|---|
| | | | | 35% | 20% | 10% |
| **Base** | 4 990 | 5 528 | 1.108 | 1.00 | 0 | 0 |
| | (4 226–6 247) | (3 779–7 919) | (0.799–1.44) | | | |
| InitialFlow | 4 933 | 5 528 | 1.125 | 1.00 | 0 | 0 |
| | (4 217–6131) | (3 832–7 914) | (0.804–1.457) | | | |
| Mhigh | 5 365 | 6 830 | 1.262 | 1.00 | 0 | 0 |
| | (4318–7 346) | (4 369–10 504) | (0.921–1.605) | | | |
| Mlow | 4 939 | 4 369 | 0.885 | 1.00 | 0 | 0 |
| | (4313–5 981) | (3 045–6 070) | (0.63–1.147) | | | |
| TSurveyProcessError | 4 421 | 4 034 | 0.901 | 1.00 | 0 | 0 |
| | (3 772–5 411) | (2 499–6 482) | (0.616–1.297) | | | |

| | $F_{SB40\%}$ | $F_{2021}/F_{SB40\%}$ | Pr($F_{2021}$ < $F_{SB40\%}$) |
|---|---|---|---|
| **Base** | | 0.44 | |
| | 0.2248 | (0.296–0.686) | 1.00 |
| InitialFlow | | 0.44 | |
| | 0.2267 | (0.294–0.691) | 1.00 |
| Mhigh | | 0.342 | |
| | 0.2342 | (0.219–0.551) | 1.00 |
| Mlow | | 0.624 | |
| | 0.2016 | (0.447–0.908) | 0.99 |
| TSurveyProcessError | | 0.593 | |
| | 0.2298 | (0.359–0.957) | 0.98 |

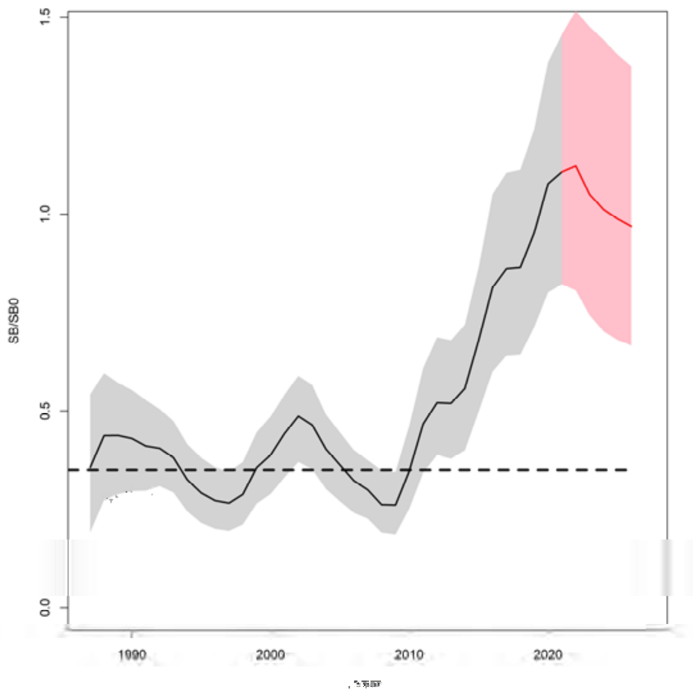



**Figure 19: Annual trend in spawning biomass relative to the 35% $SB_0$ interim target biomass level for the base model. The line represents the median and the shaded area represents the 95% confidence interval. The projection period (2022–2026) is in red. The dashed line represents the interim target level.**

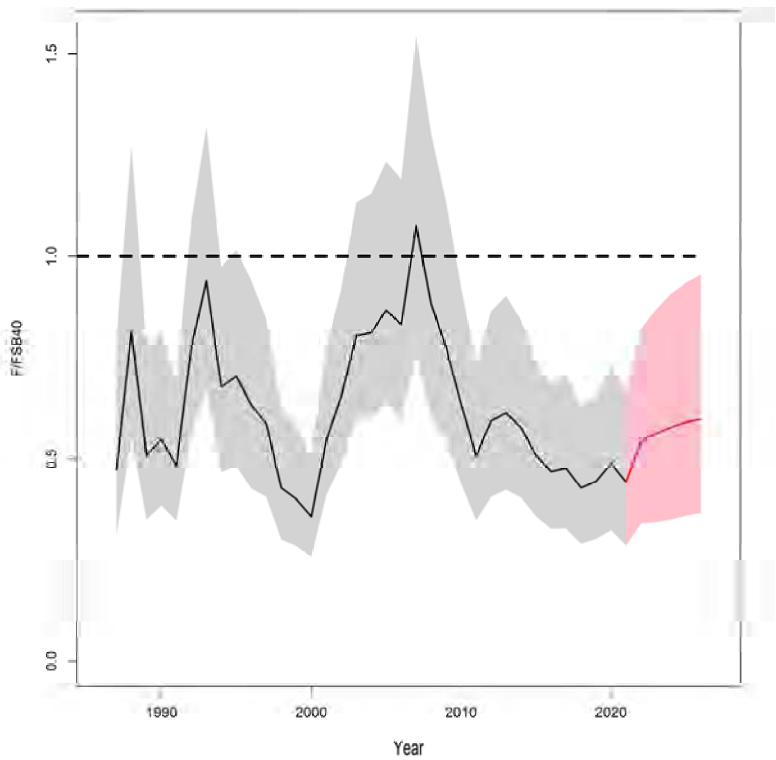



**Figure 20: Annual trend in fishing mortality relative to the $F_{SB40\%}$ threshold level for the base model. The line represents the median and the shaded area represents the 95% credible interval. The projection period (2022–2026) is in red. The dashed line represents the interim threshold level.**

For all model options, estimates of current and equilibrium yield were derived for the stock based on the fishing mortality rate that corresponds to the interim target biomass level (Table 20). Equilibrium yields at the interim target biomass level are estimated to be about 800–1000 t per annum. $F_{SB40\%}$ yields at 2020–21 biomass levels are substantially higher than the equilibrium yields (about 2000–3000 t), although the magnitude of the current $F_{SB40\%}$ yields is highly uncertain (1100–6500 t).

**Table 20: Estimates of equilibrium yield (t) at $F_{SB40\%}$ and at the 2020–21 biomass levels for the base model and the model sensitivities. The values represent the median and the 95% confidence interval from the MCMCs.**

| Model option | $F_{SB40\%}$ | |
|---|---|---|
| | Equilibrium Yield | Yield at current biomass |
| **Base** | 953 (811–1 149) | 2 748 (1 609–4 681) |
| InitialFlow | 952 (808–1 160) | 2 750 (1 583–4 957) |
| Mhigh | 1 105 (891–1 453) | 3 621 (1 964–6 547) |
| Mlow | 807 (726–906) | 1 875 (1 163–2 819) |
| TSurveyProcessError | 861 (749–1 043) | 2 020 (1 094–3 934) |

## Projections

Projections were conducted for the base model. Stock projections were conducted for the 5-year period following the terminal year of the model (i.e., 2022–2026). Projections assumed future recruitments were resampled from the average level of recent recruitment (2011–2020) and variation equivalent to sigmaR. Commercial catches in the projection period were held constant at the current TACC of 1298 t. There was no explicit allowance for unreported catch, recreational catch, or customary catch.

For the base case, stock abundance is predicted to decline during the projection period, although the biomass remains at about the $SB_0$ reference level throughout the period (Table 21).

**Table 21: Estimates of projected (2025–26) spawning biomass (t) (median and the 95% confidence interval from the MCMCs) and probability of the spawning biomass being above default biomass limits and the interim target level in 2026 from the base model projections.**

| Model option | $SB_{2026}/SB_0$ | $Pr(SB\ 2026 > X\%\ SB_0)$ | | $Pr(SB\ 2026 < X\%$ |
|---|---|---|---|---|
| | | 10% | 20% | 35% |
| **Base** | 0.969 (0.667–1.376) | 0 | 0 | 1.00 |

## Qualifying comments

There are no direct observations to determine the selectivity of the commercial fishery and the commercial catch is assumed to be composed of fish larger than 30 cm.

Reference points ($SB_0$ based) are derived from the average level of recruitment during 1987–2020. There was an apparent shift in the productivity of GUR 7 in the late 2000s. The increasing catches since 2012 were sustained by the higher level of recruitment.

The model does not include GUR 7 catches prior to 1987 and the initial level of fishing mortality (in 1987) is estimated. Prior to 1987, average annual catches were about 400 t from the early 1950s.

Because no allowance was made for unreported catch or for non-commercial harvest, the predicted yields relate only to the reported commercial catch.

## Future research considerations

- Determine the age compositions of red gurnard sampled by the WCSI trawl surveys, particularly for one or two of the most recent surveys. Also consider re-examine age compositions for the earlier surveys.
- Determine length/age composition of the catch from the GUR 7 trawl fishery to inform the model regarding the selectivity of the fishery.
- Re-examine development of a CPUE series, potentially starting in 2008. This may help to calibrate *Kaharoa* replacement.

## Management procedure (MP)

A range of management procedures were developed for GUR 7 based on the empirical linear relationship derived between the WCSI trawl survey biomass indices and the corresponding annual reported commercial catch (Figure 21). The relationship was forced through the origin to ensure catches were aligned with low survey biomass levels. The relationship provides a moderate fit to the observed data although there are a subset of records with a higher catch than predicted from the linear model.

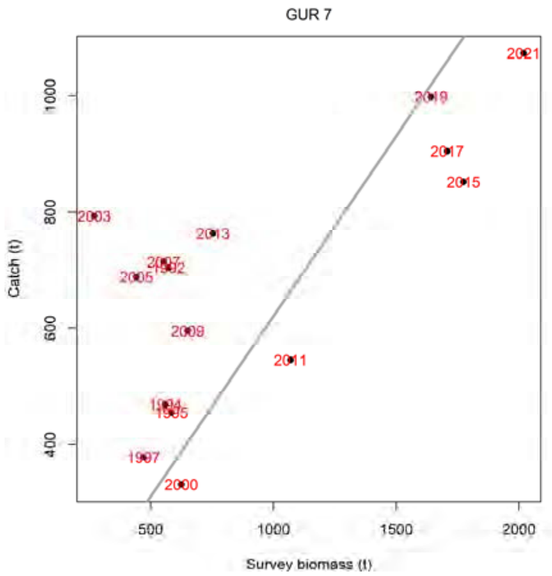



**Figure 21: Comparison of red gurnard WCSI trawl survey biomass indices and GUR 7 commercial catch from the corresponding fishing year. The grey line represents the linear relationship constrained to the origin (zero intercept). The slope of the line is denoted $F_{MSY}$ proxy.**

Conceptually, the relationship represents a constant level of fishing mortality ($F_{MSY}$ proxy). The simplest management procedures scaled the base fishing mortality level using a scalar applied to the slope coefficient (base) (0.8, 1.0, 1.2….2.0, 2.5). More complex management procedures incorporated declining levels of fishing mortality below threshold levels of the observed trawl survey biomass indices, with inflection points at the lower quartile, median or upper quartile (Figure 22).

Simulation-testing of the management procedures was carried out using the MCMC output from the 2022 GUR 7 assessment model. The individual (1000) MCMC samples were used to initialise the population age structure and projections were conducted over 100 years with recruitment resampled from the estimated recruitment deviates. Trawl surveys were conducted biennially during the projection period and the specific management procedure was applied to set the TACC for the next two years following each trawl survey (conducted in March-April).

$$TACC_{(year+1,\ year+2)} = Scalar * F_{MSY}\ proxy * TrawlSurveyBiomass_{year}$$

Constraints were applied to investigate the effect of limiting the scale of the changes in the TACC (maximum change of -/+ 20% or 50%). Two alternative periods were applied to define the projected recruitments: the entire recruitment period (1987–2020) and the lower recruitment period 1987–2007. The MPs were also tested with different levels of autocorrelation between annual recruitments and additional process error associated with the trawl survey biomass estimates.

The results of the MP evaluation indicated that a Scalar of 1.6–2.0 would yield results that were consistent with fishing the stock at the $F_{SB40\%}$ fishing mortality level, maintaining the stock at or above the HSS default target biomass level of 35% $SB_0$ (moderate productivity) and well above the 20% $SB_0$ soft limit. There was no appreciable improvement in the performance of the MP with the inclusion of more complex relationships between trawl survey biomass and $F_{MSY}$ proxy (i.e., inflection points at different biomass levels).

If recruitment was to revert to the lower (1987–2007) level, then the stock would fluctuate about the 30% $SB_0$ level with an increased probability of the stock declining below the soft limit. Nonetheless, since 2008 recruitment has been maintained at an appreciably higher level (approximately doubled) and future recruitment levels would continue to be monitored via the trawl survey. The MP could be modified if a sustained period of lower recruitment is observed (via a breakout rule).

This MP should be evaluated about every 5 years (after 2 surveys), which should include a new stock assessment.

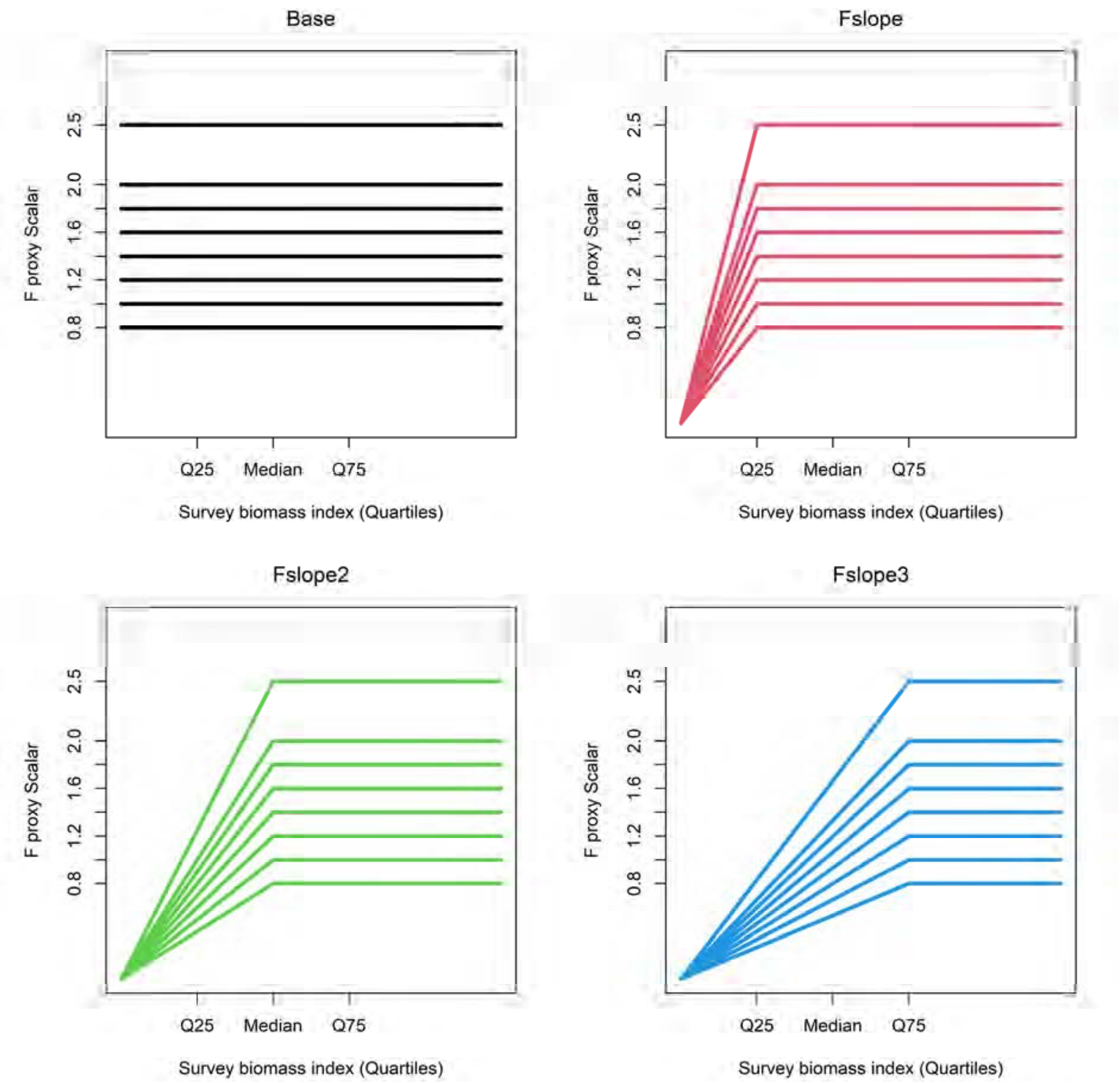



**Figure 22: The range of scalars applied to the $F_{MSY}$ proxy value in the suite of management procedures. The different functional forms of the scalars have inflection points at different levels of trawl survey biomass from on the reference data set (15 surveys).**

**Breakout rules**

- Review of the biennial trawl survey results by the Inshore Working Group, including determination of the magnitude of recent recruitment (pre-recruit biomass), survey precision and investigation of extreme catchability.

### 4.4 Other factors

Red gurnard is a major bycatch of target fisheries for several different species, such as snapper and flatfish. The target species may differ between areas and seasons. The recorded landings are influenced directly by changes in the fishing patterns of fisheries for these target species and indirectly by the abundance of these target species. Some target fishing for gurnard also occurs.

## 5. STATUS OF THE STOCKS

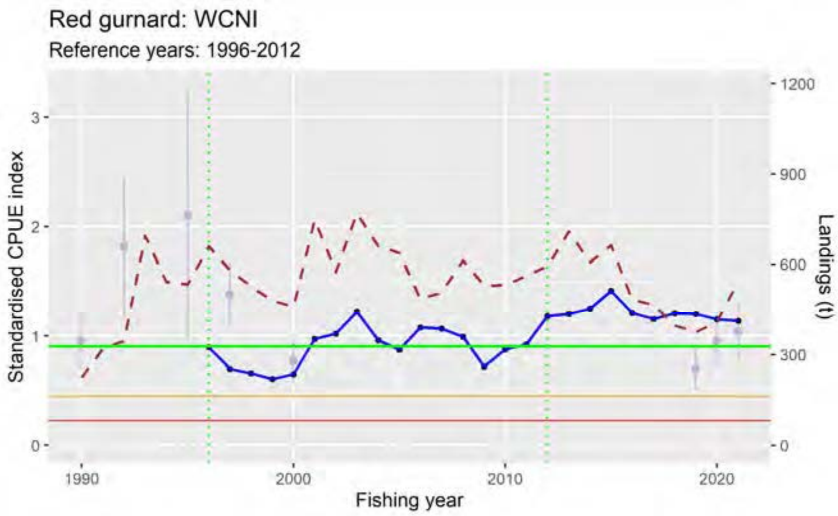
**Stock Structure Assumptions**

For the purpose of this summary GUR 1 is considered to be a single stock with three sub-stocks.

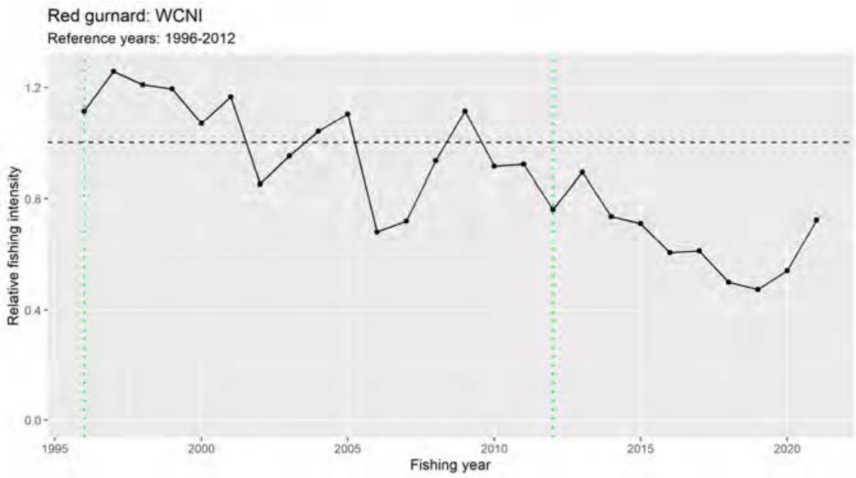
- **GUR 1W**

| **Stock Status** | |
|---|---|
| Year of Most Recent Assessment | 2022 |
| Assessment Runs Presented | Standardised CPUE and WCNI trawl survey series |
| Reference Points | Target: $B_{MSY}$-compatible proxy based on the mean CPUE from 1995–96 to 2011–12 of the bottom trawl GUR 1 west (tow) series<br>Soft Limit: 50% of target<br>Hard Limit: 25% of target<br>Overfishing threshold: $F_{MSY}$ compatible proxy based on the mean relative exploitation rate for the period: 1995–96 to 2011–12 |
| Status in relation to Target | About as Likely as Not (40–60%) to be at or above the target |
| Status in relation to Limits | Soft Limit: Unlikely (< 40%) to be below<br>Hard Limit: Very Unlikely (< 10%) to be below |
| Status in relation to Overfishing | Overfishing is About as Likely as Not (40–60%) to be occurring |

**Historical Stock Status Trajectory and Current Status**




**Landings (dashed brown line), standardised CPUE combined model using tow by tow data (blue line), and trawl survey recruited biomass indices (purple with error bars ± two standard deviations). The green, orange, and red horizontal lines represent the target, soft, and hard limits, respectively. Trawl survey recruited biomass indices are scaled to have the same arithmetic mean value as the standardised CPUE indices, over the years they have in common.**




**Annual relative exploitation rate (landings divided by standardised CPUE and normalised to an arithmetic mean of one over the reference period 1996 to 2012) for red gurnard in the GUR 1 west coast sub-stock. The horizontal grey dashed line at one represents the average relative exploitation rate during the period used to define the reference points (depicted by vertical dotted green lines).**

| Fishery and Stock Trends | |
|---|---|
| Recent Trend in Biomass or Proxy | - The CPUE has increased since 2008–09 and in 2020–21 was well above the long-term mean.<br>- The WCNI trawl survey series shows that abundance in 2018–2020 was lower than it was during the early 1990s. |
| Recent Trend in Fishing Intensity or Proxy | Relative exploitation rate declined from 1995–96 to 2018–19, and then increased to 2020–21, but remained below the threshold. |
| Other Abundance Indices | - |
| Trends in Other Relevant Indicators or Variables | - |

| Projections and Prognosis | |
|---|---|
| Stock Projections or Prognosis | Without information on recruitment, it is not possible to predict how the stock is going to respond in the next few years. |
| Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits | Current Catch<br>Soft Limit: Unlikely (< 40%)<br>Hard Limit: Unlikely (< 40%)<br>TACC<br>Unknown for both the Soft and Hard Limits |
| Probability of Current Catch or TACC causing Overfishing to continue or to commence | About as Likely as Not (40–60%) if the catch remains at current levels<br>Unknown if the catch were to increase to the level of the TACC |

| Assessment Methodology and Evaluation | | |
|---|---|---|
| Assessment Type | Level 2 - Partial Quantitative Stock Assessment | |
| Assessment Method | Standardised CPUE based on positive catches from bottom trawl | |
| Assessment Dates | Latest assessment: 2022 | Next assessment: 2025 |
| Overall assessment quality rank | 1 – High Quality | |
| Main data inputs (rank) | Catch and effort data<br>WCNI trawl survey series | 1 – High Quality<br>1 – High Quality |
| Data not used (rank) | N/A | |
| Changes to Model Structure and Assumptions | - Inclusion of WCSI trawl survey series | |
| Major Sources of Uncertainty | - | |

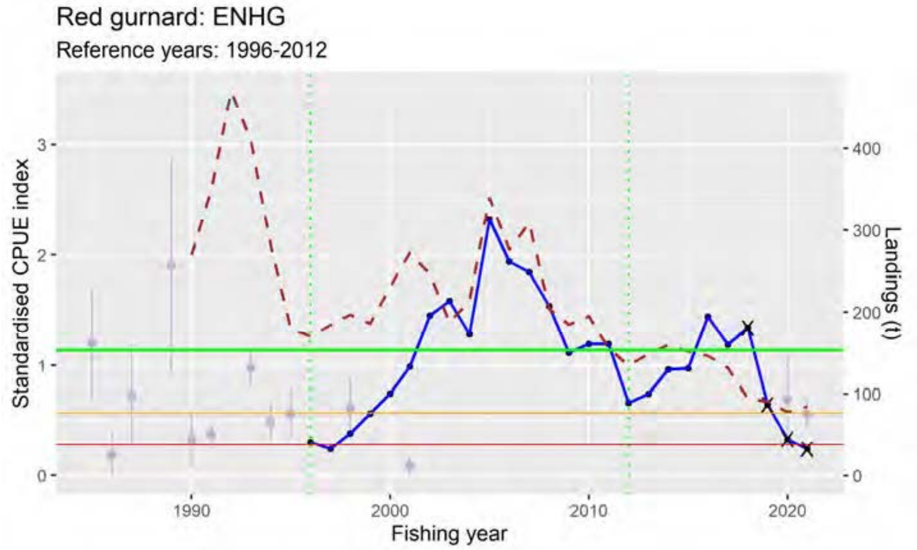
| Qualifying Comments |
|---|
| As the red gurnard fishery in FMAs 1 and 9 has a long history, it is difficult to infer stock status from recent abundance trends. The abundance of all three sub-stocks appears to be cyclical, probably in response to recruitment variation. This makes it difficult to predict future trends without recruitment information.<br><br>The WCNI trawl survey series shows a substantial decline in abundance between the 1990s (prior to the commencement of the CPUE series) and 2018–2020, leading to the Working Group moderating assessment results based on CPUE alone.<br><br>As the TACC for GUR 1 is substantially higher than the current catch, it is not possible to evaluate potential impacts if catches increased to the level of the TACC. |

| Fishery Interactions |
|---|
| Red gurnard is taken off the west coast by bottom trawl targeted at snapper and trevally.<br>A Danish seine summer fishery for red gurnard and John dory also occurs off the west coast. |

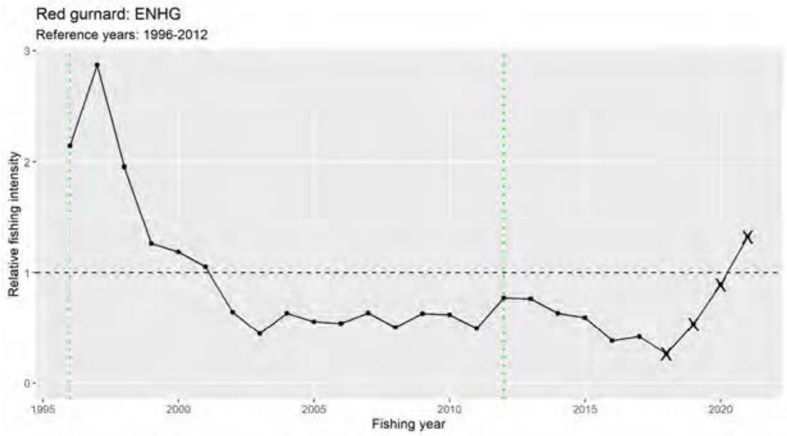
- **GUR 1E**

| Stock Status | |
|---|---|
| Year of Most Recent Assessment | 2022 |
| Assessment Runs Presented | - Standardised CPUE<br>- HG trawl survey series |
| Reference Points | Target: $B_{MSY}$-compatible proxy based on the mean CPUE from 1995–96 to 2011–12 for the bottom trawl GUR 1 East (tow) series<br>Soft Limit: 50% of target<br>Hard Limit: 25% of target<br>Overfishing threshold: $F_{MSY}$ compatible proxy based on the mean relative exploitation rate for the period: 1995–96 to 2011–12 |
| Status in relation to Target | Unknown |
| Status in relation to Limits | Soft Limit: Unlikely (< 40%) to be below<br>Hard Limit: Unlikely (< 40%) to be below |
| Status in relation to Overfishing | Unknown |

**Historical Stock Status Trajectory and Current Status**




**Landings (dashed brown line), standardised CPUE combined model using tow by tow data (blue line), and trawl survey recruited biomass indices (purple with error bars ± two standard deviations). The green, orange, and red horizontal lines represent the target, soft, and hard limits, respectively. Trawl survey recruited biomass indices are scaled to have the same arithmetic mean value as the standardised CPUE indices, over the years they have in common.**




**Annual relative exploitation rate (landings divided by standardised CPUE and normalised to an arithmetic mean of one over the reference period 1996 to 2012) for red gurnard in the GUR 1 east coast sub-stock. The horizontal grey dashed line at one represents the average relative exploitation rate during the period used to define the reference points (depicted by vertical dotted green lines). For fishing years 2018 to 2021, standardised CPUE and the annual relative exploitation rate are plotted with a cross (see Qualifying Comment below).**

| **Fishery and Stock Trends** | |
|---|---|
| Recent Trend in Biomass or Proxy | CPUE declined strongly from 2017–18 to 2020–21, but the trawl survey series showed that abundance in 2020 and 2021 was close to the series mean for the period 1984–85 to 2021. The amount of data available for CPUE declined substantially in the last four years of the series. |
| Recent Trend in Fishing Intensity or Proxy | Relative exploitation rate declined from 1995–96 to 2002–03, then fluctuated without trend below the long-term average, until rising from 2017–18. |
| Other Abundance Indices | - |
| Trends in Other Relevant Indicators or Variables | - |

| **Projections and Prognosis** | |
|---|---|
| Stock Projections or Prognosis | Without information on recruitment, it is not possible to predict how the stock is going to respond in the next few years. |
| Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits | Soft Limit: Unknown<br>Hard Limit: Unknown |
| Probability of Current Catch or TACC causing Overfishing to continue or to commence | Unknown if the catch remains at current levels |

| **Assessment Methodology and Evaluation** | | |
|---|---|---|
| Assessment Type | Level 2 - Partial Quantitative Stock Assessment | |
| Assessment Method | Standardised CPUE based on positive catches from bottom trawl | |
| Assessment Dates | Latest assessment: 2022 | Next assessment: 2025 |
| Overall assessment quality rank | 1 – High Quality | |
| Main data inputs (rank) | - Catch and effort data | 1 – High Quality |
| Data not used (rank) | N/A | |
| Changes to Model Structure and Assumptions | • Inclusion of HG trawl survey series | |
| Major Sources of Uncertainty | - | |

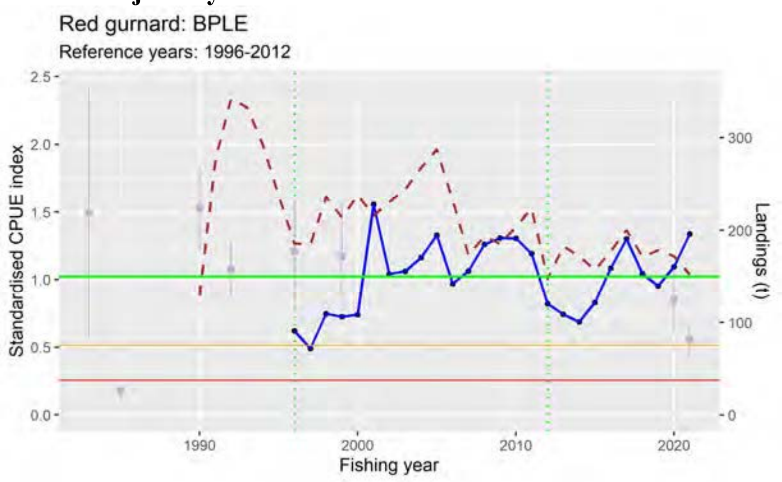
| **Qualifying Comments** |
|---|
| - As the red gurnard fishery in FMAs 1 and 9 has a long history, it is difficult to infer stock status from recent abundance trends. The abundance of all three sub-stocks appears to be cyclical, probably in response to recruitment variation. This makes it difficult to predict future trends without recruitment information.<br><br>- Largely due to vessels switching to PSH gear, bottom trawl catch and effort declined substantially after 2016–17, and the standardised CPUE may not track abundance. |

| **Fishery Interactions** |
|---|
| Red gurnard is taken as a bycatch on the east coast mainly by bottom longlines targeted at snapper, with the balance taken almost equally by bottom trawl and Danish seine targeting snapper and John dory. |

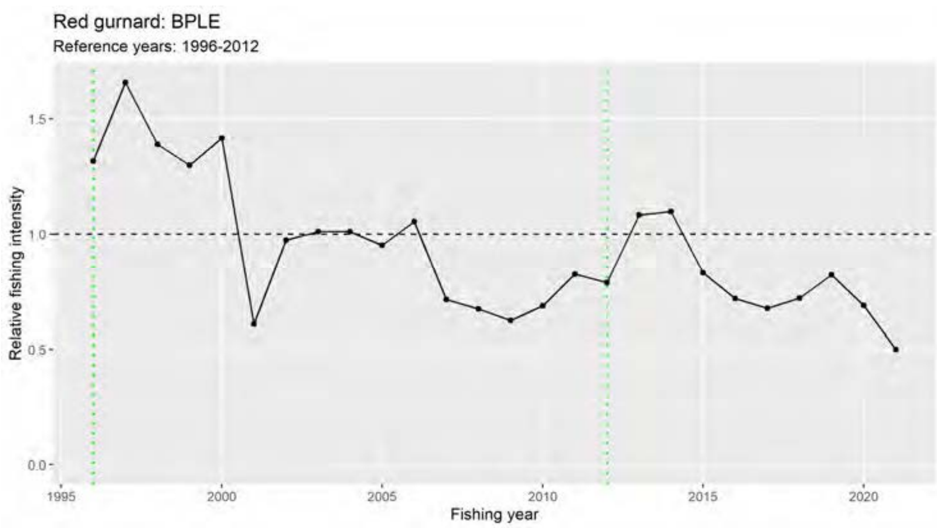
- **GUR 1 Bay of Plenty**

| **Stock Status** | |
|---|---|
| Year of Most Recent Assessment | 2022 |
| Assessment Runs Presented | - Standardised CPUE<br>- BoP trawl survey series |
| Reference Points | Target: $B_{MSY}$-compatible proxy based on the mean CPUE from 1995–96 to 2011–12 for the bottom trawl GUR 1 BoP (tow) series<br>Soft Limit: 50% of target<br>Hard Limit: 25% of target<br>Overfishing threshold: $F_{MSY}$ compatible proxy based on the mean relative exploitation rate for the period: 1995–96 to 2011–12 |
| Status in relation to Target | Unknown |
| Status in relation to Limits | Soft Limit: Unlikely (< 40%) to be below<br>Hard Limit: Very Unlikely (< 10%) to be below |
| Status in relation to Overfishing | Unknown |

**Historical Stock Status Trajectory and Current Status**




**Landings (dashed brown line), standardised CPUE combined model using tow by tow data (blue line), and trawl survey recruited biomass indices (purple with error bars ± two standard deviations). The green, orange and red horizontal lines represent the target, soft and hard limits, respectively. Trawl survey recruited biomass indices are scaled to have the same arithmetic mean value as the standardised CPUE indices, over the years they have in common.**




**Annual relative exploitation rate (landings divided by standardised CPUE and normalised to an arithmetic mean of one over the reference period 1996 to 2012) for red gurnard in the Bay of Plenty. The horizontal grey dashed line at one represents the average relative exploitation rate during the period used to define the reference points (depicted by vertical dotted green lines).**

| **Fishery and Stock Trends** | |
|---|---|
| Recent Trend in Biomass or Proxy | The CPUE index has fluctuated without trend, but the trawl survey series showed that abundance in 2019–20 and 2020–21 was below the mean for the period 1989–90 to 1998–99. |
| Recent Trend in Fishing Intensity or Proxy | Unknown |
| Other Abundance Indices | - |
| Trends in Other Relevant Indicators or Variables | - |

| **Projections and Prognosis** | |
|---|---|
| Stock Projections or Prognosis | Without information on recruitment, it is not possible to predict how the stock is going to respond in the next few years. |
| Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits | Soft Limit: Unknown<br>Hard Limit: Unknown |
| Probability of Current Catch or TACC causing Overfishing to continue or to commence | Unknown if the catch remains at current levels<br>Unknown if the catch were to increase to the level of the TACC |

| **Assessment Methodology and Evaluation** | | |
|---|---|---|
| Assessment Type | Level 2 - Partial Quantitative Stock Assessment | |
| Assessment Method | Standardised CPUE based on positive catches from bottom trawl | |
| Assessment Dates | Latest assessment: 2022 | Next assessment: 2025 |
| Overall assessment quality rank | 1 – High Quality | |
| Main data inputs (rank) | - Catch and effort data | 1 – High Quality |
| Data not used (rank) | - | |
| Changes to Model Structure and Assumptions | - Inclusion of the re-instated BoP trawl survey series. | |
| Major Sources of Uncertainty | - | |

| **Qualifying Comments** |
|---|
| - As the red gurnard fishery in FMAs 1 and 9 has a long history, it is difficult to infer stock status from recent abundance trends. The abundance of all three sub-stocks appears to be cyclical, probably in response to recruitment variation. This makes it difficult to predict future trends without recruitment information.<br><br>- CPUE fluctuated without trend, whereas trawl survey biomass in 2020–21 was lower than the average for the period 1995–96 to 2020–21. |

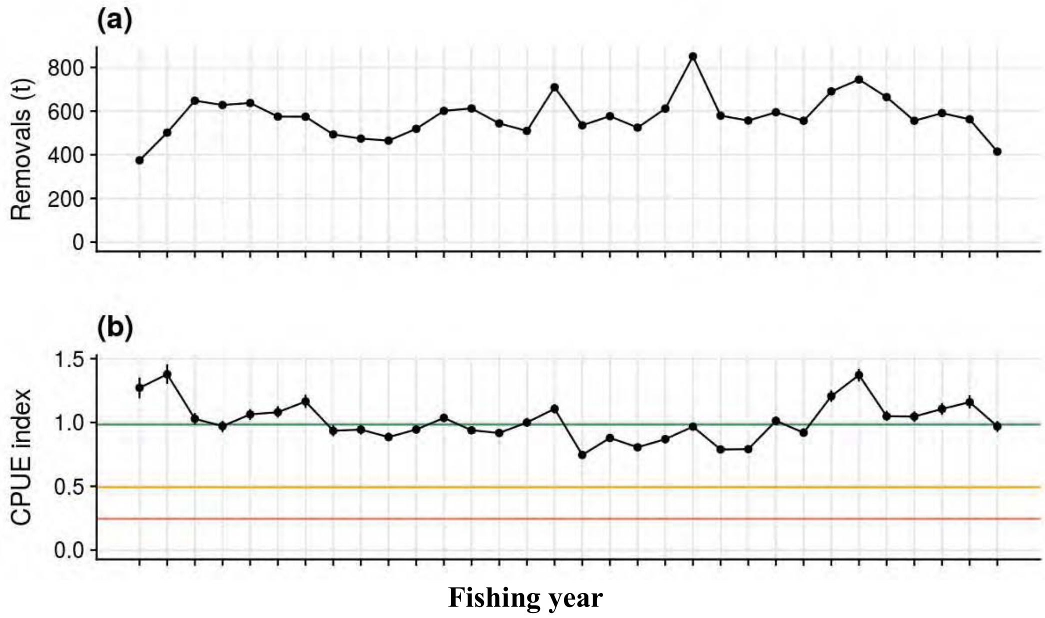
| **Fishery Interactions** |
|---|
| Red gurnard is taken as a bycatch in the Bay of Plenty mainly by bottom longline targeted at snapper, with the balance taken almost equally by bottom trawl and Danish seine targeting snapper and John dory. |

- **GUR 2**

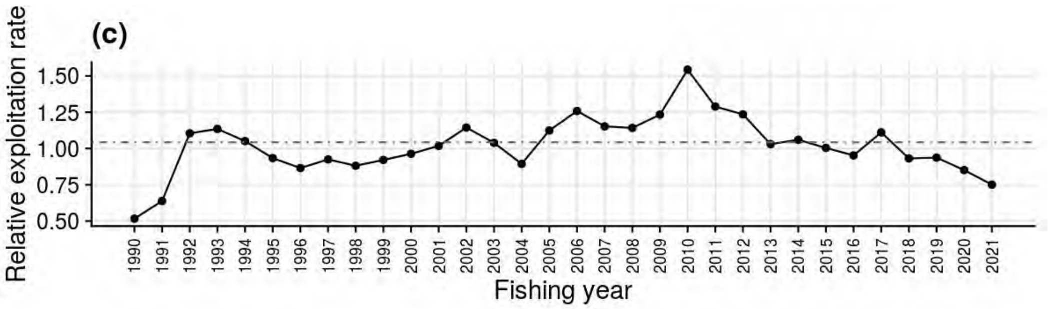
**Stock Structure Assumptions**
For the purpose of this summary GUR 2 is considered to be a single stock.

| **Stock Status** | |
|---|---|
| Year of Most Recent Assessment | 2022 |
| Assessment Runs Presented | Standardised CPUE for BT.MIX |
| Reference Points | Target: $B_{MSY}$-compatible proxy based on the mean CPUE (BT(MIX)) for period 1990–91 to 2017–18<br>Soft Limit: 50% of target<br>Hard Limit: 25% of target<br>Overfishing threshold: $F_{MSY}$ compatible proxy based on the mean relative exploitation rate for the period 1990–91 to 2017–18 |
| Status in relation to Target | About as Likely as Not (40–60%) to be at or above the target |
| Status in relation to Limits | Soft Limit: Very Unlikely (< 10%) to be below<br>Hard Limit: Very Unlikely (< 10%) to be below |
| Status in relation to Overfishing | Overfishing is Unlikely (< 40%) to be occurring |

**Historical Stock Status Trajectory and Current Status**




**(a) Annual removals for GUR 2; (b) the standardised catch per unit effort (CPUE) index, relative to the agreed reference points, for GUR 2 from bottom trawling targeting gurnard, snapper and trevally (BT-MIX) and combining data from all form types at a daily aggregation**




**(c) annual relative exploitation rate (catch/CPUE) gurnard in GUR 2.**

| **Fishery and Stock Trends** | |
|---|---|
| Recent Trend in Biomass or Proxy | Standardised CPUE decreased to just above the target in 2016–17, increased to 2019–20 before dropping to the target level in 2020–21. |
| Recent Trend in Fishing Intensity or Proxy | Relative exploitation has been below the long-term average since 2017–18. |
| Other Abundance Indices | Tow based analysis of 2007–08 to 2020–21 data closely resembles the mixed form type analysis, as does the CPUE series including tarakihi target. |
| Trends in Other Relevant Indicators or Variables | Catch curve analysis indicated that fishing mortality was at or below M in 2010 (depending on the age at full recruitment). |

| **Projections and Prognosis** | |
|---|---|
| Stock Projections or Prognosis | Without information on recruitment, it is not possible to predict how the stock is going to respond in the next few years. |
| Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits | Soft Limit: Unlikely (< 40%)<br>Hard Limit: Very Unlikely (< 10%)<br>Unknown if the catch were to increase to the level of the TACC |
| Probability of Current Catch or TACC causing Overfishing to continue or to commence | About as Likely as Not (40–60%) for current catch<br>Unknown if the catch were to increase to the level of the TACC |

| **Assessment Methodology and Evaluation** | | |
|---|---|---|
| Assessment Type | Level 2 - Partial Quantitative Stock Assessment | |
| Assessment Method | Standardised CPUE | |
| Assessment Dates | Latest assessment: 2022 | Next assessment: 2025 |
| Overall assessment quality rank | 1 – High Quality | |
| Main data inputs (rank) | BT-Mix CPUE series | 1 – High Quality |
| Data not used (rank) | N/A | |
| Changes to Model Structure and Assumptions | - | |
| Major Sources of Uncertainty | - | |

| **Qualifying Comments** |
|---|
| Most of the GUR2 commercial catch is made in Hawke Bay, and the index of abundance is naturally weighted to abundance of GUR in this area. |

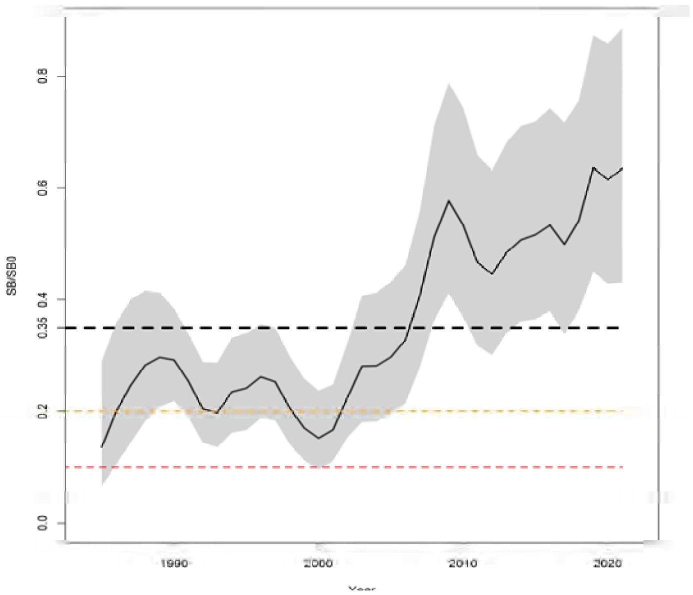
| **Fishery Interactions** |
|---|
| Red gurnard is taken in FMA 2 by the bottom trawl fishery targeting gurnard and tarakihi. |

- **GUR 3**

**Stock Structure Assumptions**
No information is available on the stock separation of red gurnard. The Fishstock GUR 3 is treated in this summary as a unit stock.

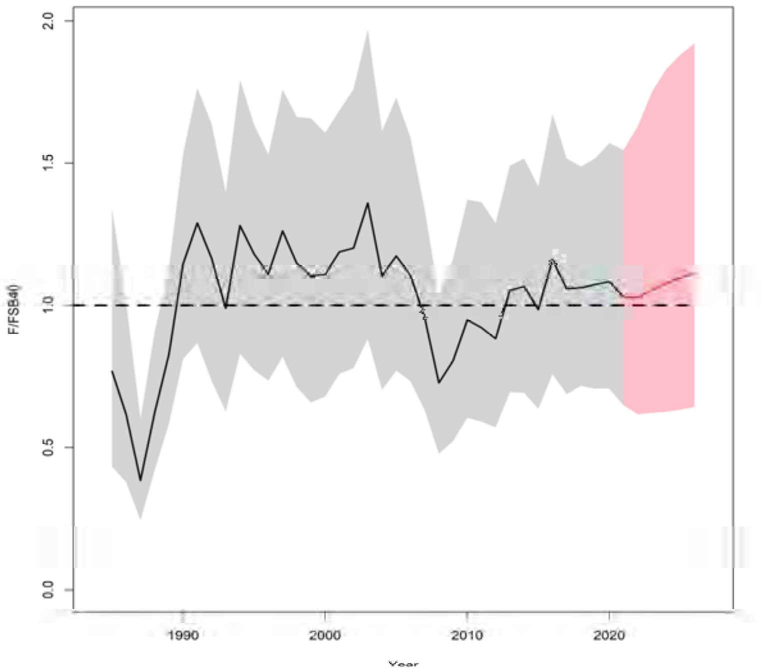
| **Stock Status** | |
|---|---|
| Year of Most Recent Assessment | 2022 |
| Assessment runs presented | Base case model |
| Reference Points | Interim Target: 35% $B_0$ (HSS default)<br>Soft Limit: 20% $B_0$ (HSS default)<br>Hard Limit: 10% $B_0$ (HSS default)<br>Overfishing threshold: $F_{SB40\%}$ (HSS default) |
| Status in relation to Target | $B_{2020–21}$ was estimated to be 64% $B_0$; Very Likely (> 90%) to be at or above the target |
| Status in relation to Limits | Soft limit: Very Unlikely (< 10%) to be below<br>Hard Limit: Exceptionally Unlikely (< 1%) to be below |
| Status in relation to Overfishing | $F_{2020–21}$ was estimated to be at about $F_{SB40\%}$. Overfishing is About as Likely as Not (40–60%) to be occurring |

**Historical Abundance and Catch Trajectories**



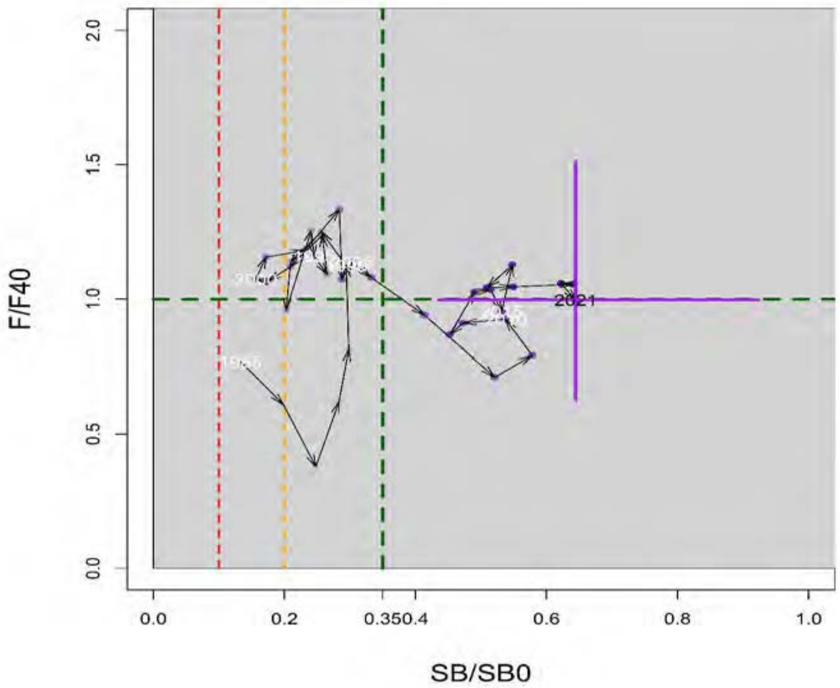

**Annual trend in spawning biomass relative to the 35% *$SB_0$* interim target biomass level for the base model. The line represents the median and the shaded area represents the 95% credible interval. The dashed line represents the interim target level. The red and orange dashed lines represent the hard and soft biomass limits, respectively.**

**Fishing Intensity Trajectory**




**Annual fishing mortality compared to the *FSB40%* interim target fishing mortality level (dashed line) for the base case model (median values from MCMCs).**

**Combined status**




**Annual spawning biomass and fishing mortality compared to the *SB35%* interim target biomass level and corresponding fishing mortality reference for the base case model (median values from MCMCs). The green dashed lines represent the biomass target and fishing mortality threshold levels. The red and orange dashed lines represent the hard and soft biomass limits, respectively.**

| Fishery and Stock Trends | |
|---|---|
| Recent trend in Biomass or Proxy | Spawning biomass was estimated to have increased from the late 2000s following above average recruitment since the mid-2000s. |

| | |
|---|---|
| Recent trend in Fishing Intensity or Proxy | Fishing mortality has been at about the target level since 2010. |
| Other Abundance Indices | - FLA BT CPUE indices have increased considerably from the early 1990s. These CPUE indices were not included in the 2022 assessment.<br>- A Southland CPUE series also had generally similar levels of increase. |
| Trends in Other Relevant Indicators or Variables | - |

| **Projections and Prognosis** | |
|---|---|
| Stock Projections or Prognosis | Abundance is Very Likely (> 90%) to remain above the target biomass level over the next five years at the current TACC or catch. |
| Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits | Soft Limit: Very Unlikely (< 10%)<br>Hard Limit: Exceptionally Unlikely (< 1%) |
| Probability of Current Catch or TACC causing Overfishing to continue or to commence | About as Likely as Not (40–60%) |

| **Assessment Methodology and Evaluation** | | |
|---|---|---|
| Assessment Type | Level 1 - Full Quantitative Stock Assessment | |
| Assessment Method | Age-structured Bayesian stock assessment implemented with Stock Synthesis software and uncertainty estimated by MCMC | |
| Assessment Dates | Latest assessment: 2022 | Next assessment: 2025 |
| Overall assessment quality rank | 1 – High Quality | |
| Main data inputs | - Commercial catch (from 1985 onwards)<br>- Survey biomass indices.<br>- Survey age/length frequencies.<br>- BT-MIX CPUE indices<br>- Estimates of biological parameters (e.g., growth, natural mortality, age-at-maturity, and length/ weight) | 1 – High Quality<br>1 – High Quality<br>1 – High Quality<br>1 – High Quality<br>1 – High Quality |
| Data not used (rank) | N/A | |
| Changes to Model Structure and Assumptions | - First implementation of full quantitative assessment, which includes trawl survey data and a new CPUE series excluding FLA target; previous (2015) assessment was a partial quantitative assessment based on the CPUE series, BT(MIX+FLA) | |
| Major Sources of Uncertainty | - Choice of the period used to derive reference points, as it is unclear whether recent increases in recruitment represent an increase in productivity<br>- Lack of recent age composition data from trawl survey and fishery<br>- The trawl survey and CPUE indices are for the FMA 3 (ECSI) area only and do not cover the entire GUR 3 QMA; approximately 25% of the GUR3 catch is taken outside FMA 3 | |

| **Qualifying Comments** |
|---|
| - |

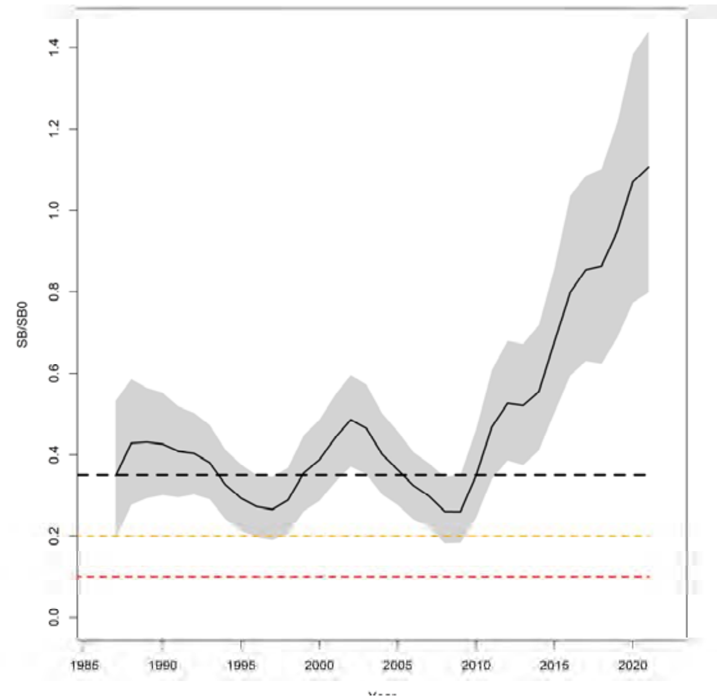
| Fishery Interactions |
|---|
| Red gurnard in GUR 3 are taken almost entirely by bottom trawl in fisheries targeted at red cod, barracouta, and flatfish. Some red gurnard are also taken in the target tarakihi and stargazer bottom trawl fisheries. The level of targeting of this species was historically low, averaging less than 10%, but has increased to approximately 25% since 2017–18. |

- **GUR 7**

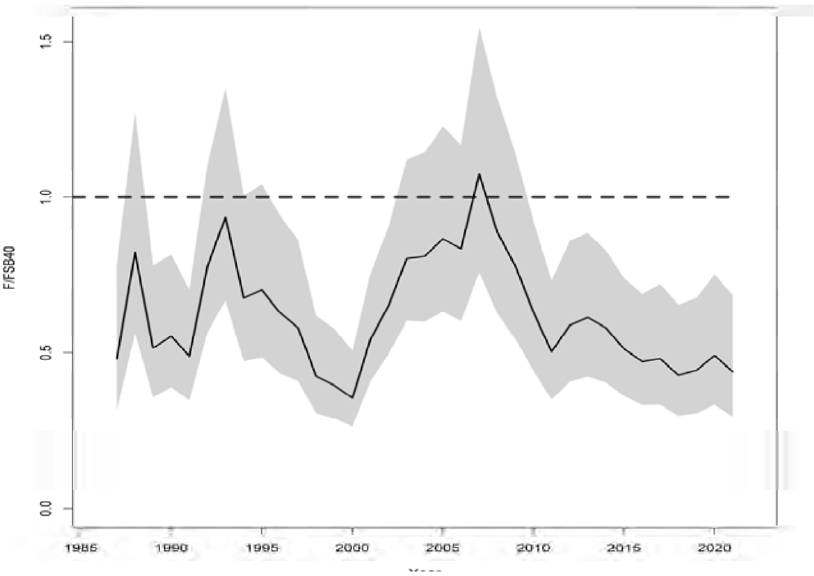
**Stock Structure Assumptions**
Stock boundaries are unknown, but for the purpose of this summary, GUR 7 is considered to be a single management unit.

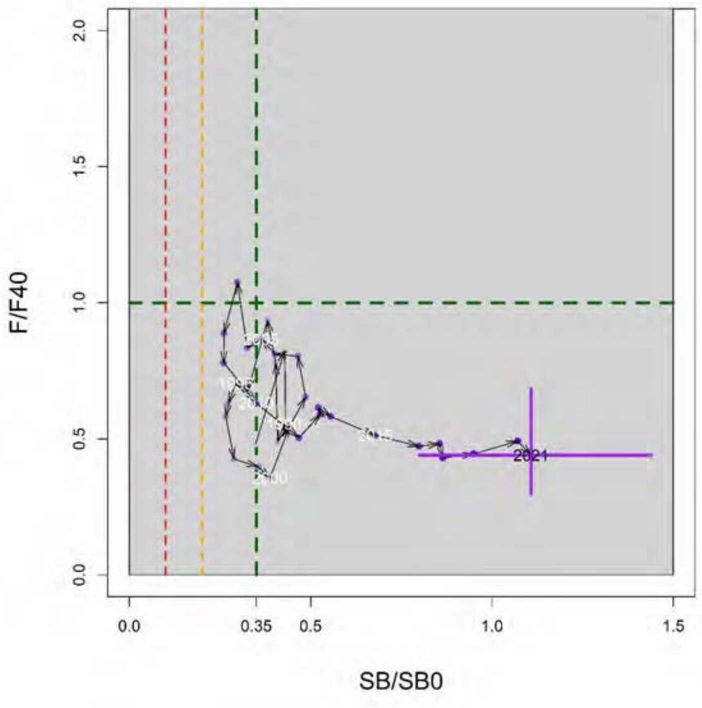
| Stock Status | |
|---|---|
| Year of Most Recent Assessment | 2022 |
| Assessment runs presented | Base case |
| Reference Points | Interim Target: 35% $B_0$ (HSS default)<br>Soft Limit: 20% $B_0$ (HSS default)<br>Hard Limit: 10% $B_0$ (HSS default)<br>Overfishing threshold: $F_{SB40\%}$ (HSS default) |
| Status in relation to Target | $B_{2020–21}$ was estimated to be 111% $B_0$. Virtually certain (> 99%) to be at or above the target |
| Status in relation to Limits | Soft limit: Exceptionally Unlikely (< 1%) to be below<br>Hard Limit: Exceptionally Unlikely (< 1%) to be below |
| Status in relation to Overfishing | $F_{2020–21}$ was estimated to be 44% $F_{SB40\%}$. Overfishing is Very Unlikely (< 10%) to be occurring |

**Historical Abundance and Catch Trajectories**




**Annual trend in spawning biomass relative to the 35% $SB_0$ interim target biomass level for the base model. The line represents the median and the shaded area represents the 95% credible interval. The dashed line represents the interim target level. The red and orange dashed lines represent the hard and soft biomass limits, respectively.**

| Fishing Intensity Trajectories |
|---|
|  |
| **Annual fishing mortality compared to the *F<sub>SB40%</sub>* interim threshold fishing mortality level (dashed line) for the interim base case model (median values from MCMCs). Grey shaded area represents 95% credible intervals.** |

| Combined trajectories |
|---|
|  |
| **Annual spawning biomass and fishing mortality compared to the *SB<sub>35%</sub>* interim target biomass level and corresponding fishing mortality threshold for the base case model (median values from MCMCs). The green dashed lines represent the biomass target and fishing mortality threshold levels. The red and orange dashed lines represent the hard and soft biomass limits, respectively. The 95% credible intervals are shown for the final year.** |

| Fishery and Stock Trends | |
|---|---|
| Recent trend in Biomass or Proxy | Spawning biomass was estimated to have increased from 2010 following above average recruitment since the late 2000s, which has continued to be high over the last 5 years. |
| Recent trend in Fishing Intensity or Proxy | Fishing mortality has been well below the threshold level since 2010. |

| | |
|---|---|
| Other Abundance Indices | The BT FLA and BT mixed CPUE indices increased from 2009–10 to 2015–16. The CPUE indices were not updated for the 2022 assessment. |
| Trends in Other Relevant Indicators or Variables | - |

| **Projections and Prognosis** | |
|---|---|
| Stock Projections or Prognosis | Abundance is Very Likely (> 90%) to remain above the target biomass level over the next five years at the current catch or TACC. |
| Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits | Soft Limit: Exceptionally Unlikely (< 1%)<br>Hard Limit: Exceptionally Unlikely (< 1%) |
| Probability of Current Catch or TACC causing Overfishing to continue or to commence | Very Unlikely (< 10%) |

| **Assessment Methodology and Evaluation** | | |
|---|---|---|
| Assessment Type | Level 1 - Full Quantitative Stock Assessment | |
| Assessment Method | Age-structured Bayesian stock assessment implemented with Stock Synthesis software and uncertainty estimated by MCMC | |
| Assessment Dates | Latest assessment: 2022 | Next assessment: 2025 |
| Overall assessment quality rank | 1 – High Quality | |
| Main data inputs | - Commercial catch (from 1987 onwards)<br>- Survey biomass indices<br>- Survey age/length frequencies<br>- Estimates of biological parameters (e.g., growth, natural mortality, age-at-maturity, and length/ weight) | 1 – High Quality<br>1 – High Quality<br>1 – High Quality<br>1 – High Quality |
| Data not used (rank) | - CPUE indices (to 2015–16) | 2 – Medium or Mixed quality: doesn't appear to be indexing abundance throughout the series |
| Changes to Model Structure and Assumptions | - First implementation of a full quantitative assessment; the previous partial quantitative assessment was based on WCSI trawl survey biomass indices relative to reference period | |
| Major Sources of Uncertainty | - Lack of recent age composition data from the trawl survey and age or length composition data from the fishery | |

| **Qualifying Comments** |
|---|
| - Reference points ($SB_0$ based) are derived from the average level of recruitment during 1987–2020. There was an apparent shift in the productivity of GUR 7 in the late 2000s. The increasing catches since 2012 were sustained by the higher level of recruitment.<br>- Stock assessment and yield estimates apply only to the reported catch from the commercial fishery. |

| **Fishery Interactions** |
|---|
| Red gurnard are primarily taken in conjunction with the following QMS species: flatfish, barracouta, stargazer, red cod, tarakihi, and other species in the west coast South Island target bottom trawl fishery. |

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